EARTHEN ARCHITECTURE AND TECHNOLOGICAL CHANGE AT POGGIO CIVITATE

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ABSTRACT

DANIEL MOORE: Earthen Architecture and Technological Change at Poggio Civitate
(Under the direction of Kenneth Sams)

The use of terracotta tiles to roof buildings in central Italy began during the mid-7^{th} c. BC. This development is usually attributed to the recent arrival of Greek colonists from Corinth into peninsular Italy. The present study examines the architectural evidence from one of the first sites in Etruria to use terracotta tiles for roofing, the 7^{th} c. BC complex at Poggio Civitate. The architecture at this site represents a mix of Italic and Near Eastern building techniques: the wattle-and-daub construction typical of northern Italy was used alongside the Near Eastern construction techniques of mudbrick and hydraulic mortar in an effort to support the first iteration of terracotta tiled roofs at the site. I argue that the appearance of these new technologies as a 'package' – mudbrick, hydraulic mortar, and terracotta tiles - at Poggio Civitate at a time roughly contemporary with the earliest terracotta tiled roofs in Corinth suggests that the development of terracotta tiled roofs in Etruria was not the result of technological diffusion from Greek colonists to Etruscan natives. Rather, the architecture at Poggio Civitate indicates that the Etruscans played an active role in the innovation of the terracotta tiled roof in Italy. Furthermore, the presence of Near Eastern construction techniques alongside the development of this new technology suggests that the wide network of communication fostered by Etruscan elites aided technological progression during the 7^{th} c. BC.

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TABLE OF CONTENTS

LIST OF TABLES

Table

LIST OF FIGURES

Figure

LIST OF MAPS

Map

CHAPTER 1:
INTRODUCTION

Earthen architecture usually does not warrant a full-length study in Old World archaeology. The Etruscan site of Poggio Civitate, however, occupies an important position in the history of architectural technology. The buildings of the 7th c. BC Orientalizing complex were among the first structures in Italy and the entire ancient Mediterranean to use the technology of architectural terracottas for roofing (Map 1). A roof of architectural terracottas consisted of several ceramic components that worked together to provide a covering for a building (Fig. 1). The most important components included flat pan tiles (85-86 in Fig. 1) with beveled edges, allowing them to lock together as they sat upon the slope of a gabled roof, and cover tiles (83-32 in Fig. 1) which sat over the junction of adjacent pan tiles, ensuring that rainwater could not penetrate the ceramic roof covering. Ridge tiles, some decorated with acroteria (70-344 in Fig. 1), sat at the apex of the gabled roof above the roof's ridge beam. Pan tiles and cover tiles along the eaves of the roof were also given decorative treatment. The edges of the pan tiles formed a lip and were shaped into the form of feline spouts at the center (83-92 in Fig. 1). The corresponding cover tiles were closed off with antefixes in the shape of human heads (85-81 in Fig. 1) so that the edge of the roof displayed a series of alternating human and feline heads to the viewer below.

The increased weight generated by the tiles and decorative terracottas should have required a more robust construction technique for wall construction, i.e. the use of fitted stones, mudbricks, or even rammed-earth walls, as was the case for the subsequent 6th c. BC buildings constructed on the site after the destruction of the 7th c. BC complex. For the walls of the 7th c. BC complex, though, the construction technique of wattle-and-daub, typical for the huts of prehistoric temperate Europe, continued in use. Wattle-and-daub has a limited bearing capacity and was usually used for walls supporting lightweight thatched roofs. This apparent contradiction of architectural technologies used at Poggio Civitate during the 7th c. BC - heavy decorative terracotta tiled roofs supported by makeshift earthen walls - raises questions about the process and nature of technological change at Poggio Civitate during the Orientalizing period. From the time of at least Augustus, Italy has been perceived to have been on the receiving end of Greek art and technology.[1] The terracotta tiled roof is no exception and its adoption in Italy during the 7th c. BC has been described by most scholars as a consequence of technological diffusion from Greece to Italy.[2] As shown in Ö. Wikander's schemata of the development of the terracotta tiled roof in Figure 2, during the 7th c. BC numerous buildings throughout Greece and Italy adopted this technology. The construction techniques at Poggio Civitate, however, do not resemble those used for the first buildings using terracotta tiled roofs in the Greek world.[3] Study of the earthen architecture recovered

[1] Hor. *Epist.* 2.1.156-7: "*Graecia capta ferum victorem cepit et artes intulit agresti Latio.*" One could take a narrow view of *artes* as having purely aesthetic connotations, but the philologist D. Feeney 2007, 130, believes, for the authors of the early Imperial period, *artes* encompassed all those things that divorced humans from nature. S. Cuomo 2007, 1-2, points out that the Latin *ars* was the equivalent of the Greek *techne* and covered a wide range of technologies.

[2] Winter 2009, 576-7; Ch. Wikander 2001, 271; Williams 1978, 345; O. Wikander 1990, 161; 1986, 127-8.

[3] Rhodes 2003, 85-94.

from the 7^{th} c. BC complex at Poggio Civitate suggests that the Etruscans were instrumental in the innovation of terracotta tiled roofs and that their contacts with the Near East spurred the initial diffusion of this new technology into the western Mediterranean. This first chapter gives a brief overview of the excavations at the site and the two different settlement phases identified by archaeologists. The theories offered to explain the development of terracotta tiled roofing in Italy during the 7^{th} c. BC will also be explored. Finally, the rationale for using evidence from the superstructure of the buildings, i.e. earthen architecture, as a method to explain the dynamics of technological change at Poggio Civitate, instead of the terracotta tiles themselves, will be offered.

1.1: The Site

The site of Poggio Civitate is best known for its 6^{th} c. BC monumental complex, discovered during excavations conducted by Bryn Mawr College under the direction of Prof. K. Phillips in the 1960s and 1970s. The complex consisted of four buildings approximately 60 meters in length surrounding an open courtyard (Fig. 3).[4] The buildings were roofed with architectural terracottas including pan and cover tiles along with ridge tiles that supported terracotta statuary. The edges of the roofs were outfitted with separate architectural terracotta components called simas. The raking simas that covered the gabled edges of the roofs were topped with strigils displaying a hare chase in relief (Fig. 4). The exterior rafters of the buildings were covered with revetment plaques displaying banqueting, procession, assembly, and racing scenes in relief along with antefixes decorated with gorgon heads (Fig. 5). Surrounding the interior courtyard, the

[4] Nielsen 1985, 66-69, 98-154; Phillips 1993, 5-49.

terracotta roofs would have ended in a lateral sima decorated with rosettes and female heads in relief, interspersed between feline-head waterspouts (Fig. 6).[5] The structures were built with walls of rammed earth (pisé) set on thick rubble stone foundations (1.2 meters thick at their base and 0.9 meters at the bearing surface) that were topped off by a layer of broken tiles and ceramics. The walls displayed a mixture of construction techniques. The exterior walls of the northern wing of the complex appear to have been incorporated into the agger that was built up around the site after its destruction. A portion of this wall was discovered by cutting into the agger, thus revealing a cross section of the building's earthen wall (Fig. 7). In order to explain the bulge of soil evident in the section above the wall's foundation, the excavators posited that the earthen walls had exterior timbers, with a tie-beam (0.25 x 0.25 m) running along the base of the wall in order to receive vertical timber reinforcements along the exterior.[6] This northern wing also displayed a series of postholes cut into the faces of its interior walls (Fig. 8). The timbers set into these postholes would have helped to strengthen the wall's interior face and perhaps also support the roof. At a width of 12.8 meters, the weight of the roof would have been substantial. At the eastern end of this wing there was evidence for postholes along its central axis that would have provided for a row of columns down the center of the room for added support. Interior walls were built with alternating courses of mudbrick and packed earth (Fig. 9).[7] The excavators assumed the earthen walls for this complex were constructed in the pisé technique (i.e. a wall formed by compacting

[5] Winter 2009, 155-57.

[6] Phillips 1968, 334.

[7] Phillips 1970, 242.

earth between wooden boards) given the profile of the wall discovered while cutting through the agger surrounding the site. [8]

Less well-known are the remains of the 7th c. BC structures found beneath and adjacent to the 6th century BC complex. Along with Rome and the southern Etruscan site of Acquarossa, this 7th c. BC settlement stands at the beginning of terracotta architectural decoration in central Italy.[9] The 7th c. BC complex consisted of at least four separate structures, although it is not clear if they existed all at the same time. Phillips and E. Nielsen presented evidence for a building beneath the eastern wing of the Archaic complex in 1983 (Fig. 10) that they called the 'Lower Building' and a structure to the north of the Archaic complex called the 'Northern Building' (Fig. 11). They also found foundation stones for a southern building that they thought might have coexisted with the Lower and Northern buildings during the 7th c. BC. The Lower Building measured 8.5 x 35.8 m and had 0.75 meter wide rubble foundation walls, while the Northern Building had similar foundations walls and measured 16.25 x 7.0 m.[10] Around the same time, E. Rystedt presented a plan of the Orientalizing Complex that differed somewhat from that of Phillips and Nielsen but was based on her experience excavating at the site during the 1970s. Her version of the 7th c. BC buildings included evidence for structures located 20-30 cm beneath the foundations of the Archaic building, including the 'Lower Building' identified by Phillips and Nielsen which she labeled 'Lower Building 1,' or 'LB1' (Fig. 12). She also identified two other buildings to the north and south which she

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[8] Phillips 1993, 13-14.

[9] Winter 2009, 55-66, 144-50.

[10] Nielsen and Phillips 1983{1986], 6-10, 23-4.

called ‘LB2’ and ‘LB3,’ but they did not coincide with the northern and southern buildings of Phillips and Nielsen. During the1980s, excavations some 50 meters to the southeast at the edge of the plateau of Poggio Civitate overseen by E. Nielsen uncovered 46 stone column bases arranged in three parallel lines running east to west. They were set into a clay-like plaster floor and supported the roof of a structure designated the ‘Southeast Building’ measuring at least 51 meters long and roughly 6.6 meters wide.[11] The stone bases were placed 2.75 meters apart, center-on-center (Fig. 13).[12] Twelve smaller stone pads were also found 0.35 meters to the north in line with the file of column pads.[13] Further excavations beneath the southern wing of the Archaic complex during the 1990s clarified the disposition of the foundation walls identified as LB3 by Rystedt in 1983. These walls served as the foundation for a tripartite structure measuring about 23.3 meters in length and 9.2 meters in width.[14] Although the foundation walls were in a poor state of preservation, they measured up to 1.5 meters in width in places where they could be discerned.[15] Based on pottery joins found between the Lower Building and the Southeast Building and the burn layer which appeared to cover these two buildings along with Rystedt’s LB3, Nielsen and A. Tuck suggested that these three buildings were part of a contemporaneous Orientalizing Complex and were destroyed simultaneously. In their lexicon, the Lower Building was designated Orientalizing Complex 1/Residence

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[11] Nielsen 1987: 91-4.

[12] Nielsen and Tuck 2001, 39. This distance may have been a multiple of the Oscan foot, which ranged from 27.5 to 27.7 cm.

[13] Ibid 37.

[14] Nielsen and Tuck 2001, 38-45.

[15] Winter 2009, 52.

because of the pottery assemblage recovered inside, the Southeast Building became Orientalizing Complex 2(OC2) /Workshop due to evidence for industrial activity associated with it, and Rystedt's LB3 was called Orientalizing Complex 3(OC3)/Tripartite (Fig. 14).[16] The relationship of this complex to the Northern and Southern buildings identified previously by Phillips and Nielsen and Rystedt's LB2 is not clear, but pottery recovered from all five buildings suggest a date prior to the beginning of the 6th c. BC.[17]

These buildings differed from those dated to the 6th c. BC in both construction technique and decoration. The walls of the buildings of the 7th c. BC Orientalizing complex appear to have been constructed largely with wattle-and-daub (Fig. 15) and also mudbricks.[18] Although rubble stone foundations were found for OC1 and OC3, excavations in and around the workshop, OC2, revealed no indication of wall socles, foundation trenches, or postholes. The only evidence for foundational support was in the

[16] Nielsen and Tuck 2001, 38.

[17] The most recent discussion of the difficult chronology of the Orientalizing buildings at Poggio Civitate is provided by Berkin 2003, 10-12, esp. n.6 and 10. Berkin rejects Rystedt's identification of a wall belonging to a building 'LB2' separate from the LB1/Lower Building/Orientalizing Complex 1(Residence). As will be discussed in this study, however, Rystedt did find significant evidence for walls in the trench, R5, sunk in the northeastern part of LB1/Lower Building/Orientalizing Complex 1(Residence), although it is not clear if this evidence belongs to a separate building or to LB1/Lower Building/Orientalizing Complex 1(Residence). A large portion of the pottery used in Berkin's study of the Orientalizing bucchero at the site comes from trench R5 and he attributes the collection to LB1/Lower Building/Orientalizing Complex 1(Residence). Berkin appears to be unfamiliar with Nielsen and Tuck 2001 and their association of Orientalizing Complex 3/Tripartite with OC1 and OC2.

[18] Phillips 1971, 261, initially and later on 1993, 55-56, assumed that the same construction technique was used for both the 6th and 7th century BC walls base d on the evidence from the initial soundings of Trench R6 in the southern portion of OC1. No representative material from trench R6 was retained in the storeroom at Vescovado di Murlo. Upon inspection of the trench books (ER2 & 3) from the adjacent trench, R5, and the finds from that trench consigned in the storeroom, it became evident that wattle-and-daub, not pisé, was used to construct OC1's walls. These artifacts are catalogued and discussed in Chapter 4. There does appear to be some confusion in publications with regard to the difference in pisé and wattle-and-daub, e.g. Wendt 1986, 59-60, Fig. 89.

form of the stone column bases.[19] In decoration, the architectural terracotta decoration for the Orientalizing buildings was decidedly less ornate than that used for the Archaic buildings. There were no decorative terracotta statues, only relatively simple cut-out acroteria that primarily displayed vegetal motifs, felines, and, in two cases, human figures.[20] Evidence for raking simas or revetment plaques is questionable. Unfired clay ribbons found on the floor of one of the buildings might have been in the process of being fashioned into revetment plaques at the time of their destruction.[21] There was only one possible fragment of a raking sima with cavetto profile and two possible revetment plaque fragments, both decorated with paint. Two of the pieces were recovered from a trench excavated to the north of the Archaic complex and the third was pulled from the agger built up around the site after its destruction; none could be associated with any particular building.[22] While the pan tiles of the 6th c. BC complex conformed to a standard size (54 x 63 cm), those belonging to the buildings of the 7th c. BC complex ranged in size from an unwieldy 50 x 79 cm to the fairly compact 40 x 51 cm.[23] The sizes of cover tiles and ridge tiles also varied, in contrast to the standardized versions

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[19] Nielsen 1996, 394.

[20] Winter 2009, 99-116.

[21] Nielsen 1998, 102-3, Fig.4; Winter 2009, 94-5.

[22] Winter 2009 72, 94. The sima and one of the revetment fragments were recovered from trench T-17, which was excavated sporadically in 1970-71 and 1977. The sima fragment was found in 1971 (catalogue # PC1971-0959) at a depth of 1.6m along with statue fragments from the 6th c. BC buildings. Winter 1999, 462 and 2000, 253, refers to the sima fragment as catalogue #PC1996-0002, but then correctly refers to it as PC1971-0959 in Winter 2009, 72, n. 57. The revetment fragment was found in 1977; no depth was recorded but it appears to have been found along with frieze fragments from the 6th c. BC complex. Winter 2009, 94, n.107, refers to the revetment fragment as catalogue # PC1996-0004, but it appears to have been catalogued initially under a different number when it was first recovered (PC1977-0297). The other possible revetment fragment was found in 1968 within the agger, presumably an Archaic context, and its catalogue # is PC1968-0285.

[23] Winter 2009, 127, 21.

used during the 6th c. BC.[24] Fragments for lateral simas and antefixes were associated with only one building (OC2/the workshop) and these were fewer in number and smaller in size than those used around the courtyard of the 6th BC complex.[25] Their iconography also differed somewhat; both the lateral simas of the 7th and 6th c. BC had feline waterspouts and female antefixes, but the 7th c. BC lateral sima lacked rosettes and included bearded male antefixes used interchangeably with the female antefixes (Fig. 16).

1.2: The Problem

Scholars explain the development and use of architectural terracottas in 7th c. BC Italy as the result of either diffusion or urbanization. In the latter case, Helene Damgaard Andersen[26] and Charlotte Sheffer[27] have suggested that higher population density could have been a factor behind the development of architectural terracotta in Italy. Örjan Wikander has suggested that the typical thatched roof of the Italian Iron Age fell out of favor during the 7th c. BC because terracotta tiles performed better as a roofing material.[28] From a functional perspective, it can be argued that terracotta roofing components are less desirable than thatched roofs. Terracotta tiles do not necessarily provide any better protection from the elements than a well-constructed thatched roof; they are more expensive and labor-intensive to produce; they cannot be easily repaired; and they require much more robust walls and foundations for support. The only substantial benefit of

[24] Winter 2009, 131, 217.

[25] Ibid 78, 87, 165, 171

[26] Damgaard Andersen 1997, 347.

[27] Sheffer 1990, 191.

[28] Wikander 1988, 206-8.

constructing a terracotta tiled roof that Wikander could think of was fire-protection. Increasing urbanization throughout the Mediterranean during the 7th c. BC resulted in higher population densities. Architecturally, this would manifest itself in closely packed huts that had a higher propensity to catch fire. The need for people to live closer together in proto-urban settlements spurred the invention of a fire-proof roofing material: the terracotta roofing tile. Sheffer concurs with the theory that urbanization was a driving force in the development of terracotta tiles in Iron Age Italy but credits the Greeks with introducing to Italian builders the concept of stone foundations and square building plans. Once the Italians had learned to build more robust superstructures capable of supporting tiled roofs, they could develop terracotta tiles as a roofing alternative without outside help.

Although sensible, these explanations fall victim to the logical fallacy of *post hoc ergo propter hoc* inherent in a functionalist view of material culture.[29] The coincidence of urbanization – if the first sites in Italy using terracotta roofing tiles can truly be called 'urban' – with terracotta roofing does not indicate that the former was the cause of the latter. Population density does not demand terracotta tiled roofing. The people of Neolithic Catal Huyuk literally lived on top of each other and survived with timber and mudbrick for construction.[30] It can be argued that Wikander's explanation has its roots in Vitruvius' observation that wattle-and-daub walls were prone to catch fire, but Vitruvius' discussion did not extend to roofing.[31] With regard to Sheffer's suggestion that only the

[29] Pfaffenberger 1992, 499.

[30] Mellart 1967, Fig 59, 60.

[31] Vitr. *De Arch*. 2.7.20.

realignment and development of foundations and building plans in Italy during the 7th and 6th centuries BC in Italy enabled the invention of roofing tiles, archaeological evidence indicates that Italians did not continuously live in dispersed round huts before the Orientalizing period. Prehistoric sites in Italy such as Fiave, Capo Millazzeze, and Filacudi displayed dense habitation from at least the Bronze Age[32] and rectilinear stone foundations have been identified for buildings at Passo di Corvo during the late Neolithic period and Tufariello in the Bronze Age.[33]

While the logic of attributing the invention of roofing tiles to urbanization can be faulted, it does attempt to take into account the social conditions that contributed to technological change. Diffusion, on the other hand, assumes the development of terracotta tiled roofs in Italy was a passive process whereby the Italians received a superior technology from Greek colonists. Diffusion has long been under attack within archaeology as an explanatory model[34] but persists in both describing and explaining the emergence and spread of roofing tile technology throughout the ancient Mediterranean. Diffusionist explanations for the emergence of architectural terracottas in Italy are rooted in the ancient sources. Pliny the Elder[35] wrote that Demaratus, an aristocrat of the ruling Bacchiad family at Corinth, brought the technology of coroplasty with him to Etruria when he and the other Bacchiads were exiled from the city in the mid-7th century BC. According to Pliny, a Corinthian potter named Butades invented the technology of molds, fashioned them into masks, pressed clay into the molds, fired them and then used

[32] Peroni 1988, 32-34.

[33] See Chapter 3.

[34] Rowe 1966, 334-7; Renfrew 1969, 153.

[35] Pliny *NH* 35.43.152.

the terracotta masks to decorate the gutter-tiles of roofs. Based upon Butades' invention, the decoration of temple pediments with architectural terracottas arose. Pliny states that Demaratus was accompanied by three Corinthian coroplasts – Euchir, Diopus, and Eugrammus - who taught Italians how to make clay molds. Other ancient writers also contribute to the outsized role of Demaratus in civilizing the Italians. Strabo remarked how Demaratus brought people with him to instruct the Italians on Greek crafts[36] and Tacitus even credits Demaratus with instructing the Etruscans on how to write.[37]

Charles Williams interpreted Pliny's story about Demaratus, along with mentions of him in Cicero,[38] as direct evidence that Demaratus introduced roofing tile technology to the Italians.[39] No ancient author, however, specifically stated that Demaratus or his companions taught the Italians to manufacture architectural terracottas, although Pliny does leave the impression that working with clay molds inevitably led to the use of architectural terracottas. Nancy Winter tied Pliny's story about Demaratus' spreading of Greek technology in Italy after his exile from Corinth to construction similarities on terracotta tiled roofs at Poggio Civitate, Corfu, and Syracuse.[40] She singled out Corfu and Syracuse because of the Corinthian role in establishing colonies in each place. Thucydides wrote that Archias, a member of Corinth's Bacchiad family, founded Syracuse in the late 8th c. BC[41] and Strabo reported that Archias left his kinsman

[36] Strab. *Geog*. 5.2.

[37] Tac. *Ann.* 11.14

[38] Cic. *Rep*, 2.19, 34; Tusc. 5. 109

[39] Williams 1978, 345.

[40] Winter 1993a; 2000; 2002/3; also Torelli 2000, 70.

[41] Thuc. 6.3.

Chersicrates to colonize Corfu along the way.[42] Cicero, Pliny the Elder, and Dionysius of Halicarnassus relate the story of Demaratus' arrival in Italy; [43] Nicolaus of Damascus wrote of Bacchiad exiles in Corfu;[44] and Plutarch mentions that Bacchiads fled to Sparta in his life of Lysander.[45] No ancient historian mentions a Bacchiad migration to Syracuse, but Winter believes it would have been an attractive option for them after exile because of the Bacchiad foundation of Syracuse in 733 BC. The only account that the historian J.B. Salmon believes has any basis in fact regarding Bacchiad exiles is that of Nicolaus of Damascus, although he concedes some kernel of truth probably exists behind the legend of Demaratus because of Corinth's aggressive trade policy in the western Mediterranean.[46]

Winter focused on three features which link the Orientalizing Complex roofs at Poggio Civitate to roofs in Corfu and Syracuse: (1) a raking sima with a cavetto profile decorated in a painted tongue pattern, (2) eaves tiles with feline waterspouts and (3) antefixes in the shape of a female head. [47] At Mon Repos in Corfu, elements of a roof belonging to an early temple of Hera were recovered from a terrace fill dated to c. 610 BC. Components included a raking sima with cavetto profile that might have had a

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[42] Strab. *Geog*. 6.2.

[43] Cic. *Rep*. 2,19; *Tusc*. 5.37.109; Dion. Hal. *Ant. Rom*. 3. 46-7.

[44] Nic. Dam. *FGrH* 90 57.7

[45] Plut. *Lys*. 1.2

[46] Salmon 1984, 86, 106, 195; Corinthian pottery is found at Pithecusae as early as the mid-8th c. BC and in Etruria by the mid-7th c. BC, see DeVries 2003, 141-56.

[47] Winter 2002/3, 228.

painted tongue pattern (Fig. 17),[48] along with antefixes that were decorated with gorgons and female heads interspersed with lion-head spouts (Fig. 18).[49] In Syracuse, terracotta roofs of the late 7th and early 6th c. BC also used a raking sima with a cavetto profile decorated in a painted tongue pattern (Fig. 19), but the earliest antefixes do not appear until the mid- 6th c. BC.[50] As noted above, the Orientalizing complex at Poggio Civitate used female antefixes between feline water spouts, and potential evidence exists for a raking sima with cavetto profile painted with a tongue decoration (Fig. 20). The presence of these three architectural and decorative peculiarities at Corfu, Syracuse, and Poggio Civitate during the late 7th c. BC, in Winter's opinion, suggests that the Bacchiads exported terracotta roofing technology to points west after their exile. In addition, the presence of clay molds for the making of antefixes at Poggio Civitate also implied a Corinthian connection.[51]

The immediate difficulty encountered in this version of technological diffusion from Corinth westwards is the fact that Corinthian terracotta roofs of the 7th c. BC do not display any of the three characteristics identified by Winter as markers of the Corinthian terracotta roofing technology. The building with the earliest dated terracotta roofing - the Old Temple at Corinth, dated sometime between 680 and 650 BC[52] - used only interlocking combination pan-and-cover tiles and specialized corner tiles to accommodate

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[48] Schleif et al. 1940, 152-4, Abb. 135, 137. This fragment was heavily damaged and only maintained some flecks of black paint. Its form could be related to a contemporary well-preserved raking sima from the 7th c. BC temple of Apollo at Thermos with painted tongue decoration.

[49] Winter 1993b, 115-17; Schlief et al. 1940, 149-52.

[50] Winter 1993b 274-5, 79.

[51] Winter 2002/3, 230; 2009, 574. Clay molds have been found in early- to mid-Bronze Age contexts for metalcasting in northern Italy (Fiave: Perini 1987, 34-6; Ledro: Rageth 1974, 174-7).

[52] Sapirstein 2008, 30.

a hipped roof (Fig. 21). There were no simas or antefixes. Phillip Sapirstein's recent study of the terracotta roofing tiles at Corinth has led him to suggest that the interlocking combination roofing tiles used on the Old Temple at Corinth might have been based on earlier prototypes developed elsewhere using separate cover and pan tiles.[53] With regard to the relationship between the Protocorinthian and Etruscan roofing tile systems, Sapirstein stated that they 'share so little in common that they should be considered to have had independent origins.'[54]

Winter acknowledged the difficulty that the evidence for earliest terracotta roofing at Corinth presented but pointed to technical and iconographic connections between the roofing systems in central Italy and the Corinthia. Tiles at both locations were manufactured using standard-sized wooden moulds coated with sand to allow easy removal of the tile; they were formed into flat pan tiles with corner beveling and cover tiles with a convex shape; the corners were notched to permit joining of the pan tiles on a slope. After manufacture, the tiles were slipped by hand and trimmed to provide a proper fit upon the roof supported upon mudbrick walls set atop stone foundations.[55] In addition, the iconography of a mid-7th c. BC lustral water basin (perirrhanterion) found in the sanctuary of Poseidon at Isthmia could have served as inspiration for exiled

[53] Sapirstein 2009, 224-6; contra Ö. Wikander 1990, 289 and 1992, 155-6, who argues that new inventions such as the Protocorinthian tile are more likely to be complex and later improvements should display more simplicity. Winter 1993b, 12 n.3, prefers Wikander's view and believes Sapirstein's study lends credence to Wikander's idea by illustrating the complexity of the Protocorinthian scheme and the need for adjustments during its implementation (personal communication).

[54] Sapirstein 2008, 353.

[55] Winter 2009, 577.

Corinthian coroplasts in the service of the Bacchiads (Fig. 22).[56] The perirrhanterion was set up at the entrance to the temple, which was decorated with terracotta roof tiles similar to those found at the Old Temple at Corinth. The marble basin was supported on a separate marble ring that had a cavetto molding painted with a tongue pattern. Sculpted figures in the shape of korai supported the basin while standing on the backs of lions (Fig. 23). Ram's heads were placed between the female figures. In this composition, these sculpted females possibly represented the potnia theron: the 'mistress of beasts.'[57] Returning to Etruria, the iconography of the potnia theron has also been suggested for the lateral sima composition at Poggio Civitate because the female antefix was bracketed by feline water spouts.[58] Despite the formal differences, Winter believes the iconography of the potnia theron provides a link between the perirrhanterion at Isthmia and the lateral sima at Poggio Civitate.[59] At Poggio Civitate, as at sites in Sicily and Corfu, the potnia theron motif was incorporated into the overall decorative scheme of the terracotta roofs and as Winter states, 'no other single monument combines so many of the decorative elements found in the early roofs of Etruria, Corfu, and Sicily.'[60]

If one were to cede that the distinct formal differences that existed between the 7th c. BC terracotta roofs of Corinth and those of Poggio Civitate, Syracuse, and Corfu could

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[56] Winter 2002/3, 229; Winter 2009, 577.

[57] Sturgeon 1987, 51-2; as a polysemous monument, Sturgeon also suggests other interpretations of the female figures carved onto the perirhanterion. Their depiction as caryatids may cast them in the role of servants, but their position on top of lions may signal divinity. As divinities, they could represent a subordinate cult for female divinity within the sanctuary, perhaps Artemis, and the divinity's relationship with Poseidon could underscore a common concern for fertility and regeneration.

[58] Nielsen 1994, 65; Tuck 2006, 132-4.

[59] Winter 2002/3, 229; Winter 2009, 577.

[60] Winter 2002/3, 229.

be attributed to the rapid indigenous and/or itinerant craftsmen's' experimentation with an adopted technology inspired by artistic conventions from another medium, there is still the concept of the potnia theron to consider in Winter's scenario of diffusion. Why should the motif of the potnia theron be viewed as an exclusively Corinthian , or even Greek, export to Etruria? Nielsen, when advancing the idea that the female antefixes of the 7th c. BC building represented the potnia theron, drew attention to the motif's presence on early 6th c. BC Etruscan bucchero vessels at the site and those found in the neighboring area of Chiusi without hazarding to guess a precise foreign origin.[61] From a ceramics standpoint, of the fifteen vessels identified as Greek imports in the pottery assemblage recovered from Orientalizing complex 1, only one is Corinthian (dated to ca. 600 BC).[62] The other vessels were either Laconian or Ionian in origin, so Corinthian influence in ceramics, while present, was not dominant.[63] Furthermore, Damgaard Andersen[64] and Ingrid Strøm[65] have suggested that the motif of potnia theron was adapted by Etruscan artisans from Near Eastern, not Greek, prototypes. Anthony Tuck cited the presence of the potnia theron motif on 7th c. BC grave goods in the Banditella necropolis at Marsiliana d'Albegna and the Regolini-Galassi tomb in Caere. An ivory figurine and gold jewelry in the respective tombs were locally manufactured but employed a Near Eastern iconography for the potnia theron, wherein the goddess was depicted nude and cupping her breasts in order to accentuate her role in fertility similar to

[61] Nielsen 1994, 65.

[62] Berkin 2003, 25.

[63] Berkin 2003, 113-14.

[64] Damgaard Andersen 1992/3, 103.

[65] Strøm 1971, 212.

representations of Astarte in the Levant. This motif could also be seen in a modified form on bucchero cups from the Orientalizing complex, where winged potnia therons would grasp hair braids falling from their heads in front of their breasts. [66]

As pointed out by Nielsen, the potnia theron motif decorated several bucchero vessels recovered from OC 1 at Poggio Civitate. Within the Orientalizing destruction layer, Jon Berkin identified what he called a 'banqueting service' that included almost 60 drinking cups and nearly 100 serving or setting vessels.[67] Handles on the Etruscan bucchero drinking vessels called kyathoi were decorated with mold-made appliqués of the potnia theron. These appliqués displayed the potnia theron holding a variety of animals: lions by the tail (Fig. 24), water-birds by the neck, and in at least one instance, with a pair of owls hovered above her shoulders (Fig. 25). Berkin thought that the latter motif was a local development since owls are not normally associated with the potnia theron,[68] but Margetta Nielsen and Annette Rathje suggested a Near Eastern source for inspiration.[69] A possible parallel may come from a Mesopotamian context: the controversial Burney relief recently acquired by the British Museum (Fig. 26). This burnt clay tablet has been dated to the early 2nd millennium BC and is of unknown provenience, but it is thought to be a product of Babylonia.[70] It is not clear who this

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[66] Tuck 2010, 211-2.

[67] Berkin 2003, 122.

[68] Berkin 2003, 99.

[69] Nielsen and Rathje 2009, 267.

[70] See Albenda 2005 and Collon 2007 for opposing views. Thermoluminescence dating of the plaque was conducted by the British Museum in 1975. Two samples taken from the middle and upper right part of the plaque were tested and returned a date between 1725 BC and 25 BC, confirming that the plaque itself is ancient. Muscarella 2008, 13, and Albenda 2005, 187, reject the dating on the grounds that samples should have been tested from the actual body of the female relief figure itself and not the plaque, although the

goddess might have been, but suggestions include the Babylonian deities Ishtar, Ereshkigal, and Lilith.[71]

A link between the potnia theron at Poggio Civitate and that found on the Burney relief might exist within the destruction level of the Orientalizing Complex. Not far from the kyathos that displayed the potnia theron paired with owls, a green serpentine intaglio was recovered that originally was thought to have represented a dancing male figure,[72] but Barbara Patzek has identified it a Lamashtu amulet (Figures 27 and 28).[73] Over 80 of these amulets have been found throughout the ancient Mediterranean, with Poggio Civitate being the western-most find spot. Lamashtu was also a Babylonian goddess and her particular role was to menace pregnant mothers and their newborns; she supposedly fed upon the bones and vitals of infants. The function of the amulet is thought to have been apotropaic, warding off the goddess who would be repelled by the site of her own image.[74] The reputation of the owl as a night bird of ill-omen cuts across cultures and

plaque seems to have been fired as one piece. Albenda also rejects the authenticity of the plaque because of its unique iconographic and stylistic attributes within the Old Babylonian artistic corpus.

[71] Ishtar: Van Buren 1936-7, 354-7; Jacobsen 1987, 7; Lilith: Frankfort 1996, 110-2; Kraeling 1937, 16-18; Ereshkigal: Porada 1980, 266, von der Osten-Sacken 2002, 479-87.

[72] Phillips 1978, 360, calls the figure an 'awkward rendition of a typical Early Corinthian or Corinthian padded dancer.' These figures were found on Greek drinking vessels and were called 'padded' because they are depicted with exaggerated bellies and buttocks. Phillips believed this motif could have been adopted by Etruscan artisans inspired by the decoration of an incised bucchero olla found in Vulci that depicted humans with outstretched arms. Also Martelli and Gilotta 2000, 455-56, who described the amulet as having a dancing male figure on front and an androphagous lion on back. The latter motif they explained as a common Orientalizing convention found in metalwork and pottery, but they offered no explanation for the former. Phillips' explanation was based on F. Magi's description (1939, 112) of the figures on the bucchero olla as degenerate Corinthian padded dancers. However, Magi's characterization of the bucchero olla in question was rejected by both M. Bonamaci 1974, 171-2, who drew parallels between the decoration on the olla and metalware decoration at Orvieto, and F. Brown 1960, 37, who classified the olla as an Etrusco-Phoenician work based on the artist's rendition of lions on the vessel.

[73] Patzek 1988, 222.

[74] Burkert 1992, 83.

played a significant role in Roman legend.[75] Ovid wrote about the goddess Carna, a pre-Roman deity who protected the future mythical king of Rome, Procas, as a newborn from the '*striges*.'[76] Ovid described the striges as half-human birds who would attack and feed upon the innards of babies at night. Striges is the plural of the Latin word *strix*, which is usually translated as 'screech-owl.'[77] These creatures appear to have played a similar role in the Italic pantheon as that of Lamashtu in the Babylonian pantheon. The description of the striges provided by Ovid is fantastic, but most philologists believe he purposely used the term striges because he envisioned them as owl-like creatures.[78] Furthermore, Carna placated the striges by sacrificing a piglet and leaving its entrails out for them to feast upon. Christopher McDonough has suggested that the similarities between the legends of Lamashtu and Carna betray a historical connection between early Italian and Mesopotamian ritual that manifested itself first in the archaeological record at Poggio Civitate in the form of the Lamashtu amulet.[79] It could be argued that the presence of the Lamashtu amulet was random and without meaning; simply a trinket kept along with exotic vessels by elites in the spirit of conspicuous consumption. However, the amulet was found among Etruscan vessels that displayed the potnia theron with an iconography seemingly derived from Near Eastern prototypes and included as part of a banqueting service. Furthermore, the underlying purpose of the Lamashtu amulet – to

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[75] Armstrong 1958, 113-24.

[76] Ov. *Fast*. 6.101-82.

[77] Cherubini 2009, 77-80, gives a comprehensive overview of the use of the word *strix* by ancient authors. She underscores that the word is inextricably linked bird-creatures and the feminine.

[78] Capponi 1981: 301-4

[79] McDonough 1997, 336. For other religions connections between Etruria and Mesopotamia, see Burkert 1992, 46-53.

ensure fertility – might also have found expression within the architecture of the Orientalizing complex at Poggio Civitate. This would not be the only evidence of a religious connection between Etruscans and Mesopotamians, as the Etruscan divination rite of hepatoscopy also has parallels in Mesopotamia.[80]

Nielsen first pointed out the stylistic similarities between the potnia theron found on bucchero handles at Poggio Civitate and the building's architectural decoration.[81] Tuck has expanded on this interpretation by bringing attention to the use of female antefixes in the Orientalizing Complex's lateral sima in concert with acroteria in the form of lotus-palmettes on top of the roofs (Fig. 29).[82] The pairing of the lotus-palmette with the potnia theron was not uncommon in Etruscan art and Tuck refers to a kyathos handle whereon the lotus-palmette is placed over the genitalia of the goddess (Fig. 30). Taken along with the male antefixes that were also used to decorate the lateral sima of the Orientalizing complex, the iconography of the roofs at Poggio Civitate not only displayed the potnia theron's mastery over animals by placing her image between lion-head spouts, but also underscored her control over fertility and reproduction by incorporating the image of her consort, the 'Master of Beasts,' on the lateral sima.[83] In his view, fertility was a key concept in the iconography of the Etruscan potnia theron in Chiusi and its environs, most notably at Poggio Civitate. The presence of the Lamashtu amulet in the

[80] Burkert 1992, 46-51, suggests that the use of livers for divination could only have origins in the Near East and was likely learned by the Etruscans via the transfer of a 'school' from Mesopotamia to Etruria. See also Jannot 2005, 18.

[81] Nielsen 1994, 65.

[82] Rystedt 1983, 73-5, 142, Fig. 41, Pl 19-21; Tuck 2006, 132.

[83] Nielsen 1994, 65; Tuck 2006, 132-3.

destruction layer of the Orientalizing complex reinforces this point. Furthermore, on the kyathos handle from Chiusi that Tuck cites, two birds can be seen above the shoulders of this potnia theron. A. Valentini, in her survey of the potnia theron image on bucchero in Etruria, only referred to them as *uccelli* (birds) in her catalogue[84] but, upon closer inspection, it can be seen that the birds have the 'figure-8' form of owls and the bird above the left shoulder of the potnia appears to have two eyes turned towards the viewer, similar in pose to the owls on the kyathos handle found at Poggio Civitate (Fig. 31). Thus, it would seem that at Poggio Civitate and in the area of Chiusi, the concept of the potnia theron might have been significantly influenced by Near Eastern prototypes. The diverse iconographies that influenced Etruscan craftsmen during this time period and the formal differences in the terracotta tiles used at Poggio Civitate and Corinth during the 7th c. BC complicate any attempt to use diffusion in describing or explaining change in technology on a supraregional scale.

1.3: GOALS OF THIS STUDY

In general, buildings in Etruria have become archaeologically 'visible' only with the advent of architectural terracottas during the 7th c. BC. By default, archaeologists have turned to the literary tradition and the chronological and geographic description of formal variations in terracotta roofing decoration separated by great geographic distances to explain architectural change in central Italy during the Orientalizing period. In an archaeological landscape as fragmentary as prehistoric architecture, it is difficult to develop an explanatory model of change well-supported by the material record.

[84] Valentini 1969, 423, no. 24.

Diffusion was a key explanatory model employed in the culture-historical research tradition and is important in describing the spread of a technology, but it is not adequate as a comprehensive explanation for technological change.[85] The use of diffusion as a vehicle of explanation by archaeologists has been aided by the perception of technology as simply the 'hardware' used to accomplish a task, whether it is a stone tool or a pump,[86] or, in the case of architectural terracottas, the tiles and decorative components of a roof. This definition casts technology as a thing separate from its societal context and the attendant processes necessary for its implementation. Anthropologists and archaeologists have recently tried to define technology more broadly, substituting the terms 'socio-technical system'[87] or 'complex technological system (CTS)'[88] in order to underscore that the term 'technology' usually represents the interplay between several artifacts requiring human interaction. The expansion of the term 'technology' to include not only the 'hardware' but also the wider social context involved requires researchers to expand their scope of inquiry beyond formal description when attempting to explain the dynamics of technological change. In the case of the development of buildings decorated with architectural terracottas in Orientalizing Etruria, this perspective necessitates consideration not only of architectural terracottas but also of the buildings themselves, the architectural tradition in the area, and the societal milieu in which they were constructed.

[85] Kristiansen2005, 56.

[86] Lechtman 1993, 245; Dobres 2009, 119-20.

[87] Pfafferberger 1992, 502

[88] Schiffer and Skibo 1987, 595.

This study will focus on a particular aspect of technological change that accompanied the use of architectural terracottas: the superstructure of the buildings. The terracottas set atop a building's roof presented a significant construction challenge to the builders at Poggio Civitate because they greatly increased the roof's weight, both vertically and laterally.[89] The Greeks met this challenge by incorporating stone into temple walls in order to support the tiles' increased weight and, at the same time, resist the lateral forces generated by tiles sloping down a pitched roof.[90] Etruscan builders appear to have developed different solutions despite having ready access to sandstone and limestone deposits[91] and the capability to quarry and carve stone, as evidenced by their funerary architecture.[92] While the form and development of architectural terracottas have been the subject of dedicated study,[93] the changes in construction technique required to permit the use of roofing tiles and terracotta decoration in Italy have not received as much attention. This omission is regrettable since the construction techniques of a people or a region are more persistent than the fashions that govern the exterior adornment of buildings and houses. Evidence for pre- and proto-historic architecture, however, is not well-documented and, as a result, decorative terracottas have taken precedence in describing and explaining architectural change during the Etruscan period.[94] To wit,

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[89] O. Wikander 1988, 207.

[90] Rhodes 2003, 85-94.

[91] Spivey and Stoddart 1990, 28-9.

[92] Prayon 2004.

[93] Winter 1993b, 2009: Rystedt 1983; Wikander 1986, 1993.

[94] One is reminded of Moses Finley 1965, 41, who suggested that archaeologists are "too often victims of that great curse of archaeology, the indestructibility of pots," in reference to his perceived exaggeration of the importance of ancient ceramic vessels as an interpretive tool.

there is no established methodology for recovering and studying the remains of earthen architecture (daub and mudbrick) found during excavation, as there is for every other class of archaeological material (e.g. pottery, glass, bones, metal). Postholes or stone socles are routinely recorded as evidence for architecture, but it is rare for daub or mudbrick to be analyzed separately in a field report. Usually, this material only gets a passing mention. Thus, the construction techniques for the walls and roofs of pre-and proto-historic buildings in Italy - most of which were constructed with earth and timber - are not well-understood. Besides describing and explaining the architectural and technological changes that took place with the use of architectural terracottas at Poggio Civitate during the 7th c. BC, this study also seeks to establish a methodology for documenting and studying earthen architecture recovered on archaeological sites.

1.4: Overview of Chapters

The second chapter outlines the current theoretical and methodological approaches taken by archaeologists who study technological change and the concept and procedures I will employ. I argue that any study of technological change has to recognize that technology is socially embedded and resistant to change. Therefore, researchers need to adopt a regional and diachronic view of a particular technology when attempting to explain any large-scale change. Taking such a broad view of the material could lead to an overly deterministic view of cultural change devoid of human actors. I intend to avoid this pitfall by focusing on technological change at a specific site (Poggio Civitate) at a particular time (7th c. BC). The broad, diachronic survey of the technology of earthen architecture in Italy is set forth in the third chapter. Archaeological evidence indicating construction techniques in northern Italy, central Italy, and southern Italy is presented from the Neolithic through to and including the Orientalizing period. The purpose of this overview is to ascertain the technological choices available to the Etruscan builder during the 7th c. BC.   The fourth chapter presents the results of the morphological, archaeometric, and engineering analyses of the remains of earthen architecture recovered from Poggio Civitate. The fifth and final chapter places the architectural evidence at Poggio Civitate into the larger context of the progression of architectural technology on the Italian peninsula and assesses the various social, political, and economic forces that might have influenced the builders to change construction practices from simple roofs of clay and straw to the more complicated systems of architectural terracottas.

Chapter 2:
Archaeological Approaches to Technological Change

Several studies have focused on technology in the ancient world,[95] but classical archaeologists who have studied ancient technology have not paid a great deal of attention to the subject of technological change.[96] This neglect stands in contrast to the concerted, and perhaps overwrought, efforts of archaeologists and anthropologists active in North America to try to understand the process of technological change and develop predictive models that might guide invention and innovation. This chapter will present an overview of the development of the study of technological change in archaeology. At the conclusion, it will be suggested that a combination of methods developed by archaeologists from the fields of European history and North American archaeology may provide a way forward in developing a theory of technological change rooted in the material record.

2.1 Background

In the early 19th century AD, the Danish scholar Christian Thomsen developed the three-age system of Stone Age, Bronze Age, and Iron Age as a dating scheme for

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[95] Forbes 1964; Landels 1978; Humphrey 1998, Oleson 1986, 2008.

[96] Greene 2008, 76-84.

prehistoric archaeological material. Inherent within this system was the belief that technological change is progressive and evolutionary.[97] This view posited that each human cultural group held the capacity to develop and change and, if left to its own devices, would progress along a similar trajectory, though at different speeds.[98] The idea of inexorable human progress undergirded by technological progression, however, was not evident to many during the societal upheavals that came about with rapid industrialization during the late 19th and early 20th centuries AD and this spurred many scholars to develop other explanations for change in societal development.[99] This new focus dovetailed with an increasing concern about the roles of ethnicity and conservatism in human culture, resulting in what has been called the 'culture-historical' tradition in archaeology. Human cultures were perceived as distinct and separate, with some cultures more adept at change than others. The capacity for technological change was no longer perceived as universally innate but rather a function of cultural interaction; in particular, migration and diffusion.[100] The 'New Archaeology' of the 1960s, also called processual archaeology, took issue with the 'culture-historical' view that technological change was often brought about by external factors like diffusion.[101] Instead, technology was perceived as a culture's internal adaptive mechanism to its respective environment and

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[97] Trigger 2006, 121-9, Trigger comments that Thomsen did not view evolution as the main cause behind technological change in Scandinavian archaeology, but he did believe it played a role in technological change in prehistoric Europe.

[98] Winthrop 1991, 83.

[99] Dobres 2009, 118.

[100] Trigger 2006, 211-23; Dobres 2010, 118-9.

[101] Renfrew 1969, 153 called V. Gordon Childe the 'arch-diffusionist.'

the demands of the environment were viewed as the primary mechanisms guiding technological change.[102]

The environmental determinism incorporated into the 'New Archaeology' did not escape the postmodern critique. The viewpoint of processual archaeologists corresponded with what the anthropologist Brian Pfaffenberger called the 'Standard View of Technology,' which, in his opinion, was analogous to the 'Standard View of Science.'[103] The 'Standard view of Science' was the term coined by sociologists who thought that previous scholarly work on the scientific process lacked sophistication because scholars assumed the scientific process was unaffected by societal forces and personal biases. Pfaffenberger characterized processual archaeology's 'Standard view of Technology' in this way:[104]

> "Necessity is the mother of invention. As Man has been faced with severe survival challenges, certain extraordinary individuals have seen, often in a brilliant flash of inspiration, how to address the challenge of Need by applying the forces, potentialities, and affordances of Nature to the fabrication of tools and material artifacts…
>
> By viewing the material record of Man's technological achievements, one can directly perceive the challenges Man faced in the past, and how he met these challenges. This record shows a uni-linear progression over time, because technology is cumulative..."

Pfaffenberger believed close scholarly study of technological change exposed all of these assumptions to be either overly simplistic or completely wrong. He didn't question so much the axiom that 'necessity is the mother of invention' but believed that culture, not

[102] Trigger 2006, 394-5.

[103] Mulkay 1978.

[104] Pfafferberger 1992, 494.

nature, determined necessity.[105] He relied very much on the historian of technology George Basalla's book, *The Evolution of Technology*. Basalla eschewed any role for necessity in technological invention since humans could feasibly survive without any tools. On the contrary, Basalla suggested that 'invention is the mother of necessity' and used the automobile as an example. He noted that there was no horse shortage during the late 19th or early 20th centuries AD in Europe or America driving the invention of a new form of personal transportation. Furthermore, even when invented, the automobile was little more than a toy for the rich during its first decade of existence.[106] Basalla also dismissed the 'genius theory' of invention, wherein a single inspired individual devised a new way of doing something in isolation. Historically, talented individuals have made a difference in creating new technologies but their work was normally part of a longer process. In his opinion, the 'genius theory' of invention was nothing more than a figment of popular imagination that arose from a variety of factors to include nationalism, the patent system, and historians' predilection to characterize technological change as 'revolutionary,' instead of placing it in its longer and more mundane context.[107] If archaeology was going to break free from deterministic explanations of technological change, it was necessary for archaeologists to develop more sophisticated and useful paradigms that better accounted for societal contingencies and the role of the individual in the process of technological development.

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[105] Pfafferberger 1992, 496.

[106] Basalla 1989, 6-7.

[107] Ibid 60-2.

2.2: Behavioral and Post-Processual Archaeological approaches

Recent studies within the social sciences on modern inventions like radar and nuclear fission suggest the views of Pfaffenberger and Basalla are probably too dismissive of external pressures, but the concept of invention as a long, iterative process instead of a revelation occurring at a particular moment in time to a gifted individual under duress seems accurate.[108] Anthropologists' and historians' dissatisfaction with environmentally deterministic explanations for technological change influenced archaeological research and resulted in new theoretical and methodological approaches. These approaches fall within two schools of thought, often referred to as processual-plus archaeology and post-processual archaeology. The processualist-plus approach, popular in North American archaeology, has confidence that technological change can be modeled and predicted. The second school of thought, developed by post-processual archaeologists, believes that technological change is context-driven and no general theories can encompass the complex dynamics involved.

The most developed North American approach to technological change is called 'behavioral' archaeology, since it attempts to reconstruct the behavior of craftsmen and society-at-large when confronted with a multiplicity of options during the process of technological change. Michael Schiffer, the foremost proponent of this school, has focused his research on modern technological developments such as the portable radio,[109]

[108] Arthur 2007.

[109] Schiffer 1993.

the adoption of electric arc-lamps in lighthouses,[110] and the telegraph.[111] In behavioral archaeology, technological change is not a single process rooted in a particular moment but a series of steps occurring over time that is guided by choice. Technological change develops in four discrete phases: the *invention* of the new technology, the *development* of that technology to certain performance characteristics through trial-and-error, its *replication* facilitated by wider manufacturing processes, and finally the *adoption* of the new technology on a wide scale by people who find that its performance exceeds that of competing technologies. Technological change needs to be broken down and examined in these discrete steps.[112] When trying to understand and describe the process of technological change, analysis of the performance characteristics of the new technology versus that of competing technologies helps to explain its development. This not only takes into account the capabilities of the new technology itself, but also helps to inform the researcher about the goals of society since certain performance characteristics were preferred over others.[113]

A problem for the development of a theory of technological change is that most archaeological studies tend to focus on the replication and adoption of new technologies. This concentration may be unavoidable, though, because of the nature of the material record. New technologies that were not adopted on a wide scale likely did not leave behind a significant material record. In order to understand the entire process of technological change and, in particular, that of invention, Schiffer recommends that

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[110] Schiffer 2004.

[111] Schiffer 2005.

[112] Schiffer 2010, 236-39.

[113] Schiffer 2004, 581.

archaeologists adopt three methodologies: (1) concentrate excavation in refuse areas with the intention of finding prototypical evidence of the new technology; (2) use ethnoarchaeology and experimental archaeology to discover technical problems that would have been encountered in deploying the new technology; and (3) focus on behavioral changes that manifest themselves in the material record during technological change.[114] In Schiffer's research, he identified spurts of activity that accompany technological change. For instance, the invention of a new material will often be put to use in a multiplicity of ways, including those for which it is entirely unsuited. Such behavior modification reflects the optimism and experimentation typical in the development of new technologies.[115]

Schiffer offers this new paradigm because of the wider implications of focusing only on replication and adoption, which are properly the components of a new technology's innovation.[116] Previously, archaeologists with an evolutionary viewpoint identified the earliest attestation of a new technology as an invention and similar technological changes at places subsequent were described as the result of diffusion from the invention's origin. In reality, since the earliest attestation of the new technology has been manufactured on a large scale, all the technological changes identified in the material record were actually innovations that may or may not have any relation to each

[114] Schiffer 2010, 236.

[115] Ibid 246.

[116] Renfrew 1978, 90, points out the importance for archaeologists to distinguish between innovation and invention. This dichotomy was set out much earlier for economists by Schumpeter 1939, 85-6.

other. Explanations can be offered only after archaeologists have identified the specific phase that they are investigating within the overall process of technological change. [117]

Schiffer presents an explicit behavioralist paradigm from which to understand technological change, but it is not without problems. Schiffer's reliance upon ethnographic models to inform archaeological data has come under a fair amount of criticism. As Lewis Binford puts it, behavioral archaeologists fail to realize the difference between 'ethnographic time' and 'archaeological time.' Ethnographers observe material culture constructed in 'quick time' during a single episode, while the material culture recovered by archaeologists was formed by iterative processes over hundreds or thousands of years. In using ethnographic data, behavioralists approach the material record as if every archaeological site was Pompeii. [118] A further complication, in Binford's opinion, is that ethnographers are actually misleading in the presentation of their data. Ethnography is normally presented as an unvarnished study about the lifeways of an indigenous culture but, in reality, ethnographers normally use interlocutors to explain indigenous cultural processes to them. This interpretative process is further corrupted by the fact that the mere presence of the ethnographer alters the environment studied and the behavior within it.[119] Binford was an early critic and a committed processualist, but even post-processualists who extensively use ethnographic data recommend caution when integrating ethnography and archaeology if the underlying difficulties of cross-cultural comparison are not explicitly taken into consideration.[120]

[117] Schiffer 2010, 240.

[118] Binford 1981, 197.

[119] Binford 1987, 395-7.

[120] Hodder 2002, 223-5.

Schiffer himself acknowledges some limitations of his program. The archaeological visibility of material involved in the invention process is low and while targeted excavation may be suited for archaeologists studying simple technologies involving stone tools at hunter-gatherer shelter sites, it is more difficult to imagine sorting through refuse pits outside large urban settlements looking for prototypes of complex technologies.[121] Schiffer's last methodological suggestion - focusing on behavioral changes or patterns during the process of technological change - offers promise.[122] However, a caveat that prehistoric archaeologists must consider is the pace of technological change itself. Schiffer researched inventions that developed in modern capitalist societies like the portable radio and telegraph. While technology in the ancient world was not static,[123] the behavioral patterns that he has identified in the process of modern technological change may not have occurred as rapidly in a premodern society.

In post-processual archaeology, scholars studying technological change espouse an individual-centered view based on anthropological theory. At the heart of post-processual approaches to technology is the belief that the artifact is only one of several components in the technological process and archaeologists' concentration on the artifact to the exclusion of other components hinders understanding. This view is based on the research of the anthropologist Pierre Lemonnier, who separated technological activity into five separate components: (1) matter, or raw materials; (2) energy, that which transforms the matter into the (3) object, or artifact; (4) gestures, or sequential

[121] Schiffer 2010, 239-40.

[122] O'Brien and Bentley 2011.

[123] Greene 1994, 2000.

movements that use the object; (5) specific knowledge, or the know-how and choices involved in using the object.[124] All of these components are context-dependent and socially-informed. When trying to construct models that subscribe to general laws, post-processualists believe that behavioralists err. General laws cannot account for the contingent decisions that craftsmen make during the process of creating a technology, which are often based on their particular social environment.[125]

Despite this fundamental theoretical disagreement, the methods that each school of thought employs are similar. The primary method that post-processualists use to study technological change is the operational chain (*chaine operatoire*). This heuristic tool was introduced by the prehistorian Andre Leroi-Gourhan and sought to explicitly define the sequence of actions necessary for the completion of a particular task.[126] The goal of this approach is to illustrate opportunities in the production sequence that could be modified or changed by the craftsman to affect a different outcome. By acquainting oneself with the freedoms and constraints of a particular technology, the scholar can reconstruct and understand the rationale behind technological change. Once the sequence is properly described, it is possible to ask whether the actions within the sequence occurred because of necessity or because of social contingency. In this way, the researcher can discover the social environment that the craftsman was working in.[127] This approach is not unlike the behavioralists' effort to define discrete steps in the process of technological change and identify performance characteristics that guide

[124] Lemonnier 1992, 2-5.

[125] Dobres 2009, 125-6.

[126] Schlanger 2005, 25-9.

[127] Lemonnier 1993, 8-9.

choice. In the opinion of post-processualists, their method is superior to that of behavioralists because it permits choice to be guided by social considerations instead of efficiency, which is the unstated but underlying theme inherent in any consideration of performance characteristics.[128] Instead, a contextual study of technology seeks to find the agency of the individual craftsman within the chaine operatoire. Post-processualists believe this can be accomplished by recognizing the deep-seated structuring and ordering principles that guide people, at all times, during their interactions with material culture.[129]

Discovering the motivations behind the choices that craftsmen make within the archaeological record has proven to be a difficult task for post-processual archaeologists. Pierre Lemonnier's work focused on the modern tribes of Papua New Guinea, whose motivations Lemonnier could inquire about in order to understand how their technological choices were socially influenced. Archaeologists researching technological change in the material record do not have that luxury. Critics of the post-processual approach maintain that, for archaeologists, the chaine operatoire by itself does not provide any clear avenue to link the artifact with the motivations behind its manufacture or the social structure in which it was produced. Archaeologists can supplement the method of the chaine operatoire with investigations into the availability of raw materials, alternative techniques, and the social, political, and ideological factors acting on a particular society to provide a contextual narrative, but deriving individual agency from artifacts is beyond the archaeologist's reach.[130] In order to find individual

[128] Dobres 2000, 36-7.

[129] Dobres 2009, 123-4.

[130] Skibo & Schiffer 2008, 22; Sillar and Tite 2000, 4-5.

agency in the artifact, post-processual archaeologists often resort to ethnographic parallels.[131] As with behavioral archaeologists, the use of ethnography - the study of modern people - to understand the motivational and societal dynamics in a prehistoric society assumes that human culture is not idiosyncratic and that modernity has not had any appreciable effect on modern societies that happen to share similar tasks with prehistoric societies. Particular criticism has been focused on post-processual archaeologists studying hunter-gatherer societies who have drawn cross-cultural ethnographic parallels, but any archaeological study that uses ethnographic data as a heuristic tool without due consideration of the societies' wider context is prone to misinterpretation.[132]

2.3: Darwinian and Annaliste approaches

Both the behavioralist and postprocessual approaches to the study of technological change have come under criticism from another group of archaeologists referred to by a variety of monikers, to include Neo-Darwinists, Selectionists, or Evolutionary archaeologists. These archaeologists generally work in North America and were inspired by the writings of the late Robert Dunnell, an archaeologist of the prehistoric American Southeast. This school of thought identifies the major flaws in

[131] E.g. Dobres 2000, 209, wherein she explains the difference in bone and antler tool processing techniques in various Paleolithic sites in France as an attempt by skilled men and women to assert themselves against elderly craftsmen. The rationale for this conclusion was offered in a previous article (1995, 41) where Dobres relies on social dynamics described in ethnographies of modern cooperatives (i.e. African hunter-gatherers and Israeli kibbutzes). In these ethnographies, cooperatives allowed equal access to the raw materials used in craftmaking to all members of society. Dobres then assumes a competitive dynamic would have existed in the prehistoric hunter-gatherer societies she studies. Sillar 2002, 594, in a book review states "I was not convinced that this evidence provided me with any clear knowledge of the 'subtle social transformations,' such as the making of skilled women and men and the unmaking of the more elderly craftspeople."

[132] Trigger 2006, 440-42, 475-6, 509.

previous archaeological programs as the belief in immutable laws of human behavior and the confidence that technological choice is conducted in an environment that permits perfect knowledge of future contingencies. Those that invent new technologies, either by accident or in response to a present need, cannot possibly know whether these new 'variants' will be successful and replicated later on. The contingencies that the new technology will face in the future and that determine its success or failure are not the same as the demands of the present. Future contingencies will privilege one variant over another and result in technological change, but those circumstances are neither under the control nor within the full comprehension of the creators. Behavioral archaeologists, by modeling technological change as an efficient process guided by a choice between competing performance characteristics, present a paradigm of technological change that is rigidly uni-linear and progressive.[133]

Selectionists are also skeptical of the ability of archaeologists to recover individual agency or intent from the archaeological record. In Dunnell's opinion, research must be undertaken with a scientific perspective and therefore necessitates an attempt to understand behavior in the aggregate, not the individual. Essentially, selectionists do not view the subject of human behavior as fundamentally different from animal behavior or even non-living things like planets. No biologist attempts to explain the history and development of a creature as a consequence of its intentions, so why should archaeologists explain the history and development of humans as a consequence of the intentions of humans? That is not to say that motivations and intentions do not exist or that they have no bearing on the future course of events; it is simply recognizing that they are proximate – not ultimate - causes of development and, in any case, the

[133] Neff 1992, 146-7, O'Brien, Lyman, and Leonard 1998, 493-4.

researcher cannot observe those motivations or intentions. Instead, biologists develop theories about the history and development of the creature that they are studying that can be confirmed or falsified using research methods. Attributing the development of a creature to its motivations would short-circuit the scientific process by providing a theory – an explanation – about the development that could neither be confirmed nor falsified.[134] Dunnell was criticizing the processualist idea of universal human desires for progress and efficiency as the cause of cultural change, but the same criticism can be leveled at post-processualists who place individual agency at the center of their research programs. Since the theory behind change – human motivation – cannot be tested by methods, the only thing left for the archaeologist to do is to' interpret' the methods used. [135] In Dunnell's view, this has a desultory effect on the discipline:

> "Particular interpretations may be more or less popular, but there is no definitive way to show one is better than another. So archaeology and other disciplines that use such methodology find themselves wandering from one interpretive fad to another, the popularity of which is mainly dictated by attitudes in the larger society rather than any increase in empirical control of the subject matter."[136]

Selectionists believe archaeological research must be guided by scientific principles and therefore turn to the biological science concerned with human development - evolution. In Darwinian evolution, change is a mechanism of the evolutionary processes of variation, transmission, and differential persistence as dictated by natural selection and drift (the imperfect transmission of traits from generation to generation). Variation is

[134] Dunnell 1989, 37-9.

[135] Dunnell 1992, 214-5; also Rindos 1985:84.

[136] Dunnell 1989, 37-8.

transmitted through inheritance and those variants either survive or perish based on their 'fitness,' or because of chance. Selectionists believe this concept of biological development can be used with artifacts because they are the 'hard parts' of the human 'phenotype,' which is defined as 'the totality of the characteristics of an individual' that survive in the archaeological record.[137] In the archaeological translation, a variation or mutation in biology is understood as a technological invention or innovation and the process of inheritance takes place through social learning. To conceptualize the process of natural selection in archaeology, it is first necessary to identify characteristics (traits) of an artifact that are functional and related to its 'fitness,' and those that are not related to fitness but simply stylistic. Certain traits enjoy a high frequency and/or wide spatial distribution, while others disappear. Archaeologists then link these variations across time and space with the processes of 'natural selection' and 'drift,' as understood in the archaeological context.[138] The archaeologist can then construct a historical 'lineage' for the artifact traits and, in the final step, explain the lineage, i.e. develop historical reasons why these traits were selected or transmitted in the archaeological record that can be tested for viability through further research.[139]

Although Neo-Darwinian/Selectionist theory ostensibly arose in response to the cultural-evolutionary view prevalent in processual archaeology, it has been criticized

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[137] Leonard 2001, 67-71.

[138] Neo-Darwinists do not agree on whether natural selection and drift result in variation of the material record by acting on humans and therefore on artifacts by proxy, or on humans and artifacts separately. Trigger 2006, 486, describes the earlier proponents of the theory as espousing the former view (Dunnell) while more recent adherents (Leonard, O'Brien, Neff) focus more on the 'cultural' selection brought to bear on artifacts and the ideas that shape them. My description of Neo-Darwinian theory conforms to the latter interpretation. Neo-Darwinian archaeology is not a unified field. Mascher and Mithen 1996, 6-9, identify four different schools of thought; Lyman and O'Brien 2000, 12, believe others who call themselves Neo-Darwinists are confused about what Darwinian evolution really means.

[139] Broughton and O'Connell 1999, 157; Lyman and O'Brien 1998, 615-16; 2000, 135-7.

itself for the same reasons. Within the paradigm, there does not appear to be any room for the consideration of human agency. This blindness results in an environmentally deterministic account of human history.[140] A more fundamental criticism is the use of a biological theory to explain material culture. Natural selection entails impersonal processes selecting traits that exhibit the best 'fitness,' but the post-processual archaeologists Michael Shanks and Christopher Tilley argue that humans do not create material objects with a view towards survival or replication.[141] As Bruce Trigger points out, humans do not create material culture in the same manner as animals, such as beavers or bees; humans have a creative ability that is not matched in the biological world.[142] Proponents counter that anyone who believes Darwinian evolution presents a uni-linear, progressive paradigm has an incomplete understanding of evolutionary theory,[143] and that humanity's intention and unique creativity are beside the point – intention is only a proximate cause of variation and human creativity will be accounted for in the archaeological record in the form of variation.[144]

Another archaeological theory that attempts to offer a paradigm transcending the perceived shortcomings of processual and post-processual archaeology is the Annales (Annaliste) school. The common thread that binds archaeologists of the Neo-Darwinist/Selectionist and Annales persuasions is the belief that archaeology needs to align itself with a historical science; in the former case, evolutionary biology, in the

[140] Loney 2000.

[141] Shanks and Tilley 1987, 154-5.

[142] Trigger 2006, 488.

[143] Neff 2001.

[144] O'Brien and Lyman 2000, 14.

latter, history.[145] The Annales school was founded by the French historians Marc Bloch and Lucien Febvre during the 1930s. At its inception, the stated goal of the Annales historians was to write a new type of history that focused on the quotidian aspects of life, instead of the history of 'great men' and events that had dominated the discipline. A student of Febvre, Fernand Braudel, gave this vision of history a structure in his 1949 thesis about 16th c. AD European history, *The Mediterranean and the Mediterranean World in the Age of Phillip II.* In Braudel's view, history progressed on three planes: the enduring history of humans and their environment, which he would later coin the *longue duree*; the gradually changing cyclical history of social, economic, and political phenomena of a *moyenne duree* called *conjonctures* or *structures*; and last, the rapid history of events (*événements*) encompassing the actions of people, battles, and moments in time. Each plane of history influenced the other, but Braudel believed that the underlying reality of the *longue duree,* enduring for centuries and millennia, and the forces generated by *conjonctures* occurring over the course of generations, truly moved the wheels of history.[146] Braudel gave short shrift to events that transpired during a human lifetime and their ability to influence the course of history. His view of the individual in history was perhaps best encapsulated in a subsequent work: [147]

> "I am always tempted to see him as enclosed in a destiny which he scarcely made, in a landscape which shows before and behind him the infinite perspective of the *longue duree*. In historical explanation as I see it, at my own risk and peril, it is always the *temps long* that ends up winning out. Annihilating masses of events, all those that it does not end up by pulling along in its own current, surely it limits the liberty of men and the role of chance itself."

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[145] Smith 1992, 123-4.

[146] Bintliff 1991, 4-6; Last 1995, 141-3, points out that the terms *structures* and *conjonctures* were coined not by Braudel but by the French Latin American historian Pierre Chaunu.

[147] Braudel 1972, 520 in Bintliff 1991, 9.

Despite this pessimism, some archaeologists have found this concept of time to be a useful heuristic tool when trying to develop explanations from archaeological data. Amongst those European archaeologists who have tried to relate their data to the Annales framework, however, there has not been agreement on the length of time that the three different planes of history operate on. In an article on the political history of the province of Boeotia in central Greece as related by inscriptions during the 3rd and 2nd c. BC, John Bintliff suggested that *conjonctures* lasted 'several generations or centuries.'[148] Bernard Knapp viewed *conjonctures* as lasting 10-50 years in his study of the development of middle and late Bronze Age ceramics of Pella, Jordan.[149] Richard Lewthwaite pursued a wider scope of time when investigating the spread of Bell-beaker pots during the Chalcolithic period throughout Europe. Similar to Bintliff, he thought that *événements* had to occupy the time span of an archaeological unit, i.e. a building phase or ceramic stylistic horizon, and pushed back *conjonctures* to a span of several centuries.[150] This phenomenon was marked by the presence of pottery beakers and associated funerary material with northern European stylistic traits throughout areas along the Atlantic and southwestern Mediterranean during the late 3rd millennium BC.[151] Lewthwaite identified the Beaker phenomenon, lasting roughly 2500 - 1700 BC, as a *conjoncture* of the Late Neolithic and early Bronze Age period set up by increased interaction among Europeans during the early and middle Neolithic period. This interaction was not only spurred by population movements, as had previously been suggested by other scholars, but also by

[148] Bintliff 1991, 7.

[149] Knapp 1993, 11.

[150] Lewthwaite 1987, 42-3.

[151] Jameson 2002, 111-12.

sophisticated trade networks. The presence of domesticated sheep of Asiatic origin in southern France and the diffusion of Impressed ware pottery during the early Neolithic suggested that inland continental trade routes existed from the Early Neolithic period. [152] Lewthwaite explained the initial spread and subsequent local development of the Beaker phenomenon as a consequence of the backdrops (*structures)* of the Mediterranean's *longue duree*, which was characterized by two over-arching modes. The dominant *structure* was Eurocentric, meaning that the material culture of the European Neolithic was composed primarily of local assemblages, indicating a focus on the hinterlands of the continent at the expense of long-distance maritime interaction. Trade spurred change in material culture but only slowly, with northern and central European cultural traits gaining the widest distribution. This Eurocentric *structure* contrasted with an infrequent Mediterranean-centric *structure* marked by widespread technological diffusion along an east-west axis. This *structure* was similar to that sketched out by Braudel in his history of 16th c. AD Europe and applied also to periods of Mediterranean integration, such as the commercial empires of the Phoenicians, Greeks, and Romans and later, that of the medieval Muslims. In Lewthwaite's view, the Bell-beaker phenomenon came at the end of the inward-looking 'European' Neolithic period and was a prelude to the integrated, outward-looking 'Mediterranean' Bronze Age.[153]

[152] Lewthwaite 1987, 36-42.

[153] Ibid 49-52. There is no consensus about the reasons behind the Bell-beaker phenomenon, but Lewthwaite's generalizations about an idiosyncratic Neolithic Europe and a more integrated Bronze Age Mediterranean have not been contradicted; see Milisauskas and Kruk, 2002, 252-3. Although Italy's Bronze Age is characterized by a number of discrete material cultures due to its geographic variation, enough Mycenaean pottery has been recovered from Italian and Sicilian Bronze age sites to tie Italian Bronze age chronologies to those of the Aegean, see Harding 2000, 274-5.

No matter the length of time one assigns to the *structures*, *conjonctures*, and *événements* of history, the concept of time within the Annales school complements archaeology's unique ability to document human activity over long periods of time far beyond the historical period. Furthermore, archaeology's difficulty in accounting for the events of individuals at specific moments in time is obviated within the Braudellian paradigm.[154] The Annales framework, though, is not without critics within archaeology. Nicholas Purcell and Peregrine Horden believe Braudel's paradigm espouses an environmentally deterministic approach to the past that, upon execution, results in little more than a geographical history.[155] Others point to the lack of individual agency[156] and the absence of a clear linking mechanism between the different planes of history as impediments to understanding and explaining change.[157] John Bintliff, citing the work of historiographer Jack Hexter, believes historians of the Annales school have overcome this difficulty by creating a 'problem history.' When writing their historical narratives, Braudel and other Annales historians often posed questions about particular historical events and then worked backwards through the *conjonctures* and *structures* in which the event was situated as a means to arrive at an explanation. In this way, people and events were not lost in a paradigm that was admittedly skewed towards describing the larger processes of history.[158] In Bintliff's study, he began with a corpus of inscriptions from late 3rd and early 2nd c. BC in the province of Boeotia that recorded donations on the part

[154] Bintliff 1991, 13-15, Hodges 1986, 138, Barker 1995, 2-3.

[155] Horden and Purcell 2000, 39-41; also McGlade 1999, 146.

[156] Sherratt 1992, 137; Moreland 2001, 20.

[157] Fletcher 1992, 39-40.

[158] Bintliff 1991, 13-15.

of wealthy individuals to different towns. These gifts of money and food suggested to Bintliff that there was some sort of economic crisis occurring in the region during that time; this crisis was his *événement*. Longer term processes in Bintliff's model were supplied by Polybius, a 2nd c. BC Greek historian, who wrote about a general decrease in population and decline in agricultural production in the region beginning in the 4th c. BC and persisting until his day. He then linked the agricultural and economic distress found in Boeotian inscriptions and the historical account of Polybius to wider trends he identified in archaeological field surveys. His surveys appeared to show an oscillation in settlement throughout Boeotia; population and rural settlement had declined markedly after the 4th c. BC through to the time of Polybius, only recovering during the 3rd c. AD and remaining robust until the 7th c. AD, when it declined once again. Bintliff diagnosed these oscillations as *conjonctures* in the form of agricultural boom-and-bust cycles that gripped Boeotia in 400 to 500 year periods and set the stage for elites to intervene in times of distress.[159]

Bintliff's study is instructive in demonstrating the utility of the Annales paradigm in studying archaeological phenomena, but it can still be criticized as deterministic. One could argue that Bintliff's model removes any agency on the part of the elites since they were compelled by environmental forces to offer assistance to cities in Boeotia during one of the troughs in the agricultural cycle. Reconstructing the motivations of people was not a pressing concern for Braudel, but the roles of group ideology and social beliefs

[159] Bintliff 1991, 19-26.

(*mentalities*) were addressed by other Annales historians.[160] Marc Bloch's seminal article published in 1935,'The advent and triumph of the watermill in medieval Europe,' demonstrated the important role that social conditions played in culture change. Bloch's research showed that the watermill had certainly been a well-known invention in the Roman world but its innovation had to wait until medieval lords perceived its exploitation as a way to gain control over grain processing and political power.[161] However, the problem of reconstructing the *mentalities* of ancient peoples remains acute for pre- and proto-historians who adopt the Annales approach, since they do not have access to the historical records that Bintliff and Bloch could call upon.

2.4: THEORETICAL APPROACH TO TECHNOLOGICAL CHANGE AT POGGIO CIVITATE

The discussion above described some of the theoretical approaches taken by archaeologists studying technological change. In assessing the problem of technological change, the behavioral and post-processual approaches offer distinct advantages. Both viewpoints have well-defined methodologies that are clearly guided by the forces of efficiency or agency. Written sources available to archaeologists such as M. Schiffer studying modern inventions provide a window into the thinking that guides the technological process. In general, the subject of technological change has not been addressed theoretically by scholars of the ancient world but the economic historian Moses Finley[162] and the Roman archaeologist Kevin Greene[163] have been able to develop

[160] Bintilff 1991, 10-11; Last 1995, 143, cites other Annaliste historians who specifically addressed the *mentalities* of their subjects were the medievalists Jacques Le Goff, Georges Duby, and Emmanuel Le Roy Ladurie.

[161] Bloch 1967 (1935). 136-68.

[162] Finley 1965, 1973.

assumptions about the attitudes of individuals and society by relying on the writings of contemporaries in the ancient sources. Comparably, pre-and proto-historic archaeologists are at a disadvantage in trying to reconstruct the decision-making processes of the societies they investigate unless they are willing to accept the efficacy of modern ethnographic studies as proxies for understanding behavior and decision-making in premodern societies. In light of this consideration, Neo-Darwinian/Selectionist and Annaliste approaches are probably better suited for studies on pre- and proto-historic technological change.

There are significant challenges, however, in using a Neo-Darwinist/Selectionist or Annaliste approach. First and foremost is the lack of a clear methodology in either school of thought. The examples cited as paradigmatic case studies for Neo-Darwinian and Annaliste research – David Braun's study on the changes in cooking vessels during the Middle Woodlands Period (B.C.200 – 600 AD) in the North American Midwest and John Bintliff's study of 3rd-2nd c. BC Boeotia, Greece, respectively[164] – were articles less than 20 pages in length and meant only to be demonstrative, not explicit, about the potential of their particular approaches. Among Neo-Darwinists/Selectionists, the problem is more severe because there is little agreement about how exactly natural selection is supposed to act on the archaeological record. Dunnell envisioned the process as acting on humans and then indirectly on artifacts.[165] This sentiment appears to be reinforced by the most prolific writers about Neo-Darwinian theory, Michael O'Brien and

[163] Greene 1994, 2000. As a historian, Finley placed much more emphasis on the use of the ancient sources than archaeology.

[164] Neff 1992, 173 cites Braun 1987; Shaw 2002, 64 cites Bintliff 1991.

[165] Dunnell 1978, 197-8.

R. Lee Lyman.[166] Other Neo-Darwinian archaeologists, however, have taken a different tack. In Robert Leonard's and George Jones' view of selection, they separate the persistence of artifact traits in the archaeological record from the process of natural selection on their human 'bearers.' To avoid any confusion with the reproductive success of humans, they offer the term 'replicative success' to describe the mechanism of selection on artifacts.[167] David Braun's work seems to adhere to Leonard and Jones' concept of selection in that his conclusions about the thinning of cooking vessel walls in Midwestern woodland pottery indicated that their thicknesses over time were 'selected' by dietary changes. He goes on to explicitly state that the technological changes he traced in vessel form cannot be linked to human biological trends.[168] Even in O'Brien's own study of projectile points from the paleo-Indian period in the southeastern United States, no effort is made to link changes in the traits of projectile points to biological success or failure. Instead, his study focuses on establishing the historical 'lineages' of projectile points based on their characteristics and identifying geographical trends.[169] Even if there was some way to tie material culture to demographic trends, Ian Hodder points out that an explanation of artifact variability derived from such a basis would only tell half the story and neglect the social components brought to bear on the process of selection.[170] This apparent methodological diversity among Neo-Darwinists/Selectionist

[166] O'Brien and Lyman 2004, 179 state "No evolutionary archaeologist to our knowledge has ever claimed that changes in technology are a result of selection working on the artifacts themselves."

[167] Leonard and Jones 1987, 214.

[168] Braun 1987, 277-8.

[169] O'Brien et al. 2003, 167-97.

[170] Hodder 2011, 166.

probably has something to do with the theory being much written about but little applied.[171]

Turning to the Annaliste approach, archaeologists who have adopted this paradigm generally have studied historical periods which have contemporaneous documentary records. This evidence provides the required background data to understand the social, political, or economic circumstances relevant to their study.[172] An exception was the study of Richard Lewthwaite, who tried to apply the Annaliste framework to the question of the Bell Beaker phenomenon in Chalcolithic Europe. Lewthwaite developed his model using an Annaliste framework based on the archaeological record alone. Besides taking advantage of archaeology's long-term perspective, the Annales school also addresses the main criticism of processual and post-processual archaeology advanced by Robert Dunnell in his promotion for a Darwinian perspective on material culture. As noted above, Dunnell turned to evolutionary biology for a model of material culture change because, in his opinion, archaeology was essentially atheoretical since none of the conclusions of its practitioners could be falsified. The anthropologist Christopher Peebles points out that an Annales approach can advance archaeological research by providing a structure to allow logico-scientific suppositions (if/then, law-like hypotheses) to be grounded in larger historical narratives.[173] In this way, archaeology could occupy a position between science and

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[171] Johnson 1999, 144.

[172] In Maya and Aztec Mexico, Iannone 2002 and Smith 1992; medieval Italy, Moreland 1992; colonial Australia, Staniforth 2003; early Islamic Afghanistan, Bulliett 1992; in Bronze Age Jordan, Knapp 1992; protohistoric Alberta, Duke 1992.

[173] Peebles 1991, 109, refers to the two methods of cognition outlined by Jerome Bruner, 1986, the 'logico-scientific' and the 'narrative' methods.

history while not belonging to either discipline, yet use the tools of each to develop and answers questions about human development that can be supported by evidence and judged on the explanation's merits. In the case of Orientalizing Italy, the usefulness of Lewthwaite's model lies not so much in its accuracy but rather as a way to think about material culture in pre- and proto-historic Europe. During times of retrenchment such as the Neolithic period and the late Bronze to early Iron Age, material culture should primarily maintain a local character while allowing limited influence to intrude from overland trade routes. During times of pan-Mediterranean integration like the Bronze Age and Orientalizing period, material culture should show more uniformity as ideas and methods were rapidly circulated via diffusion through maritime commerce.

Within the Annales paradigm, the question of technological change at Poggio Civitate during the Orientalizing period can best be addressed by incorporating the 'problem-history' approach. Technology itself is perceived as an enduring phenomenon and part of the *longue duree*.[174] During the Orientalizing period, the technique of architectural construction practiced in Etruria – timber and/or wattle-and-daub walls and roofs of clay and thatch - changed to walls constructed with more robust materials, often stones, covered with heavy roofs of terracotta tiles. This is essentially the same construction technology that endures today in many places throughout Italy and has become part of the modern *longue duree*. As a technology imported from Greece via diffusion, the phenomenon of the terracotta tiled roof can be imagined as an *événement* within the Annales paradigm. In Annaliste terms, the predominant view is that this *événement* - the introduction of terracotta tile roof technology at Poggio Civitate from

[174] Bintliff 1991, 6.

Greece - was able to change an enduring aspect of the *longue duree* of Italy during a time period (*conjoncture* or *structure*) of pan-Mediterranean integration. Through an investigation of the evidence for earthen architecture in Italy, this study seeks to test this hypothesis by answering two main research questions:

1) Did the construction techniques at Poggio Civitate represent a break from the vernacular architectural tradition? If so, how?

2) What foreign influences were present in construction materials or techniques?

These research questions are not fundamentally different from any other study of technological diffusion. Within an Annales framework, however, it is necessary to take both a regional and diachronic view of earthen construction techniques in Italy. In the introduction, it was demonstrated only that the location currently believed by some to have been the origin of terracotta tiled roof technology at Poggio Civitate – Corinth, Greece – appears to have been an unlikely candidate. The builders at Poggio Civitate were the inheritors of construction techniques traditionally practiced in northern Italy during the Bronze Age and even the Neolithic period. The explication of these methods provides a background upon which the development or intrusion of different construction practices will stand out noticeably. Changes recognized at this site in construction practice which can be linked to other places in Italy or the wider Mediterranean can help illuminate the process of the diffusion of terracotta tile roofing technology. If those changes find no comparanda elsewhere, it will increase the likelihood that this technological change was an indigenous development.

2.5: Agency within Neo-Darwinian and Annaliste Approaches

Answering the research questions outlined above will address the 'how' of technological change at Poggio Civitate during the Orientalizing period. The 'why' provided by the Annales framework, on the other hand, can be somewhat deterministic and unsatisfying. In this instance, although the introduction of terracotta tile technology via diffusion is imagined as an historical event (*événement*), it is still a consequence of larger forces (*structures*), being either (1) diffusion as part of a period of pan-Mediterranean integration or (2) local development during a time of European insularity. The grounding of the study in the *événement* of a 'problem history' attempts to link the larger forces of history with happenings that occur over the course of a human lifetime. However, studies using the Annales framework have offered no clear method to define human agency, a primary concern for post-processualists and the means by which human choice is incorporated into the historical record. Indeed, reaction to the deterministic explanations provided by processual archaeology largely drove the post-processual movement. As detailed previously, however, the post-processual remedies for finding human agency in the material record have been criticized as atheoretical by Neo-Darwinists. Trying to incorporate human agency into the processes described within an Annales paradigm represents an important challenge for the pre- and proto-historic archaeologist.

The idea of incorporating a theory of material agency, or a 'Thing theory,' has recently been broached by different groups of archaeologists. The first group describes its school of thought as 'Symmetrical Archaeology' because it aims to reassert 'symmetry' into archaeological research by focusing on the agency of both humans and things. The guiding rationale behind this viewpoint is that archaeology has become too people-centered and has departed from its original purpose - the study of 'things.' [175] In the view of symmetrical archaeologists, the conceptual isolation of humans from the material world around them is a byproduct of modernism's artificial divide between humans and nature. This dualism, wittingly or unwittingly, privileges human action and intentionality above all else in archaeological studies.[176] The idea of considering the agency of 'things' was developed not by archaeologists, but rather by scholars in other disciplines, foremost among them the English literature professor Bill Brown.[177] For archaeologists, a readily transferable paradigm of object agency was developed by the anthropologist Alfred Gell and the sociologist Bruno Latour.[178] Gell believed that the expression of agency was an effort by both humans and things; humans exerted 'primary agency' through intention but that intention could only be realized through the 'secondary agency' of a thing.[179] The term 'secondary agency' has not been adopted by archaeologists working within symmetrical archaeology, however, because of the implication that things are wholly dependent on humans. More in line with the work of Bruno Latour, the archaeologists Bjonar Olsen, Timothy Webmoor, and Christopher Witmore argue that things have agency as well as humans, and that archaeological studies should concentrate on analyzing the networks of interaction that provide people and things with agency in a manner similar to the Actor-Network Theory (ANT) developed

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[175] Webmoor 2007, 569-72.

[176] Webmoor and Witmore 2008, 60-2; Witmore 2007, 552; Shanks 2007, 590.

[177] Brown 2001.

[178] Gell 1998; Latour 1993, 2005; for overview, Preucel and Mrozowski 2010, 17-18.

[179] Gell 1998, 17.

by Latour for sociological studies of technology.[180] None of these authors, however, has offered a case study using ANT with archaeological data. Olsen has provided his view of how network theory could benefit archaeological description using a modern account by a fellow Norwegian of his trek to the South Pole. In his story, the adventurer described the journey as something he accomplished alone which is, in Olsen's opinion, total nonsense. He could only accomplish it with a pair of skis, a navigation system, a tent, freeze-dried food, etc.. Olsen suggests a symmetrical archaeological approach using network theory would include the role of not only the individual making the trek to the South Pole, but would also describe the role of each of the things he took with him and how those things contributed to his success.[181]

Carl Knappett, for his part, has attempted to demonstrate the usefulness of ANT in a case study of Minoan drinking cups. In order to find the networks in which these vessels were included, Knappett interpreted the cups as 'signs' in the fashion of Peircean semiotics, wherein the 'sign' represents an object or characteristic and was interpreted by the viewer based on the perceived relationship between the sign and object.[182] The type of relationship between the sign and the object could be formal (a relationship of *iconicity*, in Peircean terms), in the sense that the cup signifies a drinking vessel form readily recognized by a viewer; the relationship could also be associative (*indexicality*), in the sense that the context in which the cup was found (i.e. the other vessels present, the activity it was involved in) provides the viewer with the key to understanding aspects

[180] Olsen 2003, 90; Whitmore 2007, 549; Webmoor and Witmore 2008, 59; also Knappett 2007, 22-3.

[181] Olsen 2003, 99-101.

[182] See Preucel and Bauer 2010, 88-93, who trace the adoption of the 19th century American philosopher Charles Sanders Peirce's semiotic approach to material culture to cultural anthropologists in the 1990s.

of the cup's function or meaning; lastly, the relationship could be arbitrary (*symbolic*), in the sense that the Minoan word for cup, whatever it was, would represent to the viewer (hearer, as it were) a pre-arranged and accepted mental construct.[183] Components of a cup's *indexicality*, according to Knappett, could also include its clay source and method of manufacture (hand or wheel-thrown). An investigation of the clay source and manufacturing processes would reveal the craftsmen and consumer networks that the cup was bound up in.[184] While the investigation of supply and consumer networks is undoubtedly useful, it is not clear how Knappett's case study using Peircean semiotics and ANT improve archaeological investigations. In the case of investigating a vessel's *indexicality*, it introduces a complex new vocabulary to describe methods already used by most archaeologists. Ceramic reports routinely include archaeometric studies to assess a vessel's clay source and manufacturing techniques. More case studies using ANT would help to illustrate the potential of the symmetrical archaeological approach,[185] but much like Neo-Darwinian theory, it still awaits definitive implementation.

Chris Gosden has also taken up the idea of using a 'thing theory' as part of what has been called, at different times, an intuitivist, constructivist, or humanist archaeology.[186] Gosden believes that objects and built forms have 'agency' in the sense that they affect peoples' behaviors and thoughts. The extent and influence of a thing on peoples' behavior can only be ascertained if the genealogy and source of the thing's

[183] Knappett 2005, 87-104, provides his description of Peircean semiotics - which I try to concisely summarize here - but a more expansive discussion can be found in Preucel and Mrozowski 2010.

[184] Knappett 2005, 155-62.

[185] Warnier 2007, 771.

[186] Trigger 2006, 472.

morphological and decorative characteristics are taken into account. Gosden does not align with the work of the Neo-Darwinists but admits that his method draws from the Darwinian concept of descent with modification, although he does not want to use the terms associated with Darwinian evolution.[187] He presents some examples of material culture in Roman Britain which, when viewed 'genealogically,' present a picture more complicated than the traditional paradigm of British Romanization. For instance, Jeremy Taylor's study of rural buildings in the East Midlands of Roman Britain between the first and fourth centuries AD documented a multiplicity of building forms.[188] Some retained the round indigenous plans of the pre-Roman Iron Age but most were influenced by the introduction of Roman building materials and orthogonal planning. Even in orthogonally-planned buildings, the hearth was centrally located along with a grain-drier in the same manner as had been done in pre-Roman Iron Age structures. One can argue that the 'agency' of the hearth demanded construction solutions that maintained its centrality and co-location with grain processing activities; not so much as a form of resistance but rather indicative of continuity of social structures in the face of external change. The usefulness in taking the long view, or 'genealogy,' of the characteristics of British building forms is that it allows archaeologists to present a more nuanced picture of change. The importance of the hearth as the central organizing feature of the house and the persistence of certain activities associated with it suggest that, while the process of Romanization in the East Midlands profoundly affected some behaviors such as

[187] Gosden 2005, 198.

[188] Taylor 2001, 46-59.

construction practices in this instance, it left others unchanged.[189] Scholars have also used the idea of the 'secondary' agency of architectural forms to explain architectural change in the modern world. The anthropologist Denise Lawrence-Zuniga described the addition of a waiting room and bathroom at the entry of houses in modern Portugal as a means of social agency. Lower-class people would conspicuously locate these additions at the front of their houses in imitation of the houses of the bourgeoisie in order to signal that they had 'arrived.'[190]

Thing theory, which embraces an object or feature's 'secondary agency,' can fill a gap in the heuristic model provided by an Annales framework and be a useful tool in understanding the intentions of the people involved in the construction of the Orientalizing complex at Poggio Civitate. The buildings themselves had 'agency' and induced behavioral changes in a variety of ways. The introduction of terracotta tiles affected the organization and techniques employed in the buildings' construction. The increased manpower and demand for craftsmanship required for the construction of the Orientalizing complex, as opposed to buildings covered with lightweight thatched roofs, necessitated a reorganization of people and resources. After construction, certain activities became associated within the complex as evidenced by the numerous small finds recovered that could indicate new constraints on, or possibilities for, the inhabitants of Poggio Civitate. This reorganization was compelled by goals that can perhaps be placed into perspective by considering the larger, Mediterranean-centric world that Etruscan elites became a part of during the Orientalizing period.

[189] Gosden 2005, 200-2.

[190] Lawrence-Zuniga 2001, 196-8.

2.6: METHODS

In order to answer the research questions posed above, both the historical view encouraged by archaeologists inspired the Annaliste school and the scientific approach encouraged by Neo-Darwinists/Selectionists will be applied. This can be done by first constructing a 'genealogy' of earthen architecture in Italy. Although the remains of earthen architecture are frequently found during archaeological investigations, they are rarely treated as archaeological materials.[191] The wattle-and-daub fragments reported in archaeological site reports without illustration or description could be fragments from several different archaeological features, including a kiln or oven.[192] Nonetheless, enough evidence for earthen architecture in pre- and proto-historic Italy exists to construct a provisional 'genealogy' of earthen construction techniques across the peninsula. A. Ammermann has cautioned against the use of daub to classify the architectural techniques of a site in situations where the material could have been nothing more than fill.[193] Thus, for the most part, only material recovered from a dated context which can be associated with a particular structure has been incorporated into this survey. Another avenue of approach has been opened up by the recent efforts of Italian archaeologists to treat earthen architecture as an archaeological material in site reports and to use the same archaeometric techniques used on ceramics for their study, thus allowing a wider consideration of this material beyond morphological aspects. The

[191] Vencl 1991, 406-11.

[192] E.g. Urban et al. 1997, 187, Poole 2000, 212-4.

[193] Ammerman 1990, 638-9, and n. 74.

construction of a genealogy of earthen architecture in Italy requires a survey of available site reports that provide detailed information about the earthen architecture recovered. A description of the techniques of analysis used at each site will be included in this survey, along with the interpretation of the excavators of the particular type of construction technique used. The construction techniques associated with earthen architecture include fired bricks, mudbricks, pisé or rammed earth, and wattle-and-daub. Fired bricks are the most persistent archaeological form of earthen architecture archaeologically but do not figure into this study.

Evidence from archaeological sites will be broken down chronologically, starting with the Neolithic period (7500- c.2300/1850 BC),[194] the Bronze Age (c.2300/1850-c.1000 BC),[195] and the early Iron Age/Orientalizing Period (1000 – c.600 BC).[196] These chronological divisions will be subdivided further by presenting the evidence from the three different geographical regions of Italy: northern Italy, to include the sub-alpine region and the Po Valley; central Italy, the modern-day provinces of Tuscany, Lazio, Umbria, Marche, and Campania; and southern Italy, the area covered by the modern-day provinces of Abruzzo, Apulia, and Calabria, along with Sicily. These subdivisions were chosen because they reflect the distinct Italian construction cultures identified by the architectural historian Fauzia Farneti in her survey of vernacular architectural traditions

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[194] Bagolini 1992, 291.

[195] Peroni 1999, 212-214, Fig. 79. Peroni includes both the historical dates of the Bronze Age (c.1850-900 BC) and those provided by dendrochronology (c.2300-1000 BC).

[196] Bietti-Sesteri 1992, 7-8, sets the beginning of the Orientalizing period at c.730/20 BC with the arrival of Greek colonists and its end c. 580 BC.

in Italy.[197] Structures in northern Italy have traditionally been the products of a 'wood culture,' best exemplified by the timber-piled dwellings (*palafitte*) of the Bronze Age. The Apennine mountain range has produced several different architectural traditions within central Italy because of the varied habitats that exist in the short distance between mountain and coast. This mix has resulted in a vernacular architecture more technologically and structurally advanced than other parts of Italy from as far back as the Iron Age, as evidenced by the intricate jointing imagined for Romulus' 'Palatine hut'[198] and the Italic courtyard building. The drier climate of southern Italy appears to have made builders more partial to stone in construction. The typical southern Italian hut, composed of dry stones and arranged in a circular plan, can still be found in the province of Apulia and eastern Sicily. The evidence from these three different regions during three separate time periods ultimately will be presented in tabular form with a view towards revealing any trends or influences that arise in earthen construction technology in Italy over the *longue duree*.

From the scientific perspective, archaeometric tests can provide results that are useful in understanding the nature of the earthen artifacts studied as well as the construction processes involved in creating them. Twelve samples of earthen architecture to include daub, plaster, and mudbrick were tested using Thermogravimetric analysis and Laser Ablation Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS) at the Institute for Integrated Research in Materials, Environments, and Society (IIRMES), California State University - Long Beach (CSU-LB). Thermogravimetry is a technique

[197] Farneti 1997, 1564.

[198] Davico 1950-1, 29-36; 1951, 127-34.

whereby the weight of a substance is recorded as a function of time or temperature. Thermogravimetric analysis (TGA) has a variety of applications but in archaeology, its primary use is in assessing the firing temperature of a ceramic. Upon firing, the clay minerals and elements within the matrix of a vessel, tile, or daub fragment will change, resulting in weight loss. Weight loss occurs because of the evaporation of water and the decomposition of organic matter up to around 200^oC. At higher temperatures, weight loss is due to changes in the clay's mineral structure. From 200^oC to 600^oC, the dehydoxylation of clay minerals and, from 600 to 900^oC, the decomposition of carbonates are primarily responsible for ceramic weight loss. Although TGA does not indicate a precise firing temperature for a tested ceramic, its utility for this study is based on the assumption that ceramics that were fired at higher temperatures will display less relative weight loss upon reheating than ceramics fired at lower temperatures.[199]

Another application of TGA, developed primarily by conservators concerned with the rehabilitation of historic structures, assesses the permeability of a plaster/mortar by distinguishing between non-hydraulic and hydraulic plaster/mortar characteristics. Non-hydraulic mortar is derived from relatively pure limestone ($CaCO_3$); the limestone is reduced by heating it to c. 900^oC for several days in order to turn it into quicklime (CaO) and then slaked with water to create lime ($Ca(OH)_2$). Lime is then mixed with aggregates (sand or crushed stone) and water to form mortar. Non-hydraulic mortar will set once it comes into contact with air as it absorbs CO_2 and essentially returns

[199] Garraty et al. 2007, 17. More precise estimations of firing temperature can be attained by mineralogists using X-ray diffraction or Mossbauer spectroscopy, techniques that allow the observance of discrete changes in the crystalline structure of minerals which indicate the stage of heating that the ceramic experienced, in the sample over the course of increased heating, Gibson and Woods 1997, 24. This study does not require that degree of specificity. Furthermore, since one of the goals of this study is to provide methods for archaeologists to study earthen architecture, techniques used are limited to those that an archaeologist can reasonably employ themselves without recourse to specialists from other disciplines.

chemically to being limestone. If, however, the limestone used in the creation of quicklime is not pure and has significant amounts of alumina and silica within it, it can have hydraulic properties, i.e. the capacity to harden when water is added to the mix and to do so under water, due to the reaction of the alumina and the silica with the lime.[200] This type of mortar is called hydraulic and does not need to come into contact with air to set. Hydraulic mortars can also be created mechanically by adding artificial or natural pozzolans to the lime. Pozzolans are generally composed of silica and alumina able to react with the lime to bring about setting independent of the atmosphere because of their chemical structure and particle size.[201] Natural pozzolans are generally understood as volcanic sands. Artificial pozzolans are created by subjecting a natural substance to some kind of heat treatment. An artificial pozzolan can be heat-treated clay in the form of ground-up ceramics.[202] It has also been claimed that the addition of heat-treated wood in the form of the ash from charcoal can act as an artificial pozzolan.[203] The incorporation of natural pozzolans to create hydraulic lime is normally attributed to the Romans in the 3rd c. BC[204] but it is believed that artificial pozzolans were intentionally used by the Phoenicians and Israelites as early as the 11/10th c. BC to protect waterworks constructions[205] and possibly also during the Bronze Age in Greece.[206]

[200] Lanas et al. 2004, 2191.

[201] Lawrence 2006, 2-3.

[202] Genestar 2007, 377.

[203] Balfet 1969, 188-2; contra Kingery et al. 1988, 277.

[204] Blake 1959, 312.

[205] Collepardi 1990, 82-3; the use of hydraulic mortar in 11th c. BC Palestine is based on the inference of W. Albright 1965, 447, who attributes the increased and more dispersed population of the area to the invention of hydraulic lime, which permitted population dispersion away from natural water sources for the first time. Mitchell 1991, 451 expresses skepticism.

When subjected to TGA, a hydraulic mortar will dehydrate and lose weight in a manner that distinguishes it from a non-hydraulic mortar within the temperature ranges 30-120°C, 200-600°C, and 600-1000°C.[207] At the initial heating of the sample up to 120°C, hydraulic mortars will lose more weight (>3%) than non-hydraulic mortars (<1%) due to the burning off of adsorbed water, which the hydraulic mortar takes up in greater quantity than non-hydraulic mortars. Hydraulic mortars will also lose more weight (>3%) than non-hydraulic mortars (< 3%) from 200 – 600°C as water chemically bound (hydraulic H_2O) to the alumina-silicates burns off. As carbonates break down above 600°C, non-hydraulic mortars will display a greater weight loss (> 32%) than hydraulic mortars (24- 34%) because of the recarbonation that they experience as they gradually set. The ratio of weight loss due to decarbonation and that associated with chemically bound water is indicative of the 'hydraulicity' of the mortar. Hydraulic mortars that include pozzolans will contain more chemically bound water and use less lime in mixing than a non-hydraulic mortar. As an index, lower ratios are usually recorded for hydraulic mortars than non-hydraulic mortars. [208]

The present study's chemical analysis of the samples from Poggio Civitate was accomplished using LA-ICP-MS. This method of testing, despite being a spot analysis technique, has been proven as effective in analyzing the chemical signatures of ceramics as the more widely used bulk analysis techniques of INAA and XRF (X-ray fluorescence

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[206] Chiotis et al. 2001, 331

[207] Significant weight loss from 120°C to 200 °C indicates the incorporation of gypsum into the mortar, as the salts associated with this binder lose adhered water molecules.

[208] Ingo et al. 2004, 55-60; Genestar et al. 2006, 376-8; Monopolou et al. 2000, 53-55; Lanas et al. 2004, 2193-7; Maravelaki-Kalaitzaki et al. 2003, 653-5.

spectrometry).[209] In fact, LA-ICP-MS is superior to other chemical analysis techniques because it is virtually non-destructive and can detect low concentrations (low parts-per-million to parts-per-trillion) of nearly all known elements. The purpose of the chemical analysis of fragments of earthen architecture from Poggio Civitate was two-fold. First, comparison of the elemental signatures of the daub with ceramics and clay samples from the site can help to clarify the construction processes at Poggio Civitate. The twenty samples tested in this study do not constitute a large population, but the results from this analysis can be augmented by incorporating two previous studies on ceramics from Poggio Civitate: the 1986 Instrumental Neutron Activation Analysis (INAA) of ceramics and roof tiles at the site conducted by M. Tobey et al., and the 2009 LA-ICP-MS analysis on terracotta tiles performed by W. Gilstrap. The latter analysis was conducted at IIRMES under the same parameters as the current study and analyzed terracotta tiles, five coming from 7th c. BC contexts and an equal number from 6th c. BC levels. The former study was conducted at the University of Texas and included terracotta tiles, six different classes of pottery, and clay specimens from a source at the bottom of the hill at Poggio Civitate. The INAA included 19 terracotta tiles, 16 fragments of coarseware, 16 of impasto, 19 of orangeware, 26 of bucchero, 18 of greyware, 19 of fine orangeware, and 15 samples of clay.[210] In total, over 170 ceramic and clay samples from Poggio Civitate

[209] Stoltman and Mainfort, 2002, 16-7, suggest that petrographic examination is a better means to source ceramics because the chemical signature of pottery is formed not only with clay, but also with water and temper. In addition, a ceramic's use and archaeological context could contribute to their chemical signature. Neff et al. 2006. 66-7, counter that potential additives are normally taken into account during chemical characterization of ceramics and, in any case, sub-groups are formed based on large and multivariate elemental differences that cannot be attributed to minor additives or a ceramic's subsequent use or disposition.

[210] For a description of the INAA process and the ceramic fabrics identified in the 1986 study, see Tobey et al. 1986, 117. With the exception of bromide (Br), experiments have demonstrated that the elemental concentrations present in clay are not affected by firing; see Cogswell et al, 1996, 283-7.

were analyzed using either INAA or LA-ICP-MS. The chemical characterization of the same ceramics using INAA and ICP-MS has been demonstrated to provide similar results within a ninety percent confidence interval.[211] Comparison of these tests will establish whether daub was being procured from the hill or from another clay source, and if that clay source was the same one from which ceramics were being manufactured. Second, the elemental signature of the plaster fragments should provide more clarity about its manufacture. Plaster/mortar fragments that have been archaeometrically tested range anywhere from simple lime plasters having calcite contents as high as 80% [212] and the more advanced hydraulic mortars of the Roman period that only included around 25% calcite.[213] The elemental analysis of the plaster at Poggio Civitate will provide an idea about the constituents used to make it and its relative strength and effectiveness. During the Roman period, as pozzolans were introduced into plaster and mortar mixtures, their incorporation allowed builders to create high-quality mortars with less quicklime.

Although daub and ceramic production rely on the same main ingredient –clay – they do not always appear to share clay sources or production processes at sites where both daub and ceramics have been subjected to archaeometric testing.[214] At some Bronze Age sites in the province of Apulia in southern Italy and the island of Sicily, however, the daub and ceramic production processes shared clay sources and processing techniques.[215]

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[211] Tsolakidou and Kilikoglou 2002.

[212] Moropolou et al. 2003, 892.

[213] Maravelaki-Kalaitzaki et al. 2003, 656.

[214] See Chapter 3: Passo di Corvo , Broglio di Trebisacce, Torre di Satriano.

[215] See Chapter 3: Punta La Terrara, Torre Santa Sabina, Piazza Palmieri in Apulia, and La Muculufa in Sicily.

This similarity, along with the intricate planning involved in both the construction of the buildings and pottery production at the site of La Muculufa in Sicily, led the excavators there to suggest that the construction process had graduated from a chore, wherein all members of a particular household had participated, to a craft in and of itself.[216] This development would mark a change in architectural and societal organization, illustrating the transition from the egalitarian construction processes involved in the building of simple Neolithic wattle-and daub huts[217] to the complicated architectural planning of the Bronze Age wherein 'proto-architects,' who were most likely also potters, took over the direction and marshalling of resources for construction.[218] If the clay sources and composition of the earthen architecture and ceramics recovered from Poggio Civitate were similar, it would lend credence to this theory and provide an archaeometric marker of the transition from subsistence to craft technology in architecture. The overlapping of techniques used in the architectural and ceramics crafts would also speak against the presence of itinerant craftsmen at the site and support the concept of locals engaged in all aspects of societal activities.[219]

The bulk of this study consists of the morphological analysis of earthen architecture from the Orientalizing complex at Poggio Civitate. The earthen architecture

[216] McDonnell 1992b, 33-5.

[217] Ammerman, Shaffer, and Hartmann 1988, 138 imagined that the construction of huts at Piana Di Curinga would involve only the members of the household. Robb 2007, 85, believes the 'barn-raising' scenario of wattle-and-daub construction is too simplistic to be applied to complicated structures, no matter the time period.

[218] 'Proto-architect' is the term used by McDonnell 1992b, 35.

[219] Nielsen 1983, 344, argues that the high number of unworked bone and antler pieces at Poggio Civitate indicates that craftsmen were local, since itinerant craftsmen would be expected to take their material with them from site to site.

at Poggio Civitate stands at the end of the survey of construction techniques in Italy. In order to understand the architectural practices current at the site during the Orientalizing period, it is necessary to quantify and analyze the daub and mudbrick fragments recovered. Daub and mudbrick fragments have been collected at Poggio Civitate since excavation of the Archaic complex began during the 1960s.[220] The findspots for a few fragments were precisely located, but most were consigned to the excavation's depot in Vescovado di Murlo without further study. Thus, the locations of most fragments can only be assigned to the general area of a trench. The bulk of the excavation of the Archaic buildings took place from 1966 to 1973 and Orientalizing levels were identified beneath them as early as 1970. Excavations of the Orientalizing buildings have continued off and on up until the present day. For most daub and mudbrick fragments, it has been possible to associate them with particular buildings during either the Orientalizing or Archaic period, but the nature of the evidence does not allow any more precision.[221]

In attempting to quantify the fragments of earthen architecture collected over the past 40 years of excavation, as each piece was pulled from a trench's box of representative finds, it was assigned a number designator based on the trench from which it had been recovered (i.e. T26-1 indicates this fragment was the first fragment recorded from trench T-26). The fragments were initially assigned to one of the six following categories based on their shape and the presence of any impressions left in them from

[220] Phillips 1966, Pl. 40, Fig. 9.

[221] Shaffer (1983) and Tasca (1998b) at the Neolithic sites of Acconia and at Ripa Tetta, respectively, offered reconstructions of the earthen superstructure of the buildings there based on the precise mapping of individual pieces of daub as they were recovered. The data at Poggio Civitate does not lend itself to such an approach.

structural members: (1) daub with circular impressions from wattles running in a parallel direction; (2) daub with circular impressions from wattles woven together; (3) daub with circular timber impressions; (4) daub with impressions from wooden boards or terracotta tiles (5) daub with no impressions, and (6) mudbrick fragments. Previous daub reports have divided the fragments into two overall categories: daub with impressions and daub without impressions. The daub fragments with impressions provided information about the construction techniques and timber members utilized to construct the buildings. The sizes of the timbers and wattles used in concert with the earth to construct the buildings are presented in tabular form, in a similar manner to daub reports from the Neolithic sites of Acconia,[222] Trasano,[223] Balsignano,[224] Broglio di Trebisacce,[225] and Favella.[226]

This type of information about the earthen architecture provides a general sense about the timber and earthen components used to construct the buildings of the Orientalizing complex. Assessing the specific role that each fragment with impressions played in a building's architectural scheme is a more difficult task for which no defined method exists. Daub fragments at Poggio Civitate – as long as their firing temperature does not suggest otherwise – could be part of a wall, roof, or even a ceiling, since the excavators originally suggested that the building designated OC1 might have had an

[222] Shaffer 1983.

[223] Tasca 1998b.

[224] Fiorentino and Muntoni 2002.

[225] Moffa 2002.

[226] Tine 2009.

upper storey.[227] The first two daub categories - fragments with wattle impressions (diameters roughly from 0.2 to3 cm) - were divided into two separate groups because the disposition of the wattles could indicate their function. In his study of daub at Piana di Curinga, Shaffer suggested that exterior daub used on the roof or as a lathing for walls might have been indicated by the presence of a series of wattles arranged parallel that did not appear to have intersected with one another. Thicker daub fragments with evidence of woven wattles at Piana di Curinga were classified as wall daub.[228]

The third daub category, comprising daub fragments with larger circular impressions (arcs greater than 3 cm), includes those fragments that were in contact with larger timbers. At the Iron Age site of Ficana, daub with circular impressions were categorized as vertical 'poles,' with smaller poles falling between 6 and 8 cm in diameter and larger 'poles' that left impressions on the daub circumscribing a diameter that could be estimated at 18 to 30 cm.[229] In the case of Poggio Civitate, however, it must be noted that the roofing structure most likely necessitated substantial horizontal timbers that could have come in contact with daub and therefore their orientation cannot be assumed. The fourth category – daub with curvilinear or flat impressions – is essentially unique to Poggio Civitate. At other sites that had daub with flat impressions, one could be reasonably assured that those impressions resulted from flat wooden boards. At Poggio Civitate, the presence of terracotta tiles and bricks introduces other sources of contact with the daub that might have resulted in flat impressions. If the grain of a timber could

[227] Phillips 1993,56; contra Berkin 2003, 21, who believed it was more likely that the building consisted of only one storey.

[228] Shaffer 1983, 437-40.

[229] Brandt 1996, 23-7.

be discerned in the impression on the daub fragment, as at Pulo di Molfetta (Fig. 32), Murgia Timone (Fig. 40), Favella (Fig. 49), and Ficana (Fig 101), then the fragment could be classified as a fragment in contact with a flat wooden board. If not, the daub fragment was assumed to have been in contact with a terracotta tile or brick. The fifth category – daub without impressions – is difficult to place in an architectural scheme, but if the fragments were decorated it would indicate their likely incorporation into a wall. The last category- mudbrick fragments – was classified as such if the fragments had at least two finished sides meeting roughly at a right angle. Mudbricks had to be incorporated into a wall. Although the precise location of daub fragments and their interaction with other fragments is not known, a general sense of the construction techniques used for the different buildings of the Orientalizing complex can be sketched using these categories.

The information gleaned from the morphological study of the daub will provide the background for hypotheses about the construction techniques used at Poggio Civitate. The schemes delineated by the daub for the superstructure of the buildings of the Orientalizing Complex can be tested using the principles of civil engineering. Despite some drawbacks which will be discussed in Chapter 4, engineering analyses can be helpful if used in conjunction with archaeological data and offered as possibilities instead of solutions.[230] Two recent contributions in the Roman sphere include analyses of potential roofing alternatives for Hadrian's Building with Three Exedras in Tivoli[231] and

[230] Startin 1978, 150.

[231] Abruzzese et al. 2005, 183-90.

the Temple of Venus and Roma.[232] Both use calculations from computer-generated Finite Element Models to offer roofing alternatives. In the former case, they demonstrate that the 'Building with Three Exedras' at Tivoli could have been roofed with flat concrete slabs in the two outer rooms, but the stresses incurred by a flat slab roof in the central room would likely have necessitated a different solution, perhaps a timber truss. In the latter case, the researchers demonstrate that, contrary to the opinion of most architectural historians, the walls of the temple of Venus and Roma could have sustained a vault over the cella and would not have needed a timber truss roof. To their credit, both studies rely on the evidence remaining of the extant walls and roofing fragments recovered from each respective site. The use of Finite Element Modeling software, however, turns their studies into 'black boxes' that can only be readily digested and critiqued by engineers well-versed in the particular software used. Although both studies are valuable contributions, they will most likely not gain widespread distribution because of the manner in which they were presented.

With these things in mind, this study will attempt to incorporate the principles of civil engineering into the analysis of the building that provides the most data about its ground plan and superstructure – OC2. This can be done by using quick-reference tables and test results available in engineering manuals that provide guidance for designing timber rafters and earthen walls. In the former case, the American Forest and Paper Association's *Wood Structural Design Data* provides allowable loads for common structural timbers supported over several different span lengths. In the latter case, the strength properties determined for mudbrick walls by National Bureau of Standards can

[232] Gonzalez-Longo and Theodossopoulos 2005, 1383-93.

be compared to the estimated weight transferred from the rafters of OC2. The introduction of precise engineering calculations will be avoided for two main reasons. First, as mentioned by Shaffer, the use of design calculations imparts a degree of certainty that is not warranted given the data. Second, in any engineering design, the calculations themselves are much less a matter of debate than the assumptions made to justify their use as critical design factors. This was demonstrated in the discussion of the reconstructions at Luni sul Mignone and Portonaccio. An archaeologist's strength lies in finding and providing evidence for the architectural details of ancient buildings, not in assessing the viability of structural systems for which there is little or no evidence. Once a case has been made for particular construction technique, archaeologists and architectural historians can turn to materials science for further guidance and use those resources to refine their ideas. The use of data available from sources like the American Forest and Paper Association and the National Bureau of Standards only requires a familiarization with the construction techniques in question and a working knowledge of geometry and trigonometry. The utilization of tables and test results developed as quick reference guides in the design of modern buildings, for the engineer and non-engineer alike, can offer a different approach that engages a wider audience and brings the rigor of materials science to bear on architectural reconstructions in archaeological studies.

Chapter 3 will attempt to sketch the 'genealogy' of the earthen architecture of pre- and proto-historic Italy, a key concern in both the Annaliste and Neo-Darwinian approaches to material culture. The scientific approach advocated by proponents of the Neo-Darwinian school of thought will be addressed by the archaeometric, morphological, and engineering analyses of earthen architecture provided in Chapter 4. The conclusions reached in Chapter 5 will summarize how earthen architecture changed at Poggio Civitate during the 7^{th} c. BC and incorporate the paradigms provided by the Annaliste perspective, Neo-Darwinism, and 'Thing theory' in an effort to provide an explanation for these developments.

CHAPTER 3:
SURVEY OF EARTHEN ARCHITECTURE IN ITALY

3.1: TERMINOLOGY

Earthen architecture in the ancient world generally consisted of three types of wall construction: mudbrick, rammed earth, and wattle-and-daub. The mudbrick is a square or rectangular brick of clay formed in a mold and left out to dry in the sun. The molded form of the mudbrick originated some 5,000 years ago in the Near East and Mediterranean, but hand-formed mudbricks of a plano-convex shape date back 11,000 years to Jericho. Mudbrick walls can be several stories tall but in order to avoid toppling, the walls normally decrease in thickness as they rise in height.[233] Of principal importance for the integrity and bearing capacity of any mudbrick wall is a level surface. As such, mud mortar is normally used between each course of mudbrick in order to ensure an even surface. [234] In Italian literature, the mudbrick is referred to as *mattone crudo*, in French *brique crue*, in Spanish *adobe*. A rammed-earth wall may be better known by its French equivalent, *pisé*. The term pisé is generally understood and is used to describe a wall of earth packed between wooden boards. Map 2 can be consulted for locations of places mentioned in this chapter.

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[233] Van Beek 2000, 258-65.

[234] Ibid 275-8.

3.2: ANCIENT SOURCES

Commentary on earthen architecture in Italy can be found in the ancient sources and much of it is devoted to the use and forms of mudbrick. For Vitruvius, though, wattle-and-daub took pride of place as the first step towards civilization when the ancients emerged from the forests and constructed shelters constructed of timber structures covered with clay (*Primumque furcis erectis et virgulis interpositis luto parietes texerunt*). Evidence for this early architecture, Vitruvius tells us, could be seen in the walls of Romulus' hut on the Palatine and in those of the 'uncivilized' peoples of Spain, Portugal, and Gaul.[235] From a construction standpoint, however, Vitruvius relates that it would have been better if wattle-and-daub construction was never invented because of its propensity for catching fire.[236] Viable earthen construction, in the view of Vitruvius, consisted mainly of unbaked brick. The use of the thin baked bricks employed in *opus testaceum* had only recently become common when Vitruvius was writing, thus much of his discussion on bricks was devoted to the unbaked kind, mudbrick.[237] Roman building regulations prohibited any wall from being more than a foot and a half thick, so mudbrick construction gave way to concrete since it was thought that mudbricks were incapable of sustaining more than one story in height for a building.[238] This was a marked change from a century earlier when, according to Dio Cassius, the overflowing

[235] Vitr. *De Arch*. 1.2-5

[236] Vitr. *De Arch*. 2.8.20.

[237] Blake 1959, 276, explains that where Vitruvius used the Latin '*lateres*,' he meant unfired bricks unless it was modified by '*coctus*'. Fired bricks did not become common in architecture until the 1st c. AD (Lancaster 2008, 264).

[238] Vitr. *De Arch*. 2.8.17.

Tiber undermined and collapsed many of the mudbrick houses occupying the lowlands of Rome.[239] Of course, replacing mudbrick with marble in Roman construction was one of the great boasts of Augustus.[240] Nonetheless, the use of mudbrick continued alongside that of baked brick throughout the Imperial period. Diocletian's price edict of 284 A.D. set separate wages for craftsmen producing both mudbrick and baked brick.[241]

While the use of wattle-and-daub and mudbrick as building materials in Imperial Rome was uncommon, in other cities and in the countryside these techniques were cost-effective and ready options. The city walls of Arezzo[242] and the Umbrian city of Mevania were constructed of mudbrick.[243] Columella recommended that farmers construct pens for livestock using mudbrick covered with clay when stones were too expensive or unavailable.[244] Varro mentioned the different types of wall construction found on farms throughout Italy: stone walls were used in the area around Tusculum in Latium; baked brick in Umbria, mudbrick in the Sabine country; and earthen and gravel mounds (pisé walls?) in the area of Tarentum and also in Spain.[245] Cato advised that farm owners stipulate in building contracts that walls should be made of mudbrick set on top of stone foundations.[246] He also provided a technique by which one could produce a

[239] Dio Cass. 39. 62.

[240] Suet. *Aug*. 28.

[241] Lauffer 1971, 118.

[242] Vitr. *De Arch*. 2.3.8

[243] Pliny *NH* 35.49.

[244] Columella *Rust.* 9.1.2

[245] Varro *Rust.* 1. 14.4

[246] Cato *Agr.* 14.

daub suitable for farm buildings: mix chalky or red earth with straw, let sit for four days with oil dregs, and then work with a hoe into a suitable daub for walls.[247] Vitruvius recommended using mudbrick for building construction as long as the soil used in their mixture was clayey, not sandy or gravely.[248] He suggested topping a mudbrick wall with a crown of baked brick beneath the roof in order to prevent water from damaging the wall in the event that roofing tiles failed or were defective.[249] In the military sphere, Caesar cited the use of mudbrick by military engineers when constructing siege works outside of Marseilles.[250] Vitruvius did not make any mention of rammed earth or pisé walls, which Varro may have been describing in Tarentum and Spain. Pliny specifically mentioned the use of pisé walls in Spain and Africa, but not Italy. He called these walls *parietes formaceos* and described them as earthen walls formed by packing earth between two flat boards.[251]

As part of temperate Europe, builders in Italy probably did not view mudbrick as a particularly advantageous selection for construction. Timber, on the other hand, was an abundant and more durable building material in damp conditions. Vitruvius does not state explicitly but leaves the impression that mudbricks were an Eastern import since, according to him, the Romans used 'Lydian' bricks that were rectangular in shape, one and a half feet wide and one foot long. Greeks also used mudbricks but they were square

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[247] Cato *Agr.* 128. Blake 1959, 318, interprets this passage as instructions for making plaster, i.e. the lime-based covering for an existing wall. Cato makes no mention of lime (*calx*) in this passage, however. He uses the verb '*delutare*' which is derived from '*lutum*,' dirt or clay.

[248] Vitr. *De Arch*. 2. 3

[249] Vitr. *De Arch*. 2.18. 8

[250] Caes. *B Civ*. 2.8

[251] Pliny *NH* 35.48.

in shape.[252] Pliny the Elder related a similar story about mudbricks and attributed the invention of earthen construction to two brothers from Athens, Euryalus and Hyperbius.[253] Vitruvius also mentions special mudbricks made of a local soil, similar to pumice, at Calentum in Spain (near Cordoba), Marseilles in France, and Pitane in Turkey (near Izmir) that floated on water. Both Pliny and Strabo include the story of 'floating' mudbricks, but Strabo also mentions Tyrrhennia (Etruria) in addition to Pitane and Spain as places where they were used.[254] Vitruvius highly recommended this particular type of mudbrick for construction because it was light and impervious to rain.[255]

The study of ancient architecture is largely based on stone and fired brick since these are the components that endure. From a brief survey of the ancient sources on Italy, however, it is clear that much of their built world must have been composed of perishable architecture. Most of this is lost to us but enough archaeological evidence remains to sketch a rough picture of the techniques used to build the houses and buildings that populated the prehistoric landscape of Italy. By taking a broad chronological view of the evidence from the Neolithic to the Orientalizing period, it will be possible to recognize developments and patterns in the construction of perishable architecture throughout Italy.

3.3: Archaeological Evidence

Earthen architecture – mudbricks, pisé walls, and wattle-and-daub – often does not survive in the archaeological record. Accidental or intentional firing of these

[252] Vitr. *De Arch*. 2.3.3-4.

[253] Pliny *NH* 35.49; 7.57.

[254] Strab. *Geog.*13, 1, 67.

[255] Vitr. *De Arch*. 2.3.3.

elements can occur, however, and their remains aid in the discovery of prehistoric sites. This survey does not incorporate every archaeological report in Italy that mentions the recovery of earthen architecture during excavation, but only those that subjected the material to some type of dedicated analysis. Most excavations that have preserved and studied earthen architecture were prehistoric and situated in southern Italy, particularly in the province of Puglia.

3.3.1: Neolithic Period

A. Robb characterizes settlement during the Neolithic period in Italy as a series of small villages, 100 to 150 meters in diameter, populated by houses of one room covering an area no greater than 3-5 meters wide and 5-7 meters long. These structures were normally separated from one another and constructed with wattle-and-daub walls which were either set on stone socles or hooked into larger vertical timbers set into postholes. Roofs are thought to have been made of thatch. The Neolithic villages of central and southern Italy were sometimes surrounded by a ditch but most settlements identified were small open-area settlements.[256] Both rectangular and round hut plans have been found in southern Italy, along with evidence for path construction and allowance for open central spaces. Evidence for plans and organization from central and northern Italy is not as abundant as that from the south,[257] but the remains of earthen architecture used for building superstructures in Neolithic Italy show clear differences in construction techniques and traditions in the north and south of the peninsula.

[256] Robb 2007, 76-77.

[257] Boethius 1978, 10-11.

3.3.1.1: Southern Italy

One of the first in-depth discussions about wattle-and-daub appeared in 1910 in the excavation report by A. Mosso of the early Neolithic necropolis at **Pulo di Molfetta**, located on the Adriatic coast in Puglia. At a level postdating the tombs, excavators uncovered evidence for rectangular huts, approximately 3-4 meters in diameter with floors of beaten clay. Daub with timber impressions averaging 5-6 cm in width was found above the floors along with the imprints of postholes. Using a microscope, the fabric of the daub was described as a mixture of clay and pulverized charcoal. Mosso believed the clay was mixed with charcoal and perhaps also animal dung in order to make it more water resistant. He did not offer any ethnographic examples in support of this hypothesis but thought the addition of these components to the daub mixture would increase its density, thus making it better able to withstand humidity and water than a simple mixture of mud. The specific weight of a fragment of daub from the site was found to be 1.35. As compared to a fired brick with a specific weight averaging around 2, the daub was less dense but any additives added during its preparation that helped to make the daub more workable without losing its cohesion could be perceived as an improvement.[258] Another interesting insight provided by the daub from Molfetta was the presence of a flat timber impression, indicating that Neolithic buildings spilt timbers for construction purposes (Fig. 32). In this fragment of daub, three wattles 6 cm in diameter appear to intersect a wooden board measuring at least 12 cm in width. Since similar pieces of daub outlined the perimeter of the huts, Mosso suggested that flat boards

[258] Mosso 1910, 239-40.

formed part of the lower walls while vertical timber members intersected them cross-wise to form the upper part. The beaten clay floors also displayed hollows that suggested to Mosso that the floors had also been reinforced with flat wooden boards.[259]

The next Neolithic site that took a critical look at the daub recovered during an excavation comes from the report by M. Acanfora on the Neolithic site of **Francavilla Fontana**, also in the province of Puglia. The site produced about 100 kg of daub mixed in with stones. Defined plans for huts were not able to be identified. The soil used for the daub appeared to be local, and this assumption was confirmed by the examination of some fragments with a stereoscopic microscope. All fragments of any size displayed impressions of wattles (identified as reeds, 'canne,' in the report) ranging from 2 to 6 cm in diameter. The impressions usually displayed wattles running parallel and in some instances wattles ran crosswise to the parallel impressions but they did not appear to be interwoven (Fig. 33).[260] Some fragments were smoothed on the side opposite the wattle impressions. The smoothed surfaces often displayed a concave profile, suggesting to the excavators that those fragments were part of the internal walls of a hut and that the pieces only represented one side of a full earthen wall (Fig. 34). Given this assumption, the thickness of the hut walls was estimated to have been approximately 20 cm and the weight of every square meter of wall would equal about 160 kg. A daubed wall, then, would have been a substantial structure requiring a prepared foundation, but stones for a socle were not found, nor were any postholes identified. To compensate, Acanfora suggested that the timber skeleton of the wall could have been set onto the ground at an

[259] Mosso 1910, 242.

[260] Acanfora 1952, 217 and n.1, 218.

oblique angle and secured at its base with a mass of earth and stones. In support of this hypothesis, she drew attention to some of the structures identified at the nearby site of Serra d'Alto, which produced a good deal of daub but lacked evidence for postholes or stone socles. Excavators did, though, record the presence of loose collections of stones at both sites.[261]

Acanfora also drew a comparison in construction technique between Francavilla Fontana and the Early Bronze age tumulus discovered in Helmsdorf, Germany. At Helmsdorf, the tumulus covered a tomb chamber constructed of wooden boards set obliquely on the ground and set in place with large stones, not unlike her suggestion regarding the walls of the hut at Francavilla Fontana. This construction technique is probably best illustrated at a contemporary tomb of the same Unetice culture in Leugingen, Saxony (Fig. 35).[262] Some fragments of daub about 1cm thick at Francavilla Fontana displayed flat cordons ranging from 2-4 cm in width, perhaps suggesting the daub was pressed to fill space between two flat boards. Acanfora drew attention to these pieces because they suggest similar woodworking techniques between a site in Germany and one in Italy. The opposite sides of these particular pieces, though, displayed the impressions of straw.[263] It is not clear how these thin pieces could have functioned as part of a wall along with straw, but it is conceivable that they might have been part of a roof and used as a means of waterproofing along with the straw.

[261] Acanfora 1952, 219.

[262] Ginmbutas 1965, 260-64.

[263] Acanfora 1952, 220.

Excavations of the Neolithic village at **Trasano** near Matera in the region of Basilicata recovered 253 kg of daub, 1247 fragments in all, which did not appear to belong to any specific structure. The majority of these fragments preserved imprints of curved wattles and timbers, although some displayed imprints of pieces of wood that were flat or straight. Most of the flat pieces had rectangular sections measuring between 2 and 7 cm in width, with the widest being 12 cm. In some cases the grain of wood left an impression on the daub indicating timbers were split lengthwise. For daub that had circular impressions, they calculated that wattles ranged from 2 to 5 cm, although diameters as large as 23 cm were estimated (Fig. 36). The larger circular impressions undoubtedly belonged to structural support members while the more numerous smaller impressions were made by wattles comprising the 'skeleton' of the daub walls. Almost 600 fragments held impressions of more than one wattle and 290 of those were on the opposite side of a finished face. The wattles were normally spaced about 2 cm apart and most met up with imprints running perpendicular, but there was no evidence that the wattles were woven or crossed. Instead, imprints of bindings that would have secured the less numerous perpendicular wattles to the overall wattle fabric appeared on some daub fragments (Fig. 37). Thus, the excavators believed the skeleton of the daub walls was characterized by numerous horizontal wattles placed close together interspersed by vertical wattles secured with bindings. This skeleton would then be covered over by about 2cm of daub. There were instances where the impressions of the wattles of a piece of daub intersected with the finished face on the opposite side, suggesting to the excavators that some wattles were exposed on the exterior. No daub recovered exhibited finished faces on both sides, so it was not known if daub was applied on one side or both of the wattle skeletons. The daub included traces of vegetal matter such as straw and seeds, likely added intentionally to the mixture to improve workability. Traces of small leaves and fragments of stones, ceramics and even bones got mixed in somehow. The surface of the daub was smoothed and in some cases finished with a finer and thinner application of daub.[264]

Also in Basilicata about 11km from Matera was the settlement of **Tirlecchia**. This was a large circular village of the Middle Neolithic period surrounded by a moat and excavated in the 1970-80s by M. Bernabo Brea. The targeted excavations uncovered evidence for circular dwellings supported by postholes but the sizes of dwellings and complete ground plans were not able to be ascertained.[265] Excavators did recover 250 fragments of daub associated with the targeted excavations inside the village that included some with imprints of wattles and reeds ranging in diameter from 0.7 to 3 cm. One particular piece commented upon was 0.9 - 1.6 cm thick with thin parallel impressions of wattles on one side and white slip on the other. This slip was then painted with a red zig-zag decoration (Fig. 38). Bernabo Brea could draw no comparanda for this fragment, other than recognizing that it was a different type of daub decoration than that found up north at Rocca di Rivoli (see below) and might have some relation to painted daub and the house models decorated in geometric motifs recovered from Neolithic contexts in the Balkans, along the Danube, and the Aegean.[266]

[264] Tasca 1998b, 77-87, 80-1.

[265] Bernabo Brea 1984, 32-3.

[266] Ibid 58-9.

The mid-to-sub Neolithic site of **Murgia Timone** was only 4 km from Matera and also was enclosed by a moat, in the same manner as nearby Tirlecchia. Excavations there uncovered structures that varied in plan but were roughly semicircular and measured no greater than 12m in diameter.[267] Several daub fragments were recovered from both mid and sub-Neolithic levels, although they could not be associated with specific structures. Five fragments were illustrated from the mid-Neolithic levels which were 3.5 to 6 cm in thickness and 8 to 14 cm long. The fragments had small wattle impressions that appeared to intersect in places and one larger wattle/sapling impression measuring 3.5 cm in diameter (Fig. 39).[268] Another fragment found in the western part of the site but also not associated with any structure in particular displayed the imprint of a flat wooden board, measuring at least 5 cm in width (Fig. 40).[269] There were no wattle impressions on the piece but it was most likely part of a wall and not part of a roof since the fragment was7cm thick.

In the province of Bari, archaeologists uncovered a rectangular structure measuring 8 x 6 m at the early Neolithic site of **Le Grottelline**. The walls of the building had a rough stone foundation and the floor was composed of beaten earth. Most daub fragments were recovered near and above the wall foundations but some were also found in the interior of the structure. Only about 7% (54) of the total number of the daub fragments recovered displayed impressions of wooden members. Based on a sieve analysis, the daub was very fine-grained but had a number of large mineral and organic inclusions, suggesting that it was minimally processed. Pieces on the exterior of the

[267] Lo Porto 1998, 55.

[268] Lo Porto 1998, 35-6.

[269] Ibid 83.

building were washed over with a diluted surfacing of daub. In total, there were 87 impressions of timbers (Fig. 41). The majority of those were curved (60%) and most of those impressions fell between 2– 3 cm in width; the largest was 6 cm. About a quarter of the impressions were flat, and most of those had widths measuring only 1 cm. Eight impressions were classified as plano-convex; they only preserved a portion of the timber's profile and appeared alone, seemingly not interacting with any other timbers. There were also six impressions that preserved vegetal elements, one of which appears to show the grain of a split timber but the excavators suggest it might have been the impressions of packed straw. The excavators also classified the orientation of the imprints. About a third of the imprints ran parallel with each other, a third ran perpendicular to each other, and a third appeared alone. There was no indication about how the perpendicular timbers were bound to each other or woven together. No reconstruction of the building's superstructure was offered.[270] Wattle-and-daub certainly played a role in the building's superstructure but the small diameter of the impressions, the vast majority of daub (93%) without any timber impressions, and the presence of daub with flat impressions suggest that split or flattened timbers might have constituted at least part of the building's earthen walls, as at Francavilla Fontana.

Another Neolithic village that produced a large amount of daub was **Ripa Tetta** near Lucera in the province of Puglia. The material recovered from this excavation was associated with a particular building of quadrangular shape, measuring about 4.5 to 5 meters on each side (Fig. 42). The number of daub fragments that displayed flat wood impressions far outnumbered those with wattle impressions in this instance. Timber impressions on the daub indicated that the wood came from timbers that were split

[270] Lorenzi and Serradimigni 2009, 56-60.

lengthwise. The few fragments that displayed more than one impression in parallel generally did not run into any impressions crosswise. Left with a majority of daub pieces with flat impressions, the excavators advanced the idea that the building's walls were not composed of wattle-and-daub but rather a split-timber frame. In their view, the evidence suggested that flat wooden boards about 8-13 cm in width were set horizontally and bound with a few vertical members, with about 2 cm between the boards to allow for the daub to adhere to the timber frame. Alternately, the absence of any evidence for a stone socle to protect the wattle-and-daub walls from ground water led the excavators to offer an alternate hypothesis about the disposition of the daub based on construction techniques found in excavations of Vinca culture settlements in Neolithic Serbia. At the site of Divostin in Serbia, wattle-and-daub walls were set on top of floors made of beaten earth reinforced with squared timbers (Fig. 43). It is possible that a similar technique was used at Ripa Tetta, wherein the daub recovered represented nothing other than a clay floor reinforced with split timbers. Any direct contact between the two cultures at such an early date would be surprising, in any case.[271] Arguing against this latter scenario, though, is the fact that the daub at Ripa Tetta appeared to have been fired more intensely on the side that exhibited impressions of split timbers. If the timbers had been used as floor boards, the side exhibiting impressions would have been shielded from the most intense heat of the fire.

The most extensive analysis of daub from any archaeological site in Italy was carried out at **Piana di Curinga**, on the west coast of Calabria. Techniques included not only a morphological analysis of the daub, but also a study of plant impressions, a

[271] Tasca 1998b, 81-84; McPherron and Srejovic 1988, 76-8. Unfortunately, the site report from Divostin does not include any illustrations or photos of the daub. Thus, no comparison can be made.

petrographic analysis of thin sections, and an archaeomagnetic study of the fragments. A magnetometer survey along with extensive excavations uncovered 48 different structures within a two hectare area. The structures were built upon sand dunes, indicating that the clay used for daubing the buildings had to be transported from elsewhere. The sand dunes provided the advantage, though, of providing drainage beneath the daub walls that would protect them from water damage. No evidence for postholes was found. One house in the area designated 'H' was subjected to intensive study. This discrete area produced over 1000 kg of daub and 1065 individual fragments. Each piece of daub over 9 cm in length was plotted in plan to provide a distribution map over the surface of excavation (Fig. 44). Based on this data, it appeared that the walls of the house collapsed into a 2 meter band of daub adjacent to the original run of the wall, allowing the excavators to identify a 4.5 x 3.5 m rectangular plan for this particular structure (Fig. 45). Daub did not appear to be used for the floor of the structure. Over 900 fragments included impressions for the timber skeleton of the walls. Nearly 200 daub fragments displayed the impressions of more than one wattle running in a parallel direction and 20 fragments displayed wattle impressions running crosswise to each other. Based on the orientation of the daub pieces with wattle impression in the collapse zone, the excavators determined that the majority of wattle impressions appeared to have run horizontally and, at points, they were bound to vertical posts. Up to 70 pieces of daub had impressions of the cordage that was used to bind the wattles together.[272] The wattles were of moderate size, usually measuring at least 3.5 cm in diameter. Seventeen fragments preserved

[272] Shaffer 1983, 221- 225.

timber impressions measuring up to 15 cm in diameter. Fourteen fragments contained the impressions of flat timbers or saplings that had been split lengthwise.[273]

Petrographic examination revealed that the clay for the daub was procured from a streambed located at a distance of 100 meters or more to the south of the site. Grass and ferns were intentionally added to the daub mixture, along with occasional bits of obsidian and pottery. Forty fragments of daub included one finished surface and had an average thickness of about 6 cm. Assuming that these pieces represented the outer surface of the daub wall skeleton, excavators estimated the average thickness of the wall to be about 16 cm. In total, it was estimated that the builders would have had to procure 3 cubic meters (approximately 5500 kg) of clay to daub the entire house in area H. The leaf impressions found in the daub suggest that the daubing process most likely occurred during the spring, when certain plants used in construction were all in season.[274] Plants and leaf impressions that could be identified included the common reed, the European alder, the holm and cork oak, the white willow, and the common and bracken fern.[275] Oaks were probably used for structural members, willows for the wattles of the walls, and reeds for the roofing or as a thin lathing surface for the walls. The suggestion that slender reeds were used for roofing or lathing a wall surface was based on the fact that their impressions (about 1 cm in diameter) normally were set close together on thin fragments of daub that were finished on the opposite side (Fig. 46). In fact, the average distance between the imprint of a reed and the exterior surface of the daub fragment was only 0.9

[273] Ammermann et al. 1988., 124-8.

[274] Ammermann et al. 1988., 138.

[275] Shaffer 1983, 425-6.

cm, which was much less than that found on pieces of daub that were identified as wall fragments. In support of this opinion, Shaffer cited ethnographic studies that documented the use of reeds to roof huts in the Italian countryside and in modern-day France. In the latter case, reed roofs were covered over with a thin layer of loam in order to make them water resistant.[276]

Shaffer's analysis also included the construction and destruction of a wattle-and-daub wall and enclosure. Useful observations were gleaned both about daub as a building material and also its survival as an archaeological artifact. In constructing the skeleton of the wattle wall, it was difficult to wend the horizontal wattles around larger vertical posts - as is often depicted in artistic renditions - without significantly increasing the thickness of the daub wall. Therefore, Shaffer believed the wattles usually would have been secured to vertical timbers by means of binding.[277] In the destruction of the wattle-and-daub wall by 'accidental' firing (meaning that there was no concerted effort to achieve a high-temperature fire), it appeared that only fairly thin pieces were completely fired through and preserved for the archaeological record. This circumstance had implications for estimating the width of wattle-and-daub walls. Shaffer had assumed that a daub wall's thickness could be estimated by measuring the thickness of a piece of daub with a finished (exterior) face, doubling it to account for the wall's opposite face, and adding in the estimated width of the wattle skeleton (Fig. 47). This technique presumed that, during the fire, the wattles would burn away and the inner and outer face of the daub wall would separate. The wall that Shaffer had constructed was 20cm thick, but applying

[276] Shaffer 1983, 437-40; he cites the ethnographic studeis of Fiori,1923-5, 60 in Italy and Meirion-Jones 1976, 51-3 in France.

[277] Shaffer 1983, 78.

his measuring technique to the preserved remains resulted in an estimated thickness of 7 cm. In Shaffer's opinion, he had erred in thinking that wattles would consistently occupy the center of a wall. The daub fragments that preserved wattle impressions after the fire were usually no thicker than 3.2 cm. Therefore, only those parts of the wall where wattles bowed away from the center and were covered with a relatively thin covering of daub were completely fired through, leading to an underestimation of wall thickness.[278] In total, Shaffer estimated that only about three percent of the experimental daub wall was preserved by sintering during its controlled destruction. That quantity was similar to the amount recorded by an experiment in Serbia in which the archaeologists estimated that no more than one percent of the total of the daubed house burned was preserved in the fire.[279] The problem lay in the fact that an 'accidental' firing of daub walls would not reach a temperature high enough (circa 400^{o}C) to fire the daub into a ceramic throughout the entirety of a wall. Shaffer attributed the large amount of daub recovered from Piana di Curinga to the intentional firing of huts by their occupants. He believed that the firing of the walls occurred while they were still at least partially standing based on the magnetic orientation of iron compounds within the daub. When fired above 600^{o}C, the ferric oxides hematite and magnetite become paramagnetic; this means that their orientation within the mineral structure of the clay aligns with the area's ambient magnetic field. Barring any interference, the ferric oxides in clay will reorient themselves within the clay matrix in the same direction as that of the earth's magnetic field. This magnetic orientation can be observed in ceramic fragments using a Complete

[278] Shaffer 1983, 91-93.

[279] Bankoff and Winter 1979, 13.

Result Magnetometer. It follows, then, that daub fragments adjacent to one another would demonstrate a similar magnetic orientation under examination. This method was developed by ceramists in order to aid in pottery vessel reconstruction.[280] Shaffer tested 93 fragments and found that many displayed similar magnetic orientations. In his opinion, if the wall had collapsed onto the ground into a jumble and then had been fired, the magnetic orientation of the daub fragments would have shown more variance. Instead, the inhabitants might have set controlled burns of old huts or partially collapsed walls so they could use the daub in subsequent construction activities as a bedding or filler and avoid transporting more clay to the sand dunes from a distance.[281] There are, however, limitations to this approach that Shaffer acknowledged. Most importantly, the ferric oxides in ceramics will reorient themselves during subsequent heating. Shaffer's rationale for the controlled burning of daub walls - their inclusion in other huts –invites this scenario.[282] Furthermore, the inclusion of large ceramics or stones within a daub wall could increase cracking and fragmentation in the wall after application while the clay dried.

The study at Piana di Curinga remains the most in-depth archaeological investigation of earthen architecture. Recent studies on Neolithic daub have approached the material from a more archaeometric standpoint with less concern about morphological analysis. Since daub was a ceramic, archaeologists began to use the same techniques commonly employed in pottery analysis on daub. Archaeologists at the Neolithic site of **Balsignano**, near Bari on the Adriatic coast in southern Italy, analyzed

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[280] Burnham and Tarling 1975, 152-7.

[281] Shaffer 1983, 553-7.

[282] Shaffer 1993, 72-3.

nearly 1300 fragments of daub from a large rectangular structure measuring 7.3 x 4 m. The excavators estimated that walls were at least 20 cm thick, with daub accounting for half of that thickness (Fig. 48). Circular imprints of wooden members were broken down into three rough categories: small (circa 3 cm), medium (circa 5 cm), and large (15 to 35 cm). Small diameters comprised the largest number of impressions. In the opinion of the excavators, this was a result of the builders' use of reeds to construct the skeleton of the wattle-and-daub wall. Medium imprints were significantly less in number and it was not clear how they interacted with the smaller members. The handful of large impressions most likely belonged to structural members which supported the roofing frame of the structure. Other fragments included those that had imprints of the cordage used to tie together members of the wall's timber skeleton. There were also some flat and convex imprints, probably from daub pressed against split timbers. As at Piana di Curinga, the excavators also conducted a thermomagnetic residue analysis on samples. Thirty of the larger fragments were subjected to this type of study. Unfortunately, none of the samples displayed similar magnetic orientations, most likely due to secondary displacement after the collapse of the structure.[283] Daub samples were also subjected to petrographic examination using a polarized-light microscope, along with X-ray diffraction and X-ray fluorescence analyses. At Balsignano, the soil used for daub was similar to local sources, but testing revealed the addition of vegetal temper and a small amount of crushed limestone. No sample's mineralogical structure suggested a firing temperature above

[283] Fiornentino and Muntoni 2002, 168-73

500^{o}C, suggesting that their firing had not occurred in a kiln but was the result of accidental firing during the destruction of the building.[284]

At the Neolithic site of **Torre Sabea** in Puglia, archaeologists subjected 250 samples of daub recovered from a partially excavated circular structure to petrographic and archaeobotanical analyses. Sieve analysis tests of the raw material of the daub found it to be very fine-grained, suggesting the daub mixture had been purified during preparation. The imprints of seeds from five different types of cultivated grains were discovered under microscopic analysis, including those of the fava bean. This information was significant since it suggested that the people at Torre Sabea were actively cultivating the countryside. Paleobotanists were also able to extract pollen grains from the daub by subjecting the samples to solutions of hydrochloride and hydrofluoride. These corrosive chemicals freed the pollen grains from the daub matrix and permitted them to be examined and identified under microscope. Pollen grains from the holm oak, evergreen shrubs, plants from the mint family, reeds, rushes, and willows indicated that the area that the environment in which the building was constructed was very ecologically diverse. The archaeologists drew a correlation between these results and that of the faunal analysis for the site, which determined that the animal bones recovered belonged to species of wild animals. The diverse ecological system surrounding the village was typical of a society which had yet to domesticate animals. A society that relied upon domesticated animals would probably be located in an

[284] Laviano et al. 1999, 134.

environment characterized by herbaceous plants and bushes suitable to sustain grazing habits.[285]

One of the more recent and thorough investigations of earthen architecture in Neolithic Italy was conducted at the site of **Favella**, an early Neolithic village in northeastern Calabria. Several pits produced daub attributed to at least five structures that was subjected to both morphological and archaeometric analysis. As in most Neolithic contexts, there was no clear foundation (postholes or stone socle remains) to delineate the limits of these structures but excavators surmised a series of rectangular plans measuring roughly 4-5 x 6-7 m based on the distribution of river stones and daub adjacent to the daub pits. On average, structures left behind approximately 500 kg of fired daub.[286] For one particular structure (D), about 58% of the daub fragments recovered retained impressions of wooden elements. The majority of pieces (80%) were larger than 10 cm in length. Thickness of the fragments varied from 1 to 13cm, with nearly two-thirds falling within the range of 5 to 8 cm.[287]

The impressions on the daub fragments were evenly distributed between those that were circular, flat, or angled (Fig. 49). The fragments were divided into two categories: structural elements (*pali*) and reeds (*canne*). The reed impressions left circular imprints with diameters ranging from 0.2 to 1.3 cm. These impressions only accounted for 11% of impressions overall (about a third of the curved impressions). Their small number and the lack of any evidence about how they interacted with the impressions

[285] Constantini et al. 2003, 243-5.

[286] It is worth noting that at Piana di Curinga, approximately twice as much daub was associated with structure H, which had a ground plan about half the size of that estimated for structures at Favella.

[287] Tine 2009, 133-4.

representing structural members prompted excavators to suggest that they were from a separate part of the superstructure, or part of internal screen walls. For the structural members, most flat impressions had a width of 5-7 cm, angled impressions had an average width of 6cm, and curved impression clustered around 6-7 cm. The daub evidence was not dissimilar to that found at Ripa Tetta, where excavators envisioned either a daubed wall of upright planks or even a timber-girded daub floor. There was, however, some variability in the thicknesses of the daub fragments which led the excavators at Favella to discount the latter hypothesis since, in their opinion, one should expect a floor to have more uniformity in its thickness. This left the possibility that the fragments belonged to walls. Thicker fragments probably belonged to the base of walls while thinner ones belonged to a tapered top. In cases of daub with multiple impressions (about half of all fragments), all but one daub fragment displayed impressions running in parallel directions. This evidence did not suggest a 'weaved' wattle-and-daub wall. Instead, the excavators suggested a series of upright split timbers with daub applied on one side similar to Ripa Tetta (Fig. 50). The varied impressions - flat, circular, and angled - could represent the sides of timbers quartered for inclusion in the daub wall skeleton. Daub fragments were smoothed on one side and none exhibited two smooth faces. For this reason, the excavators assumed the wall skeleton was only daubed on one side (presumably the exterior even though there was no obvious surface treatment or decoration). For the roof, excavators imagined a lightweight thatched gabled roof since the walls, lacking embedded timber posts or the heft of a thick wall daubed on both sides, could not support a great deal of weight (Fig. 51).[288] It is possible, though, that the

[288] Tine 2009, 135-7, 189, 197-8.

excavators at Favella underestimated the thickness of the daub walls since they did not take into account the results of Shaffer's experiments at Piana di Curinga. There, Shaffer found that the thickness of daub recovered from his test fires, when doubled and added to the estimated width of the timber skeleton, did not accurately reflect the true thickness of the daub wall he had constructed. If wall thickness was closer to 20 cm, instead of the 10 cm estimated at Favella, the walls probably could have supported a roof covered with thin reeds and clay packing. A clay roof packing could account for the 11% of daub with circular impressions smaller than 1.3 cm.

Archaeometric analyses were also conducted on some of the fragments of daub recovered from the different structures of the early Neolithic village. These included X-ray diffraction, X-ray fluorescence, and petrographic examination of thin sections using optical microscope. For these tests, the researchers discriminated between the daub which held impressions of architectural members (*intonaco*) and all other pieces (*concotto*). The concotto, although fired, had a ceramic matrix that would not be confused with a vessel fabric but might have served some other use such as the walls of a kiln.[289] Petrographic examination and X-ray fluorescence revealed few differences between the fabrics of the concotti and the intonaci. Both matrices contained gaps, indicating the use of organics as a temper to aid in drying and workability of the daub mixture. Two of the intonaci samples appeared to display a red-brown finish on the exterior, perhaps the results of finishing or burnishing for an exterior surface. Unsurprisingly, the daub fabrics had petrographic compositions similar to local soil samples. X-ray diffraction, however, showed a difference in firing temperatures between

[289]Tine 2009, 146-7.

the concotti and intonaci. Concotti samples were associated with a hypothesized furnace that fired at temperatures between 800 and 900°C, while those samples that were classified as intonaci had firing temperatures below 700°C, usually somewhere between 450° and 600°C. These results reflect their different functions: the accidental firing of daub used architecturally (intonaci) came about in relatively low temperatures, but daub used for the walls of a furnace (concotti) were markedly higher.[290]

Finally, the early Neolithic village of **Passo di Corvo** in Puglia is worth mentioning (Fig. 52). Archaeologists recovered daub from the site and even subjected a sample to archaeometric analysis, but did not elaborate on the amount that they found or the impressions that were left on the fragments.[291] Several structures were excavated but none provided full plans. Enough architectural evidence remained to allow the excavators to offer a composite reconstruction of a typical hut. The walls would have been supported by two rows of stones comprising a socle measuring circa 45cm in width. Evidence for postholes was also found indicating a substantial roofing structure. The excavators imagined a wooden superstructure covered by a gabled roof of straw. In the view of the excavator, the only use for daub would have been at the juncture between the wooden walls and the stone socle. A daub sample, along with a number of ceramic samples, was subjected to petrographic and X-ray diffraction analysis. Interestingly, only the daub sample included grog in the form of ground-up potsherds within its fabric under microscopic analysis.[292] It is not clear why the inhabitants of Passo di Corvo would

[290] Tine 2009, 199-213.

[291] Tine 1983, 53.

[292] Ibid 96.

incorporate grog into daub preparation since it is more useful in preparing vessels for expansion during firing. The reconstruction of a typical hut included in the site report does not include daub and without any further information, it is impossible to know the material's role in the architecture of the site.

3.3.1.2: Central Italy

Evidence for earthen architecture from central Italy during the Neolithic period is scant. From the settlement of **Tor Vergata** outside of Rome, 118 pieces of daub were included in the site report published in 1984. The excavators believed they were the remains of hut walls although no clear foundations or plans were discovered. Some fragments exhibited imprints of reeds that were met perpendicularly by larger imprints of horizontal members ranging in diameter from 3-5 cm (Fig. 53). In the opinion of the excavators, the vertical and horizontal members did not appear to intersect on the same plane. Thus, it was thought that the horizontal members were tied into the larger vertical posts that held up the roof, while the vertical members that appear in daub served no other function than as the framework on which the daub was applied.[293]

Daub was also recovered from excavations of a Neolithic settlement at **Pienza** in the modern province of Tuscany. The daub fragments belonged to a second phase of occupation and were associated with a series of huts whose plans were partially demarcated by postholes having an elliptical shape. The postholes were spaced about 1m from each other, measuring 15 to 30 cm in diameter and 10 to 30 cm in depth. The daub was illustrated but not described and shows fragments with parallel impressions from

[293] Cazzella and Moscoloni 1984, 107.

timber members, but there was no evidence of wattle-weaving (Fig. 54). One of the fragmentary hut plans also displayed a rock-and-clay packing around the postholes that must have been used to hold the vertical posts upright.[294]

3.3.1.3: NORTHERN ITALY

Further north in the province of Verona, the Neolithic settlement of **Rocca di Rivoli** produced a pit containing daub fragments that could not be attributed to any specific building. The excavators divided the daub into two types: decorated (type A) and undecorated (type B). The latter group included smaller, more numerous, and more heavily burnt fragments that displayed impressions of wattles, similar to daub from other Neolithic sites. The former included less numerous but larger fragments that appeared to have been intentionally grooved and whitewashed for decorative purposes. The grooves were about 1cm wide and separated from each other by ridges of the same width. The decorated fragments were smoothed on the ridged face but had a rough back where it had been pressed against a timber, some displaying a concave profile and others a right angle. The decorative ridges were generally straight and parallel but some were curved, suggesting they were part of some spiral or circular decoration (Fig. 55).[295] The excavators believed these decorated pieces were part of the outside daubing of a wooden structure, some having been squared timbers and others circular ranging up to 18 cm in diameter. In their estimation, the decorative technique bore resemblance to that used on fluted columns during the classical period. The closest parallel the excavators could point

[294] Calvi Rezia 1972, 290-3.

[295] Barfield 1966 , 18-19.

to in the use of decorative daub was in Bronze Age Slovakia, where daub with ribbed decoration was used at settlements of the Otomani and Madarovce cultures (Fig. 56). There, daub applied to house fronts, wooden pillars, and hearths was grooved with straight lines and spirals in a manner similar to that found at Rocca di Rivoli.[296]

There were also a number of undecorated triangular fragments with wattle impressions averaging about 2 cm in width. The impressions appeared on opposite sides of the fragments and appeared to have passed, one in front of the other, at the apex. They had a slightly concave profile and an irregular outer surface that appeared to display straw impressions (Fig. 57). Other undecorated fragments were rectangular with parallel wattle impressions. The excavators thought the concave profile of these pieces was due to the smearing of the daub against the wattles.[297] This is hard to visualize, though, unless the walls of the structure were somehow bowed or curved. Another possibility is that these daub pieces belonged to a structure's roof, which would help to explain the concave profile and the appearance of straw impressions on one side. These impressions would be expected on a thatched roof. Similar to other Neolithic sites, the daub impressions give no indication that the wattles were woven. The triangular pieces of daub indicate a different type of skeleton construction to allow application for the daub. The wattles were most likely connected to each other with some type of binding or cordage for which no trace remains.

The nearby Late Neolithic site of **Isera - La Torretta** also produced daub during excavations in the 1990s. There, the fragmentary remains of three huts were uncovered with floors of beaten clay (Fig. 58). The huts were not contemporaneous but consecutive,

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[296] Barfield 1976, 21; Paulik 1962, Fig. 7, 8, 9.

[297] Barfield 1976, 19-20.

with the last two huts appearing to display a change in construction technique. These last two huts were half-sunken beneath the ground surface, surrounded by a canal, and had no evidence of internal supports for the roof. This was a marked contrast from the first hut constructed on site, which was above ground and had three postholes running down its center axis. The interior of the last two huts, measuring about 3 meters in width, was occupied by three separate hearths. Therefore, all the weight of the roof was absorbed by the wattle-and-daub walls, as evidenced by the significant quantities of fired daub with timber impressions present. The excavators imagined a gabled roof set upon walls of wattle-and-daub. The timber skeleton of the wall would have then been hooked into a wooden baseboard, as there was no evidence for postholes or stone socles along the perimeter. They attribute the adoption of this new technique to northern contacts beyond the Alps. This scenario of foreign construction practices being adopted by northern Italians during the Neolithic period is supported by the presence of decorated daub similar to that found at Rocca di Rivoli (Fig. 59). Instead of Bronze Age Slovakia, the excavators at Isera looked for inspiration to a Neolithic house model from Kodzadermen, Bulgaria, with gabled roofs and decorated walls (Fig. 60).[298]

Daub from the Late Neolithic site of **Palu di Livenza**, located above the Adriatic Sea near the Slovenian border, has been subjected to a variety of tests to determine its microstructure, likely source, and firing temperature. The samples were not taken from any particular building but were representative of the 250 specimens recovered. Morphologically, they included samples with the imprints of reeds (average diameter c. 2 cm) and vegetal elements, and also those with finished surfaces. Examination of thin

[298] Pedrotti 2000, 155-58.

sections under a microscope revealed fine-grained sand with some vegetal and bone inclusions. There was no significant difference among the samples' microstructure. This fact, along with the seemingly random inclusions of vegetal and bone material, led the archaeologists to suggest that the soil source was within the settlement and prepared without a great deal of processing. X-ray fluorescence tests of the daub revealed a high level of phosphorous, attributed to pollution of the site and contamination of the artifacts. The mineralogical structure revealed in the X-ray diffraction of specimens indicated a range of firing temperatures for the specimens between 500 ^{o}C and 700^{o}C, suggesting they were not part of an oven or hearth.[299]

3.3.2: Bronze Age

The Bronze Age spans 1300 years and has been divided into four phases by scholars: *Bronzo antico* (2300-1700 BC), *Bronzo medio* (1700-1350 BC), *Bronzo recente* (1350-1200 BC), and *Bronzo finale* (1200 – 1000 BC), with the last two phases being referred to collectively as the late Bronze Age. [300] Settlements during the first phase of the Bronze Age were small and short-lived, only presenting one or two phases of occupation. Buildings with round plans were common throughout Italy during the Bronzo antico. In the north, however, lake-side settlements arose that relied on skilled carpentry. During the Bronzo antico, the pile-dwelling settlements of northern Italy in the Lake Garda region called *palafitte* had rectangular plans.[301] In the Po plain, similarly

[299] Fabbri et al. 2007, 79-80.

[300] Moscati 1999, 15.

[301] De Marinis 2009, 535-6.

constructed dwellings called *terramare* appeared during the Bronzo medio. The terramare settlements were larger and surrounded by rectangular earthen embankments and moats.[302] Towards the end of the Bronzo antico and into the beginning of the next phase, the Bronzo medio, persistent settlements at places like Bologna, Rome, Bari and Taranto were established. From around 1500 BC until the late Bronze/early Iron Age, central and southern Italy shared a material culture called 'Apennine' by scholars.[303] Architecture was largely characterized by wattle-and-daub huts, but new architectural developments could be seen in central Italy with the construction of large oval buildings with parallel sides, in particular at Luni sul Mignone.[304] In the latter part of the Bronze Age, settlement and construction techniques experienced significant change in northern and southern Italy. Around 1200 BC, the entire settlement system in northern Italy appears to have collapsed and the area did not see substantial settlement activity until well into the Iron Age.[305] In southern Italy and Sicily, stone buildings with rectangular plans appeared at Thapsos, Pantalica, and Scoglio del Tonno, their form and construction techniques most likely influenced by Mycenaean contacts. Settlements increased in size throughout Italy. During the earlier part of the Bronze Age, settlements usually covered about a hectare in plan, but towards the latter two phases of the Bronze Age, they grew markedly and some covered over ten hectares in area.[306]

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[302] Marzatico 2004, 84.

[303] Pulgisi 1959.

[304] Peroni 1994, 46; Boethius 1982, 13.

[305] De Marinis 2009, 536.

[306] Peroni 1994, 220-1.

The building materials used throughout Italy varied. Straw and reeds appear to have remained the typical roofing material. Stonework became a common feature of wall construction for buildings constructed on round or oval plans in the south and Sicily.[307] Archaeological evidence from a site buried in an eruption of Vesuvius, Nola-Croce del Pape,[308] along with sites in central Italy suggest their superstructures were constructed solely with lightweight wooden frames.[309] Earthen construction persisted throughout Italy but, once again, most archaeological evidence comes from southern Italy.

3.3.2.1: Southern Italy

Turning to excavations that have produced the remains of earthen architecture from the Bronze Age, the village of **Tufariello** provided evidence for wattle-and-daub huts that were well-constructed and possessed prepared rectangular foundations. This hilltop site near Buccino in southern Italy was excavated by R. Ross Holloway in the late 1960s and early 1970s and was settled by a sedentary population during a period that scholars previously thought was organized around a pastoral lifestyle. Five houses were laid out on rectangular plans that had foundation trenches about 1m wide cut into hard clay (Fig. 61). These trenches were filled with a layer of yellow sand and small pebbles. Limestone socles were then set into the foundation trenches for the wattle-and-daub walls. The few remaining weathered and displaced stones measured 0.7 x 0.5 x 0.4 m. No entrances could be identified, but the buildings seemed to be organized around a

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[307] Harding 2000, 36-7; Peroni 1994, 46.

[308] Albore Livadi 2002, 941.

[309] Negrone Cattachio and Domanico 2001. 337-59.

central courtyard as suggested by the discovery of a posthole at the front of one of the houses. For the wall construction of the houses, there was no evidence of postholes to support the wattle-and-daub frame. The only evidence was some pieces of fairly thin baked daub which presumably belonged to the walls but their thinness might suggest roofing material (Fig. 62).[310]

In south-central Sicily, excavations at the early Bronze Age site of **La Muculufa** near the modern city of Licata uncovered the remains of several huts. The structures had circular or ovoid plans with stone socles (Fig. 63). The huts also displayed evidence for terracotta floors (6cm thick in some places) and prepared gravel foundations. Though the site was degraded, the excavators found enough evidence to offer a reconstruction of two huts in particular. Erosion had cut away half of hut 2's ground plan but a stone socle, bonded by a gypsum packing, outlined an ovoid ground plan approximately 8 x 5 m. An earthen bench mixed with gypsum chips hugged the remains of the wall socle, measuring 1m wide and rose 16 cm above the floor level. The edge was defined by a terracotta surface 7cm thick, spotty remains of which were mixed in with wall daub across the floor. A posthole 30 cm in diameter and 24 cm deep was found on the northern side of the hut, most likely as a setting for a timber that would have supported the roof. In the center, a ceramic base for the central timber post remained, measuring 23 cm in diameter and extending 8.5 cm into the floor. Outside of the hut's plan, the surface appeared to have been prepared with a thin layer of gypsum chips in a manner similar to that of the hut's bench.[311] The remains of the other huts were more fragmentary but included

[310] Holloway 1975, 24-33.

[311] McDonnell 1992b, 28-30.

similar architectural conventions. Over 140 daub fragments were recovered from the area of the huts and over half of them had impressions from reeds, wattles, or timbers. The excavators divided the size of the impressions into three groups: those with impressions with a diameter 1 cm or less, 1 to 10 cm, and those more than 10 cm. The largest group was the first one (1 cm or less) at 61%; the second, 30%, the last, 9%. The most numerous group, representing the impressions of small reeds and straw, displayed impressions that were both parallel and criss-crossed but excavators did not note any explicit evidence that the wattles were woven. The second group, representing impressions of larger reeds, wattles, and small poles, did not display any weaving either but did in some instances criss-cross the smaller impressions. There were also instances where two of these middle-range impressions appear together. There were only 6 impressions displaying a diameter greater than 10 cm (23 cm the largest) and these timbers must have supported the superstructure. All of the daub impressions were circular with one exception: a piece of daub displayed a right angle impression, not permitting the excavators to estimate a size but suggesting that hewn timber was also used for construction. No daub offered any evidence for the manner in which timber and reeds were connected but the impressions allowed them to sketch the variety of ways that reeds and wattles intersected (Fig. 64).[312]

The excavators speculated that the daub displaying the small impressions of reeds and straw might have been ignited on application in order to harden the daub and make it waterproof. Shaffer had a similar notion at Piana di Curinga but, upon experimentation, found it too difficult to ensure an even firing on standing walls. During Shaffer's

[312] McDonnell 1992b, 31-33.

experiment, he also noted that exposed wattles could catch fire during any attempted controlled burn of a daubed surface and thereby ignite the entire structure.[313] The excavators acknowledged that it was not possible to discern any difference between daub fired in a destruction and that fired as part of the building process. Alternately, they suggested the daubing might have taken place during the summer in order to allow the sun to bake the exposed sides and thus make it somewhat waterproof.[314] Nonetheless, the excavators offered reconstructions of two of the huts based on the stone socles and daub recovered (Fig. 65 and Fig. 66). In their view, the wattle-and-daub would have belonged to either a gently sloping roof set upon stone socles measuring at least 1meter in height, or to vertical walls and a sloping roof set upon one row of stones. Postholes found in the interior of the huts would have been for timbers supporting the roof and the walls. Connections presumably would have been lashed together. For the reconstruction of Hut 2 with a circular ground plan, one would have expected a fair amount of curvature on the preserved pieces of daub associated with that hut. The excavators, however, do not elaborate on any curvature for the daub fragments.

The daub was also analyzed petrographically. Two samples of daub were examined along with 18 ceramics fragments and found to be similar mineralogically with two exceptions. First, the daub appeared to have many more voids within its matrix, most likely due to the addition of organic material as a temper in the daub mixture. Second, the daub samples did not contain any grog (added as a temper to the ceramics to

[313] Shaffer 1983, 556.

[314] McDonnell 1992b, 32.

aid in firing).[315] Since the fabric of the daub was similar to that of the ceramics on site, the excavators suggested that its use was related to the specialized processes involved in ceramic production. As ceramicists were accustomed to elaborating and decorating the vessels they produced, it is conceivable that those working with daub might do the same in the construction of a house. Five pieces from Hut 3 had two flat surfaces and smooth, curved edges which could have belonged to architectural moldings used on an entryway, a smoke hole in the roof, a wall niche, or a ledge.[316] No daub fragments displayed any decoration, however, or elaboration in the manner seen in northern Italy.

Punta la Terrare, an early Bronze Age site in southern Italy near Brindisi, produced architectural evidence during excavations in the 1960s and 1980s. Evidence for circular and subrectangular huts was uncovered in the form of dry stone socles and floors of beaten clay during the 1960s, without any indication for their superstructure. In later campaigns, daub was recovered from a rectangular structure sunken 70 cm beneath the ground surface, measuring 2.4 x 1.7 m. The structure was originally thought to have been a kiln but the interior walls and floor did not display any evidence of intense sintering and there was no evidence for furnace or ceramic-manufacturing activities in the immediate area. In places, the exterior of the degraded daub walls was covered with a grayish mortar about 1cm thick. The interior of the structure was filled with daub fragments, some displaying impressions of timbers. Seven daub fragments along with a number of ceramics recovered from the area were subjected to archaeometric tests including X-ray diffraction, thin section analysis with polarizing light microscope, and X-

[315] McDonnell 1992a, 69-70.

[316] McDonnell 1992a, 24-27; sizes of the daub with curved sides are mentioned in note 36 but no illustrations were provided.

ray fluorescence. Mineralogical tests revealed that both fabrics were composed primarily of quartz and feldspars in a mixture dominated by silts and sands, although there were more minerals associated with clays present in the ceramic fabrics. The daub matrix was porous, reflecting the likely use of vegetal matter in preparation. Predictably, and in keeping with the excavators assumption that the structure was not a kiln, the firing temperature of the daub was significantly lower (300-400^{o}C) than that of the ceramics (600-800^{o}C). Circular imprints on the daub ranged from 1 to 8 cm in diameter, while the only flat timber imprint had a width of at least 6 cm.[317]

The site of **Coppa Nevigata** in northern Puglia was a fortified settlement that carried on long distance trade with the Mycenaean world and was occupied from the Neolithic period through the Iron Age. The Bronze Age strata produced a modest amount of daub. The impressions averaged 2-4 cm in diameter and usually ran parallel to one another (Fig. 67). Some pieces displayed impressions meeting perpendicularly but not within the same plane. Vertical and horizontal wattles were most likely secured to each other by means of ligatures.[318] The remains of the huts were incomplete but had floors of beaten earth. An early Bronze Age hut might have been elliptical or apsidal and had exterior postholes with diameters averaging about 40 cm, with two internal postholes measuring 40 and 73 cm respectively. The excavators believed large timbers supported the ridge beam of a gabled roof (Fig. 68).[319]

Excavations in northeast Calabria at **Broglio di Trebisacce** produced 138 kg of daub. Settlements on this site spanned from the Middle Bronze age to the Early Iron age

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[317] Laviano et al.1995, 461-7.

[318] Cazzella and Moscoloni 1988, 185-7.

[319] Ibid 109-13.

and were set on a series of steep plateaus overlooking a river plain. The daub could be associated with at least five different structures and provided enough evidence to allow the excavators to offer reconstructions for two of them. Fragments were analyzed petrographically using thin sections and divided into two categories: daub mixed with chopped straw and that without. These two categories were further divided into three subcategories based on the granulometry of the daub fabric: fine, medium, and coarse. The majority (75%) of the daub analyzed was made with straw but traces of chaff, olive leaves, some bone fragments, slugs and dung were also included into the daub mixture. Two-thirds of the daub fragments measured 2 -5 cm in thickness, while the other third ranged in thickness from 6 to 12 cm. Over 60% of the daub mixed with straw had one smoothed surface and, in a few cases from contexts dated to the middle Bronze Age, was finished over with a layer of very fine mortar that was either red or white in color. Chemical and mineralogical analyses of this fine finish were not conducted so it is unknown if its composition differed from the daub. The remaining daub fragments (25%) were all thin and made without straw. Two-thirds had a fine to medium fabric which must have been levigated. The clay content of this fine daub was higher than the daub made with straw, leading the excavators to suggest that vegetal tempers were added to mixtures that were clay-poor in order to improve their workability. Fragments comprised of fine-to-medium-grained daub without straw had a smoothed surface about a third of the time, but no fine mortar finish. There were also some curved fragments with a finished surface that excavators suggested might have been coverings for timbers or decorative in purpose (Fig. 69).[320]

[320] Moffa 2002, 22-34.

Only 292 fragments (12.7% of total) of daub displayed impressions from wooden members and the majority of those were circular (Fig. 70). Most of the diameters of these impressions were on the small side, concentrated between 0.4 and 1.2 cm. In a few instances, diameters were larger (5 to14 cm). The excavators suggested three different techniques of wall construction (Fig. 71): bundles of grass or straw and small reeds (D = 0.1 to 0.3 cm) attached to wooden stakes (*fascine* or *caotica*); a wattled (D = 0.4 to 1.2 cm) wall in the traditional fashion but with the majority of wattles running vertically instead of horizontally (*incannucciata*);[321] and a framework of horizontal and vertical timbers (D = 2.5 to 5cm) with spaces set 15 cm apart into which daub was placed (*telaio*). The diameters of the impressions on the daub without straw were heavily weighted to the smallest range, 0.1 to 0.3 cm. These small diameters appeared in narrow concentrations starting in the mid-to-late Bronze Age, leading the excavators to suggest that this particular type of daub – a fine fabric with high clay content free of temper - was an innovation developed to waterproof a building's roof. [322]

The two buildings for which the excavators offered reconstructions were dated to the late Bronze Age. The earlier *casa centrale* was a horseshoe-shaped building, measuring 8 x 7.5 m, whose plan was outlined by postholes spaced about 2 meters apart on the apsidal side and 4 meters apart along the straight sides (Fig. 73). Nearly 30 kg of daub was recovered but only 24 fragments displayed any timber impressions. The

[321] A potential problem with running close-set wattles vertically is the flaking off of daub from the timber framework. This can be seen at the experimental archaeological park at Populonia, where archaeologists have constructed a wattle-and-daub hut with vertical wattles. Much of the daub walling has cracked, dried, and detached from the wall (Fig. 72). Daub applied to wattles set horizontally with space inbetween them will grip the wattles as they dry and shrink, thus making the daub less likely to flake off the timber skeleton.

[322] Moffa 2002, 36-9.

excavators estimated that the daub recovered only would have amounted to 1.5% of the total used to construct the building.[323] There was no evidence for foundations besides postholes, so the *casa centrale* was reconstructed with wattle-and-daub walls seemingly without a stone socle. The daub did not display any evidence of how the wattles were connected to the horizontal and vertical timber members, but the excavators assume they would have been lashed. In the other reconstructed building dated to the late Bronze Age, daub appears to have been used differently (Fig. 74). The building was semi-subterranean and had a rectangular ground plan, measuring 6.6 x 3.3 m, and was built primarily with stones without any mortar binding. This area produced only about 5.1 kg of daub, composed of a finely-grained fabric, smoothed on one side and having a flat back on the opposite face. In their opinion, this daub could have been used to cover a roof built with flat boards or applied to the face of the stone walls.[324] Alternatively, the daub fragments with flat impressions could have been part of a wall structure similar to that envisioned by excavators at the Neolithic site of Favella.

Recent archaeometric analyses of daub and ceramics recovered from Bronze Age sites in the province of Puglia has demonstrated inter-site similarities in daub composition and preparation. At **Torre Santa Sabina**, archaeologists tested fragments of daub from two quasi-rectangular structures with beaten clay floors measuring 3 meters in width set 1.2 meters into the ground, along with ceramic samples from vessels and a kiln found on site. Petrographic analysis revealed that all samples came from a common source, a local non-calcareous clay called terra rossa. Both ceramic and daub samples

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[323] Moffa 2002, 22; the excavators estimated about 50-110kg would be required per cubic meter of wall; for this building, they assumed walls 2m in height.

[324] Ibid 41-4.

exhibited the inclusion of grog, suggesting that the raw materials used for vessels and construction were prepared together in a similar manner. Analysis by X-ray diffraction indicated that the daub was fired at a much lower temperature (300-400^{o}C) than the ceramics (700-800^{o}C).[325] Daub from a Bronze Age settlement at **Piazza Palmieri** provided similar data, as did the archaeometric analyses conducted on daub from the site of Punta Le Terrare cited above.[326] These analyses illustrate that similar practices were used in the acquisition of raw materials for daub and ceramics and their subsequent processing along the coast of the Adriatic in Puglia during the Bronze Age.[327]

3.3.2.2: Central Italy

Bronze Age architecture in central Italy has been defined by the reconstructions offered of buildings at the hilltop sites of **Sorgenti della Nova** and **Luni sul Mignone** in the region of Lazio. At the former site, a series of oval and elliptical huts, some as large as 11 x 5 m with internal supports, were identified by the remains of postholes. The excavators believed the superstructures of the buildings at Sorgenti della Nova were composed of large and small timbers only since there was no evidence for the use of daub.[328] Within the acropolis of **Luni sul Mignone**, the foundations of three structures dated to the late Bronze Age were found (Fig. 75). They consisted of stone socles without mortar. Each structure was approximately 4 meters wide but two of them, the *casa nord* and *casa sud*, had lengths measuring at least 30 and 42 meters, respectively.

[325] Acquafredda et al. 2006a, 170.

[326] Acquafredda et al. 2006b, 29-30; Laviano et al. 1995, 461-7.

[327] Acquafredda et al. 2006a, 170.

[328] Negroni Cattachio 1983, 53-55.

The only postholes found were those that might have served to hold up posts for an entrance porch. Without any evidence for daub or wooden supports, the excavators assumed that the walls were made of stone and that the roofs were composed of reeds covered with clay.[329] There were also fragmentary remains of huts on a small plain below and east of the acropolis called Tre Erici. There, huts dating to the Copper and Bronze Age appeared to have postholes describing an oval plan, and some fragments of daub dated to the Copper Age suggested a wattle-and-daub frame but were not illustrated.[330]

Another site in central Italy during the Bronze Age that included daub in a field report was **Belverde**. Two pieces of daub were illustrated along with a description of the quadrilinear ground plans of huts as outlined by cuttings into the hilltop for the reception of wall timbers. There was no mention of socle stones, but since the hilltop was a rock shelf there might have been no need to insulate the walls from the floor surface. No sizes are given for the structures of the daub, but from the photographs it can be discerned that the impressions on the daub that the wattles would have been interwoven (Fig. 76). No evidence for roofing material was recovered.[331]

3.3.2.3: NORTHERN ITALY

From the *terramare* culture of the middle Bronze Age, the site of **Pilastri** in the province of Emiglia-Romana preserved daub from houses that was subjected to

[329] Ostenberg 1967, 99-104.

[330] Ibid 42-4.

[331] Calzoni 1954, 38-9.

archaeometric examination. The fact that daub has been recovered from any *terramare* settlement is surprising given its environment. *Terramare* settlements occupied lakeshores and basins in the Po river valley from the mid-to-late Bronze Age (Fig. 77).[332] The excavators used X-ray diffraction, electron microscope, and thermogravimetric analysis to analyze the daub. The daub itself fired light brown and gray but there was no significant difference in the clay matrix among any of the samples tested. Interestingly, the daub at this site was decorated with a white patina (Fig. 78). However, these surfaces did not display the typical mineralogical spectrum associated with lime (CaO) under X-ray diffraction analysis. The excavators then suggested that the white surface was attained by mechanical abrasion perhaps aided by some kind of organic substance. This mixture, when applied to the daub surface, might have reacted with the air to form the white patina. No ethnographic comparisons were offered to support this hypothesis. It is also possible the daub was mixed from a primary clay and thus naturally presented a white patina. The heating induced during the thermogravimetric analysis resulted in a loss of weight in the specimens as water escaped the matrices of the ceramic between 100 and 750^{o}C. These results suggest the daub had been fired at a fairly low temperature.[333]

In Liguria, an excavation of two huts from **Camogli** dated to the late Bronze Age produced 607 pieces of daub. The daub varied from 2-3 to 8-9 cm in thickness and left little evidence of the architectural structure. Dry stone socles delimited the area of the huts, but there was no evidence for postholes to support a timber skeleton or a roof. The daub fragments had one finished side which in some instances was covered over with a

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[332] Marzatico 2004, 92-3.

[333] Celli 1995, 62-3.

white-greenish slip. Only 6.6% of the daub fragments displayed timber or wattle impressions on their opposite side. The excavators suggested that the fragments which did not display the impressions of wattles on one side played some other role that was not related to a hut's architecture (Fig. 79). No fragments were found in situ and they did not appear to have any relation to the hut's floor surface. They also suggested that the white-green slip was probably applied as a water-proofing mechanism that worked to protect the exterior of the hut's walls but would have worked just as well as lining for a cistern or some other domestic utensil.[334] The problem with this interpretation is that no storage cavities or pits were associated with the huts. Furthermore, it may not be reasonable to exclude daub without wattle impressions from the superstructure of a hut. In Shaffer's experimental hut destruction, for instance, not all of the wall daub recovered displayed signs of timber impressions.[335]

In the province of Cremona, the settlement of **Vidolasco** produced some peculiar pieces of terracotta that were classified as either firedogs (ceramic stands used to hold wood above a fire and allow for air circulation) or 'horns of consecration.' This proto-Villanovan site produced evidence for a group of huts, as outlined by postholes delimiting circular plans. In a burn layer in the southern part of the settlement, numerous terracotta and ceramic fragments were recovered including the above mentioned pieces.[336] Two fragments labeled 'firedogs' since the excavators thought they were part of a hearth appear to be pieces of daub with wattle impressions, but might also have been

[334] Milanese 1983, 215-8.

[335] Shaffer 1983, 96.

[336] Fusco 1969, 4-5.

architectural decoration (Fig. 80). The other two fragments measured 14 cm in height and 17 cm in thickness and were decorated on both sides with circular grooves and nodules (Fig. 81). The excavators offered a variety of theories for these pieces: firedogs, 'horns of consecration,' grooves representing the sun, or the nodules might have been nipples to indicate a female cult object.[337] The possibility that it might have been a cult object was supported, in their opinion, by the fact that funerary urns appeared to have been manufactured there.[338] The relatively small size of these fragments, though, might argue against their use as cult objects. They are reminiscent of decorations used in Neolithic Slovakia mentioned above. A particular piece from Slovakia thought to have decorated a roof displayed parallel grooving similar to that decorating the fragments from Vidolasco (Fig. 82).

3.3.3: Iron Age and Orientalizing Period

The Iron Age in Italy spanned from the end of the 10th until the late 8th c. BC. Around this time, Italian material culture entered into the Orientalizing period, which was characterized by the increased presence of eastern imports and native imitations. The Orientalizing period was followed by the Archaic period with the onset of the 6th c. BC.[339] Renato Peroni described Italy at the end of the Bronze Age as a peninsula divided into two zones which, at first, followed different trajectories but together set upon the path to urbanization during the 8th c. BC. The first zone was comprised of Etruria,

[337] Mirabella Roberti 1962, 14-5.

[338] Fusco 1959, 7.

[339] Bietti Sestieri 1992, 7.

northern Latium, Campania, the area around Bologna, and the modern province of Emilia-Romagna. These areas experienced a sharp break in settlement patterns after the Bronze Age as the inhabitants progressed towards proto-urban environments at places like Veii, Orvieto, Cerveteri, Tarquinia, and Vulci. The second zone included the remainder of the peninsula, including the greater part of northern Italy, the areas facing the Adriatic, and the peninsula south of Campania. These areas did not see any significant change in settlement type at the end of the Bronze Age, but rather experienced a gradual development towards urbanization.[340] Settlement development in Sicily appears to have traveled a similar route as that in southern Italy during the Iron Age.[341] Although Iron Age hut huts have been identified at the sites of Casalecchio di Reno[342] and in Bologna,[343] most evidence for earthen architecture during the Iron Age and Orientalizing period comes from central and southern Italy.

Settlements in central Italy during the early Iron Age started out as hut villages set upon easily defensible hills and increasingly grew in size. Remnants of Iron Age huts presumably built with wattle-and-daub have been found in south Etruria at San Giovenale,[344] Veii,[345] and Tarquinia;[346] in Latium at Rome[347] and Lavinium.[348] At

[340] Peroni 1988, 12-22.

[341] Leighton 2005, 282.

[342] Bloch 1963, 69-73, Tav. 2, provides a cross-section of a trench showing daub fragments lodged in the baulk wall but no other illustrations.

[343] Grenier 1912, 68-78, provides plans of huts dated to the Villanovan period.

[344] Pohl 1977, 14-32, found the remains of two oval huts dated to the Iron Age, one fairly large measuring approximately 5 x 8m. Daub with impressions, called 'clay revetment' by the excavators, was found in several strata associated with the huts (57, 64, 69, 73, 79). No postholes were found, though, so it is not clear how they envisioned the stone foundations interacting with the presumed wattle-and-daub walls of the huts.

Satricum in Latium, excavators apparently uncovered a 0.30 meter wide wattle-and-daub wall in situ set directly on top of the subsoil, but no photos or illustrations of the daub were provided.[349] In northern Etruria at Populonia, the development of architectural form from the Iron Age into the Orientalizing period may best be illustrated by recent excavations at the settlement found on Poggio del Telegrafo. During the 9th c. BC, a large oval building constructed of wattle-and-daub, timber posts, and presumably a thatched roof, was constructed on the hill. This structure was followed by a similarly constructed rectangular building at the end of the 8th c. BC, which was reconstructed three more times during the 7th c. BC (Fig. 83). Excavators have dubbed this building the 'House of the King' because of its large size and the deposit of kyathoi associated with

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[345] Ward-Perkins 1959, 50-65, excavated an Iron Age hut village next to the northwest gate and found postholes delineating oval and rectangular timber structures along with daub. The timber structure measured 7.5 x 11.4m. No daub was described or illustrated. Stefani 1953, 102-3, found the remains of several Iron Age huts at Portonaccio, one very large (9.3 x 5.71).

[346] Linington 1976, 453-4, found the plans of 13 huts delineated by trenches carved into the bedrock of both oval and rectangular shape. One oval plan, Fig 3, measured 16 x 7m and had two rows of postholes running down its center to support a roof. No daub was mentioned.

[347] Gjerstad 1953, 48-9; 1963, 49-50, Fig. 8, reported daub fragments and postholes in the area of the Equus Domitiani but his conclusions were based not on his own soundings but rather on the excavation records and photos of G.Boni, who had excavated there in 1904. Daub was also recovered from a oblong hut identified by postholes beneath the Domus Augustana on the Palatine, Gjerstad 1960, 63, Fig. 38:3-4, otherdaub fragments were unassociated with any hut plan (Fig. 39:12-13). None of the daub fragments illustrated provide any idea about construction techniques, though. Ammermann 1990, 627-33 and 639-9, does not accept Gjerstad's identification of prehistoric huts in the forum in general and, in particular, those identified near the Equus Domitiani. In his opinion, the fragments of daub illustrated are too small (less than 6cm across) and the 'walls' identified by Gjerstad from the photos are too thin (10cm). No full plan of any hut was recovered and, in his view, the 'walls' were actually created by Boni's workers to deal with the rising water table during excavation.

[348] Fenelli 1984, 329-31, Fig. 4 and 5; no daub was reported.

[349] Maaskant-Kliebrink 1992, 44-6, 54. Excavators recovered 1726 fragments of daub in this area. Daub was also associated with finds from other huts, 75, 78, 81-82, 85, but no quantities were given. Maaskant-Kliebrink 1991, 93-5 and Fig. 24, discussed the nature of the daub found at Satricum and suggested it had belonged to wattle-and-daub walls supported by vertical wooden posts set into a tufa socle, in a manner similar to that envisioned at San Giovenale.

it.[350] In the south, the encroachment of Greek colonists was reflected in the transformation of the indigenous architectural traditions to reflect Greek influences, beginning with the shift from circular to orthogonal plans and the adoption of mudbrick for walls at Incoronata during the Orientalizing period (Fig. 84).[351]

3.3.3.1: SOUTHERN ITALY

Evidence for an Iron Age hut village in southern Italy comes from the **Cittadella** hill at Morgantina in interior Sicily. The partial remains of several 'long houses' were uncovered dated to the late 10th - 9th c. BC (Ausonian period). A large amount of daub was recovered but only a small portion of that was retained for study. The most complete plan for a house was elliptical in shape, measuring 18.75 x 4.25 m, and divided into two rooms. The best evidence for wall construction came from another structure partially excavated (Fig. 85). There, the walls were built with a combination of timber and stone. Postholes about half a meter deep were cut into the bedrock at intervals of about 1.25 meters in order to receive vertical timbers. Stone socles up to 6 courses high in some places and about 1.5 meters in width were then set in place around the timbers. On the far stretch of the exposed wall, daub remaining in situ had been used to cover the outer surface of the stones.[352] The daub that was retained displayed impressions of larger branches or saplings 4-5 cm in diameter (Fig. 86). There were also fragments with flat or slightly curved impressions, which may have been pressed against stones with wooden

[350] Bartoloni 2009, 162-64; 2010, 14. This excavation is ongoing and only preliminary reports have been published. More clarity on the earthen architecture at this site may become available once excavation concludes and a final report is provided.

[351] Boethius 1978, 23, 29.

[352] Leighton 1993, 25-7, 37-43.

boards. Cut planks of wood were recovered during the excavation but not retained for study. [353] The excavators believed that the lower part of the walls was composed of stone but that the upper parts would have been constructed with wattle-and-daub because of the large amounts recovered. Evidence for central supports was found in three trenches, so it is possible that the huts had gabled or shed roofs covered in thatch.[354]

On the peninsula, similar techniques were used in southern Italy at Gravina, Porto Saturo, Metaponto, and Salapia, wherein stone socles were used for apsidal and elliptical huts whose walls were presumably built with wattle-and-daub.[355] A significant shift in southern Italian settlements coincided with the arrival of Greek and Phoenician colonists who used cut stone and mudbrick as building materials. Some of the earliest occurrences for the use of mudbrick are at **Incoronata** in Basilicata[356] and at **Montagnoli** and **Manuzza** in western Sicily during the 8th c. BC.[357] This development changed architectural techniques in southern Italy irrevocably and that change is best illustrated by the recent excavations at **Torre di Satriano**, a hilltop site located about 20 km outside of Potenza in Basilicata. A megaron-type building, dated to the mid-6th c. BC and set on a rectangular plan, was discovered during excavations in 2008. The building was decorated with architectural terracottas whose themes bore resemblance to Corinthian prototypes.[358] This building would be succeeded by another large building decorated

[353] Leighton 1993, 89-90.

[354] Ibid 141-2.

[355] Russo Tagliente 1992. 25-32.

[356] Lambrugo 2005, 773-777.

[357] Spatafora 1997, 153.

[358] Serio 2009, 117-26.

with architectural terracottas dubbed the 'anaktoron' by the excavators. Both of these Greek-influenced buildings were preceded by a large building of apsidal shape, measuring at least 22 x 12m (Fig. 87) dated to the end of the 7th c. BC. Fragments of daub were recovered that displayed timber impressions, ranging in length from 10 to 20 cm. Evidence for a stone socle was found in the portion of the wall that formed the apse. Based on this evidence, the excavators suggested a wall constructed in the 'reinforced pisé' method (Fig. 88). This term was introduced by J. Warner in her study of the earthen architecture at the Bronze Age Anatolian site of Karatas to define an earthen wall that does not have a weaved wattle-and-daub skeleton, but rather used centrally placed timber posts surrounded by packed earth on either side.[359] Walls such as these are common in modern-day western Africa and normally range from 20-30 cm in thickness.[360] No illustrations of the daub classified as parts of a wall were provided in either field report.

The excavators did provide illustrations of decorated daub that they believed may have been applied to the front wall of the building behind an entrance portico (Fig. 89). There was no evidence for a foundation for this front wall, though, only postholes. The decorated daub was incised with geometric meander motives, perhaps derived from pottery decoration.[361] Ceramics at the site, including some samples of daub, were examined petrographically using thin section analysis and archaeometrically using X-ray diffraction, X-ray fluorescence, and ICP-MS. The raw material used for the daub was different from that of the ceramics; it was more workable, having been mixed with small

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[359] Warner 1979, 139.

[360] Moffa 2005, 654.

[361] Carollo 2009, 19-23.

pebbles and organic material, and most likely derived from a different clay source. The firing temperature of the daub appeared to be higher than that of many ceramics. The ceramics normally were fired somewhere between 700°C and 830°C, while the daub tested revealed a firing temperature around 900°C.[362] It is possible that the daub samples tested were actually from a hearth or one of the several small ovens identified on the floor of the building, but no specific information about the samples' locations was provided.

3.3.3.2: CENTRAL ITALY

During the Iron Age at **Luni sul Mignone**, hut construction techniques became more robust. The huts included both oval and rectangular plans, floors of beaten clay, and were surrounded by embankments of rough stones. Daub fragments with impressions of timbers were recovered indicating that the huts had earthen walls which were probably reinforced by surrounding stone embankments (Fig. 90). A fairly large piece of daub (18.5 x 27 cm) recovered from the level of the rectangular Iron Age hut displayed a double-cordon decoration along its surface (Fig. 91).[363] No further description was provided of the daub fragments recovered from this area. Luni sul Mignone is best known for its monumental Iron Age building on the acropolis discussed in Chapter 2, measuring 17 x 9 m in plan and cut into the hillside at a depth ranging from 1.65 to 6 m. There were 12 strata excavated within the dugout that served as the interior of this structure (Fig. 92). Within the bottom strata, charcoal of several different species of wood were recovered along with fragments of daub with timber impressions. The

[362] Giammatteo 2009, 211-12.

[363] Ostenberg 1967, 40-44.

excavators, however, did not include this daub in their reconstruction of the building. Rather, they drew parallels to the construction techniques of thatch and stone huts at Anzio and in modern Lazio when providing a reconstruction of the superstructure. In their view, the floor surface of the building would have been raised up 3meters above the dugout surface. A beaten clay floor would have been set upon a mat of 5cm thick timbers, which would in turn be supported by vertical posts set into holes carved out of the surface of the dugout (Fig. 93). Holes had been cut into the dugout floor, but they were set at irregular intervals and their spread did not encompass the dugout's entire surface. Around the dugout, a rubble wall approximately one meter thick and high would have supported a timber A-frame covered with thatch, at a slope of 60 degrees, rising 13 meters above the dugout floor and 8.5 meters above the top of the wall (Fig. 94).[364] As mentioned previously, though, it is not clear if the builders could have acquired timbers of that size in the immediate area. Furthermore, the modern ethnographic parallels offered by the excavators for comparison have interior widths no greater than 6 meters, while the A-frame at Luni sul Mignone would have spanned approximately 11 meters.[365] Lastly, the daub found within the dugout was not incorporated into the building reconstruction. Several pieces were recovered illustrating both familiar and peculiar impressions (Fig. 95). One piece 4.7 cm thick displays parallel impressions 1-1.5 cm in width, similar to that found on daub covering a roof of straw or reeds (No. 1 in Fig. 95). Another piece 5 cm thick has circular impressions on one side 0.5-1.5 cm in width and

[364] Hellström 1975, 65-72.

[365] Hellström 1975, 71-72. There are huts in southern Lazio which measure 6 x18 m, covered by an A-frame 3m high set on top of rock walls approximately 1m wide and 1.5m high. The height of the roofs in these buildings is only about one-third of that envisioned for the structure at Luni sul Mignone.

displays a pronounced rectangular cordon along its bottom half, as if it had been impressed between two flat boards (No. 2 in Fig. 95). The largest piece, 12 cm thick, is semi-cylindrical in shape with a deep impression set into it 8-8.5 cm in depth (No. 3 in Fig. 95). No cross-sections were provided of these pieces.

The omission of the daub from the reconstruction of this monumental Iron Age building is problematic since it is part of the stratum that provides the dating for the reconstructed building. This stratum included pottery from the local Iron Age Tolfa culture and allowed the excavators to date the building to the late 8th c. BC.[366] No impressions on the daub recovered suggest they were part of the beaten-clay floor envisioned by the excavators since the diameter of the secondary beam included in their reconstruction was fairly large, measuring 5 cm.[367] Perhaps the daub was part of the roof, but at a slope of 60 degrees set 8.5 meters above the ground, the builders would have encountered great difficulty in trying to apply clay to the A-frame. It is possible that this daub was part of earlier buildings and then incorporated into the fill of the dugout before the construction of the large Iron Age enclosure.[368] Certain aspects of the morphology of the daub suggest otherwise, though. The rectangular cordon on one piece (No. 2 in Fig. 95) indicates that daub was pressed between two flat faces, perhaps wooden boards or tiles. There is no evidence, however, for woodworking at the site to suggest the builders were splitting and smoothing timber boards. The semicylindrical piece (No. 3 in Fig. 95) must have been pressed into a cylindrical cavity in order to obtain that shape; it bears

[366] Hellström 1975, 97.

[367] Ibid 68, Fig.1, 69 Table 1.

[368] Bietti Sestieri 1981,

resemblance to daub fragments at Poggio Civitate that have been identified as fillers between cover tiles and pan tiles. Fragments of roof tiles were found in the stratum immediately above (stratum 11), which was dated to the late 5th c. BC because of the presence of black-glazed and bucchero pottery.[369] In short, if these pieces of daub belonged to a roof with terracotta tiles, the dating of the Iron Age building reconstructed at Luni sul Mignone can no longer be secure.

At **Fidenae** just north of Rome, an Iron Age structure dated to the 9th c. BC used a different method to construct its earthen walls. The building was rectangular in plan, had a floor of beaten earth, and was fairly large, measuring 6.2 x 5.2 m (Fig. 96). Instead of using wattle-and-daub, the excavators there believe that the walls were constructed in the pisé method by packing earth between flat boards, as illustrated in experimental construction of a hut for the site's archaeological park (Fig. 97). The earthen wall had collapsed but significant portions had been preserved during the building's destruction (Fig. 98). Postholes adjacent to the interior of the walls (circa 25-30 cm in thickness) suggested that the walls were further reinforced by vertical timbers set at intervals of about 2 meters. Postholes were also found set off about 1m from the exterior of the walls (with the exception of the rear wall of the hut). These posts presumably would have helped support a gabled roof and provide a shallow veranda around the hut. Beyond the veranda on the south side of the hut, a small canal had been cut into the bedrock that appeared to run parallel to the wall. [370] The use of canals around hut walls was also

[369] Hellström 1975, 98.

[370] Bietti Sesteri and De Santis 2001, 212-13; Bietti Sestieri 1990 et al., 175-80.

identified during the excavations of Iron age huts on the Palatine and the Germalo.[371] The exterior of the pisé walls was then covered over with a layer of plaster and painted with decorative meander motives similar to the decorative techniques found on contemporary pottery (Fig. 99). According to the excavators, Fidenae is part of a broader architectural change in Lazio marked by the introduction of pisé construction during the first part of the Iron Age.[372] As noted above, though, evidence for earthen architecture from as early as the Neolithic period in southern Italy demonstrates that the use of earth compacted between wooden boards for construction purposes has a long history in Italy.

Excavations at the settlement of **Ficana** south of Rome uncovered the incomplete remains of 14 huts dated to the first half of the 8th c. BC. The huts were laid out on both oval and rectangular plans (Fig. 100). The entire plan of any one hut in particular could not be delineated, but the remains of postholes and daub indicated that their roofs were supported by timbers measuring 55-65 cm, on average, set into the ground. The distance between the postholes ranged between 2.1 to 4.2 meters. The earthen walls of these huts were set into 20 to 40 cm wide trenches without any evidence for stone socles. It was at first thought that the trenches were canals for water drainage but since the remains of postholes were found inside the trenches, the excavators concluded that they were indeed used for wall emplacement. The daub (330 fragments at 83.71 kg) contained roughly four different types of impressions (Fig. 101). The first (a) were those of reeds with a diameter averaging between 0.2 to 2 cm, with concentrations falling between 0.2 to 0.6 cm and 0.8 to1.2 cm (154 fragments at 36.27 kg). The second (b) were poles, assumed to run vertically, with an average thickness falling between 6 and 8 cm (57 fragments at 17.71

[371] Puglisi 1951, 36; Davico 1951, 133.

[372] Bietti Sesteri and De Santis 2001, 219.

kg). The third (c) were larger poles, also assumed to run vertically, that left impressions on the daub that did not circumscribe their entire diameter but could be estimated at 18 to 30 cm (27 fragments at 8.47 kg). The last category (d) included daub that displayed flat impressions from split timbers (92 fragments at 21.26 kg). The excavators assumed these flat impressions were from wooden boards that would have been used to construct pisé walls, in a similar manner to the construction method at Fidenae. They base this assumption on the relatively high frequency of flat impressions associated with one hut in particular (capanna D in sector 3c). Other huts would have been constructed in the wattle-and-daub technique. Some pieces of daub displayed smoothed surfaces that had been finished with a thin layer of reddish clay, most likely because they were part of an exposed surface (128 fragments at 13.16 kg). Some pieces had a thin decorative layer (2 to 3 mm) that had been burnished to a pale white (22 fragments at 3.38 kg).[373] No archaeometric tests were conducted on the daub or decorative layers.

Closer in time to Poggio Civitate was the first settlement at **Roselle**, dated to the mid-7th c. BC. In the center of the settlement, a large enclosure was marked out by clay brick walls containing a circular building of similar construction (Fig. 102). A canal and a beaten earth walkway bordered the longest stretch of the wall of the enclosure, most likely to provide for water drainage in order to protect the wall socle.[374] The wall ranged from 70 to 80 cm thick and was cut in its western part by the emplacement of a Roman-era pilaster. This cut allowed the excavators to obtain a partial cross-section of the wall, which showed clay-bricks measuring 8 cm in height and 29 cm in length, stacked one on

[373] Brandt 1996, 23-7.

[374] Laviosa 1966, 213.

top of the other and separated by a yellow layer (Fig. 103).[375] The bricks were stacked on top of one another to form the wall, similar to the arrangement of the clay bricks discovered in the old city wall of Roselle, also dated to the 7th c. BC.[376] The enclosure wall lay directly on a compacted layer of clay and incorporated a wooden frame to support a doorway, as evidenced by the carbonized remains of a beam that served as a doorpost. Since this was the only evidence for timber construction associated with clay brick walls in the enclosure, Claudia Laviosa suggested that the walls at this early period of occupation were constructed completely of clay bricks with the exception of doorways and windows.[377] It was not clear how this building was roofed. Wattle-and-daub recovered at the eastern stretch of the wall along with evidence of burning suggested a thatched-clay roof to protect the mudbrick wall.[378] A large rectangular posthole (0.94 x 0.74 m) and a line of stones set into the beaten clay surface ran parallel to the wall on the far side of the canal. It is possible that these features also played some role in roofing the mudbrick wall.[379] The eastern stretch of the mudbrick enclosure wall was cut by a rubble stone wall that was part of a rectilinear building with two rooms. This building's exterior walls were made of unworked stones but the interior dividing wall was constructed of mudbrick. The walls were preserved up to two meters in height and lay upon the bedrock, which was cut and leveled out with a layer of clay to provide an even surface.[380]

[375] Laviosa 1961, 41; tav. 5a, b.

[376] Naumann and Hiller 1959, 14, Abb. 9.

[377] Laviosa 1960, 307; Laviosa 1966, 213.

[378] Laviosa 1965, 66.

[379] Ibid 67.

[380] Laviosa 1969, 581.

In the southern room, fragments of wattle-and-daub were mixed into the fill and concentrated along the western rock wall. In the northern room, numerous fragments of roofing tiles were recovered in the center of the room and also along the western and northern rock walls.[381] The roofing tile fragments were concentrated near the walls and were few in number with regard to the size of the building, leading Laviosa to suggest that they may have been fragments from the *lorica testecea* mentioned by Vitruvius.[382] This term described the practice of encasing the highest part of a brick wall with a range of eighteen inch high terracottas with projecting cornices and antefixes for discharging the water from the roof. The clay bricks at Roselle varied in size, ranging from 7-12 cm in width, 25-32 cm in height, and 37-50 cm in length.[383]

Two mid-to-late 7th c. BC sites that record the presence of daub along with roofing tiles are Acquarossa and San Giovenale. **Acquarossa** was a short-lived settlement of the 7th-5th c. BC covering about 32 hectares, located about 6 km north of Viterbo on a strategic hilltop. Several zones (designated A through O) were excavated along the hilltop which produced the remains of at least 40 houses.[384] The curvilinear plans of several huts with presumably thatched roofs in Zone K were uncovered along with a good amount of daub, but it was not quantified or published.[385] Zones F and C produced the best evidence for habitations, most of which had rectangular foundations

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[381] Laviosa 1971, 525.

[382] Vitr. *De Arch*. 2.8; Laviosa 1966, 214.

[383] Laviosa 1966, 214.

[384] Persson 1986, 40-3.

[385] Rystedt 2000, 24.

with rectangular-cut stones measuring 0.9 to 1.1 meter in length, 0.3 to 0.6 meters in height, and 0.4 meters in width in one or two courses (Fig.104). The excavators believed that the walls were constructed of either wattle-and-daub or pisé.[386] The only daub fragments quantified came from Zone A, where excavators estimated that about 25 kg of daub was recovered from late 7th and early 6th c. BC strata. No complete structures were identified in Zone A but the socles were composed of cut stone.[387] The problem at Acquarossa for incorporating wattle-and-daub walls into the architectural scheme is the fact that the socle stones were set end-to-end with no space in between the stones to set timber uprights and no evidence that the stones were altered to accept the insertion of vertical timbers. The reconstruction for a wattle-and-daub wall offered by the excavators (Fig. 105) was based on a single anomalous structure (Casa A) in zone D which had socle stones adjacent to a series of postholes (Fig. 106). In their view, the spaces in between the postholes delimiting Casa A would have been spanned by a stone socle topped by wattle-and-daub walls (Fig. 107) hooked into timber vertical uprights. There are no postholes, though, located within or among the stone socle *in situ* at the far end of Casa A on the short side of the structure. Elsewhere, the excavators suggested that the walls might have been constructed in the pisé technique with the stone socles serving as a base for the earthen wall.[388] There was no evidence for pisé construction, however. At the sites with good evidence for pisé walls, the compacted earthen walls generally had direct contact with the ground (Fidenae, Ficana) or were set on a rubble foundation (Poggio

[386] Wendt 1986, 59.

[387] C. Wikander 1982, 26-7.

[388] Wendt 1986, 59-60. There also may be some confusion on the different terms used since the excavators point to an illustration of a fragment of daub (Fig. 39 in Wendt) with wattle impressions as evidence of the pisé technique.

Civitate Archaic Complex). While a stone socle for a pisé wall would help protect it from ground moisture, the smooth level surface provided by cut stones would have no mechanical bond with the rammed earth that rested upon it. This arrangement would severely degrade the wall's ability to resist lateral force. In any case, the lack of publication prevents assessing the amount of daub present (with the exception of Zone A) or the nature of the daub (size, thickness, impression type, etc.). Earth was certainly incorporated into construction at the site, but whether fragments were incorporated into the roof, floor, wall, or part of an oven, is not clear. A single fragmentary mudbrick was also found atop a stone socle in Zone L, Casa A,[389] but construction in this zone was dated to the mid-6th c. BC.[390]

About 30 km south of Viterbo was the settlement of **San Giovenale**. Structures were distributed between two hills (the acropolis and the Borgo) on a mountain ridge. Curvilinear Iron Age huts were uncovered on the western side of the acropolis in Area D of the excavation that were presumably constructed out of wattle-and-daub.[391] After the middle of the 7th c. BC, construction techniques at the settlement changed. Buildings were routinely constructed with rectangular cut stone and topped with terracotta roofs. Houses on the Borgo preserved cut-stone walls several courses high ranging in thickness from 0.3 meters for walls composed of a single file of stone, to 1.0 meter for walls composed with two files of stones (Fig. 108).[392] The remains of a rectangular structure

[389] Wendt 1986, 60.

[390] Winter 2009, 14, Roof 1-12.

[391] Pohl 1977, 14-32.

[392] Blome 1986, 57.

that was possibly constructed of daub have been identified on the acropolis in Area F East, which was excavated in the 1960s but only recently published by L. Karlsson. This rectangular house (House I) was dated to 675-625 BC and its strata lay beneath a structure built of ashlar masonry and roofed with terracotta tiles from the late Orientalizing/early Archaic period (625 – 550 BC). It was a large structure (12 x 5.9 m) with a portico in front, as evidenced by four postholes set 3.8 meters in front of the building's front wall (Fig. 109). The walls of the structure were made of wattle-and-daub and measured only 0.45 meters in width, yet presumably supported a gabled roof covered in thatch.[393] The assumption of a wattle-and-daub superstructure resulted from the presence of daub in the lower strata of House I and the presence of postholes cut into the bedrock shelf. These postholes were not large, ranging from 5 to 30 cm in diameter and 3 to 25 cm in depth.[394] Karlsson suggests that the walls were topped with a wooden beam in order to receive the roofing rafters (Fig. 110), as is done in traditional Scandinavian architecture. If these 'top-sill' beams running on top of all four walls were connected with interlocking joints, they potentially could resist the outward pressure from a gabled roof.[395] Several pieces of daub from House I were illustrated which display the impressions of reeds or small timbers (Fig. 111), but their sizes and diameters were not provided. Only a handful of daub fragments were recovered from House I: 38 in total and 14 in the strata associated with the earthen rectangular house. The highest number of daub fragments came from the area associated with an adjacent structure, House III. The

[393] Karlsson 2006, 142.

[394] Ibid 32.

[395] Ibid 147.

late Orientalizing/early Archaic house had a rectangular plan (15 x 6.25 m) with a central wall dividing the structure into two rooms (Fig. 112). The walls were supported on cut-stone socles. Along the eastern wall, a second course of stones was preserved atop the stone socle. Two of these stones had circular holes with diameters of 15-18 cm. Karlsson suggests that this second course of stones might have received vertical timber posts to support wattle-and-daub walls, but believes ashlar masonry would have been a more likely option because that was the construction technique used on contemporaneous structures in Area F east.[396] Nonetheless, a total of 88 daub fragments were associated with this level, many of which displayed imprints of reeds or branches but no sizes or dimensions were provided.[397] Beneath House III, short stretches of rubble walls belonging to two oval huts were uncovered that were dated to sometime during the 8th-early 7th c. BC. The highest number of daub pieces – 275 – was recovered from strata associated with these huts. Several of these pieces were decorated with relief cordons for which Karlsson could not find any comparanda but he believed that they decorated the exterior walls of the Iron Age huts (Fig. 113).[398] As noted above, however, this type of

[396] Karlsson 2006, 159.

[397] Ibid 135.

[398] Karlsson 2006, Fig. 188, 211, and 224. Linington et al. 1976, 14-18, Tav. 5, discussed ceramic finds associated with huts at Tarquinia which included fragments of cooking stands with cordoned decoration similar to that at San Giovenale. Similar decorated fragments, also identified as cooking stands, were recovered from the levels associated with the Iron Age huts of the Palatine (Gjerstad 1963, 70-1, Fig. 39:10). Holloway and Lukesh 1995, 54-5, found objects whose morphology suggested that they were cooking stands (lacking cordoned decoration) but none of the objects displayed any evidence of burning. They suggested instead that 'cooking stands' (*alari* in Italian) with no evidence of burning served some other function, perhaps as stands for bowls or dippers. None of the ceramics identified as cooking stands with cordoned decoration display evidence for burning so it is possible that they played some other role. They are usually associated with domestic ceramics assemblages but at San Giovenale, Karlsson associates similarly decorated fragments with architecture.

decoration appeared in northern Italy during the Neolithic period and again in central and southern Italy during the Iron Age.

3.3.3.3: Northern Italy

Evidence for architecture in northern Italy during the early Iron Age is lacking in general, though the settlement of Vadena/Pfatten in south Tyrol near the Austrian border provides some information. The site was located at a valley bottom and had houses with rectangular plans and stone socles without mortar; presumably the superstructures were constructed out of timber.[399] To the east, earthen architecture was found at the hilltop site in **Pozzuolo del Friuli** near the border of Slovakia. There, 236 pieces of daub were recovered from levels spanning from the late Bronze Age to the early Iron Age. Only a small number of the daub fragments retained impressions of wattles or timbers. Others displayed impressions from smooth stones that likely were part of a pavement. No complete structure was identified during excavation, but it was surmised that the daub with impressions either belonged to a structure or the pavement of an open-air workspace. This latter assumption was based on finds at the site including two fragments of daub that contained residues of bronze, suggesting they might have belonged to a working surface or a furnace. No tests were performed to determine the firing temperature of the daub. The imprints of wattles were generally small and circular, displaying a diameter between 1 and 2 cm. Some pieces showed flat impressions at least 6.6 cm in width. The thickness of the daub pieces ranged from 0.8 to 6.8 cm. They were composed of a granular silty-clay that included grog.[400] Architectural evidence from the

[399] Dal Ri 1992, 490-2.

[400] Tasca 1998a, 247-8.

Iron Age in the valleys of the Po plain is scant. After the collapse of the terramare settlements during the late Bronze Age, the valleys of the Po Plain appear to have been abandoned.[401]

3.4: The Genealogy of earthen architecture in Italy

The construction of a ‘genealogy’ of earthen architecture in Italy is hampered by its exclusion from most pre- and proto-historic excavation reports, which usually focus only on building plans in an architectural discussion. However, enough evidence is provided by the sites mentioned above in the form of illustrations and/or in-depth descriptions to at least sketch out the prevailing methods of construction in different areas of Italy from the Neolithic up through the Orientalizing period. The different methods of wall construction employed at the sites mentioned in this chapter are displayed in Table 1. The use of wattle-and-daub can be seen throughout Italy during every time period but most evidence comes from southern and central Italy. Central Italian sites present more evidence for earthen architecture beginning in the Iron Age but the majority of evidence for prehistoric structures comes from southern Italy, at least during the prehistoric period.

Table 1: Earthen Architecture in pre- and proto-historic Italy

Italy	**Southern**		**Central**		**Northern**	
Neolithic	Pulo di Molfetta	═/│█│	Tor Vergata	‡‡‡‡	Rocca di Rivoli	‡‡‡‡
	Francavilla Fontana	‡‡‡‡	Pienza	‡‡‡‡	Isera - La Torretta	‡‡‡‡
	Trasano	‡‡‡‡			Palu di Livenza	‡‡‡‡
	Ripa Tetta	═/│█│				
	Tirlecchia	═				
	Murgia Timone	‡‡/│█│				

[401] De Marinis 2009, 537.

Italy	Southern		Central		Northern	
	Le Grottelline	‡‡⁄|█|				
	Piana di Curinga	‡‡‡‡				
	Balsignano	‡‡‡‡				
	Torre Sabea	‡‡‡‡				
	Favella	‡‡⁄|█|				
Bronze Age	Tufariello	═	Luni sul Mignone	‡‡‡‡	Pilastri	‡‡‡‡
	La Muculufa	‡‡‡‡	Belverde	‡‡‡‡	Camogli	‡‡‡‡
	Punta la Terrare	‡‡‡‡			Vidolasco	‡‡‡‡
	Coppa Nevigata	‡‡‡‡				
	Broglio di Trebisacce	‡‡⁄|█|				
10th – 7th c.BC	Cittadella	‡‡‡‡	Luni sul Mignone	‡‡‡‡	Pozzuolo del Friuli	‡‡‡‡
	Incoronata	▤	Populonia	‡‡‡‡		
	Montagnoli	▤	Fidenae	|█|		
	Torre di Satriano	|█|	Ficana	‡‡⁄|█|		
			Acquarossa	‡‡‡‡		
			San Giovenale	‡‡‡‡		
			Roselle	‡‡ / ▤		

Legend:			
Pisé/Rammed earth	|█|	Wattle & daub (Perpendicular)	‡‡‡‡
Mudbrick	▤	Wattle & daub (Parallel only)	═

There could be several reasons for the predominance of southern Italy in the archaeological record of earthen architecture. It simply may be the result of a more aggressive program of excavation and publication of prehistoric archaeological sites in the area. Alternately, the increased use of mudbrick and stone in southern Italy following Greek colonization could account for the drop-off in earthen architecture in southern Italy beginning in the Iron Age. Mudbrick is less likely to be retained in the archaeological record than daub because of its thickness. Thin pieces of daub can be thoroughly fired in a house destruction and the impressions of timbers left on them might spur archaeologists to retain them for study. The entire profile of an individual mudbrick is less likely to survive an accidental fire. If only a portion of a mudbrick were fired in a house destruction, it would present itself archaeologically as a non-descript fragment of ceramic and attract little attention.

Referring to Table 1 above, the two most conspicuous trends in the development of earthen architecture in pre- and proto-historic Italy are the spread of evidence for the pisé technique and the appearance of mudbrick. The pisé technique first appeared in southern Italy during the Neolithic period and continued in use through to the Orientalizing period. Beginning in the Iron Age, this technique was used in central Italy at Fidenae and Ficana in Latium and ultimately appeared in northern Etruria in the Archaic Complex at Poggio Civitate (Fig. 7). The early appearance of the pisé technique in southern Italy can perhaps be attributed to environmental factors. In Osvaldo Baldacci's survey of earthen construction in early 20th c. AD Italy, he observed that earthen houses – in his definition, those constructed of mudbrick or in the pisé technique - only persisted in areas which had less than 600 mm (semi-arid) of rain annually.[402] The amount of rainfall in an area would have significant implications for an earthen house because the structure depends on the integrity of the earthen material to support the roof. Rainfall would not be as much of a concern for wattle-and-daub structures since the building's superstructure relies upon interior timber supports. Looking at Table 2, which records the annual rainfall in a variety of Italian and Sicilian cities over two decades

[402] Baldacci 1958, 31.

during the middle of the 20^{th} c. AD, it can be observed that those cities sitting at lower latitudes generally had less rainfall.

Table 2: Annual Rainfall in select Italian Cities[403]

	Latitude	Longitude	Elevation (m)	Annual rainfall (mm)
Ustica	38° 42’	13° 10’	259	375
Pantelleria	36° 49’	11° 57’	254	415
Cagliari	39° 12’	9° 05’	7	451
Foggia	41° 28’	15° 33’	74	465
Taranto	40° 28’	17° 14’	15	469
Palermo	38° 06’	13° 19’	31	512
Trapani	38° 01’	12° 30’	15	516
Bari	41° 07’	16° 52’	12	609
Crotone	39° 05’	17° 08’	6	633
Brindisi	40° 38’	17° 56’	28	644
Ponza	40° 51’	12° 57’	185	659
Verona	45° 26’	10° 59’	60	726
Roma	41° 54’	12° 29’	17	744
Venizia	45° 27’	12° 19’	1	770
Pescara	42° 48’	14° 13’	10	772
Catania	37° 30’	15° 06’	45	786
Siena	43° 41’	11° 20’	348	790
Potenza	40° 38’	15° 46’	823	799
Bologna	44° 30’	11° 21’	60	804
Firenze	43° 46’	11° 15’	51	825
Torino	45° 04’	7° 40’	238	845
L'Aquila	42° 21’	13° 24’	735	875
Perugia	43° 07’	12° 21’	493	893
Napoli	40° 53’	14° 17’	110	915
Pisa	43° 42’	10° 24’	6	960
Milano	45° 28’	9° 11’	121	1017
Genova	44° 25’	8° 55’	21	1270

The cities of the province which produced the most earthen architecture and the earliest evidence for the pisé technique – Puglia – had relatively low annual rainfalls: Foggia (465 mm), Taranto (469 mm), Bari (609 mm), and Brindisi (644 mm). The major cities

[403] Adapted from Meteorological Office of Great Britian 1972, Part 3, 71-87.

of northern Italy, Turin (867 mm), Milan (1017 mm), and Genova (1270 mm), all had annual rainfall totals well in excess of 600 mm, while cities in central Italy generally averaged somewhere around 750 to 800 mm of rainfall annually.

Architectural tradition was different in northern and central Italy, with a heavier reliance on timber and by extension, wattle-and-daub. Archaeological evidence from Bronze Age contexts in northern and central Italy provides direct evidence for the primacy of timber as a building material. Wooden buildings comprised the early Bronze Age settlement buried by eruption of Mount Vesuvius in Campania, Nola-Croce della Papa (Fig. 114). The early and middle Bronze Age *palafitte* and *terramare* cultures were distinguished by the skilled wood-working techniques used to construct their piled dwellings (Fig. 115). The most significant late Bronze Age settlement of central Italy, Sorgenti della Nova, was populated by buildings thought to have been constructed wholly out of timber (Fig. 116). In the early Iron Age, the wooden throne of Verucchio, located in the region of Emilia-Romagna, depicted individuals building a large structure with a gabled roof, most likely constructed of wood (Fig. 117). The reliance on timber construction in northern and central Italy may also be attributed to environmental factors. Today, the best forests in Italy are located in the north on the foothills of the Alps.[404] Italian government estimates of forest area during the late 19th c. AD indicated that the northern and central provinces of Italy generally had greater timber capacity and devoted more land area to its cultivation.[405] American officials noted the discrepancies between north and south Italy in timber construction when assessing Italy's lumber requirements

[404] Kuusela 1994, 68.

[405] Brown 1919, 65.

after World War I. The hot, dry summers in the south compelled residents to build thick walls constructed of stone, concrete or brick, and to use ceramic tiles for their floors in order to maintain cooler temperatures indoors. In contrast, northern houses usually had wooden flooring because the use of brick, stone, or ceramic tiles as a floor covering would be too cold on the feet during the cold and damp winters.[406] The vast demand for timber in northern Italy was represented by the import quantities received at major ports in Italy, with Genova accounting for almost half of all imported forestry products in Italy in 1914. Milan, Turin, and Genova were estimated to be the three top consumers of lumber in Italy.[407]

Despite the wide availability of substitute materials like concrete and brick, builders in northern Italy during the late 19th and early 20th c. AD still relied on timber for construction purposes because of the climate. Builders in southern Italy required timber for concrete forms, roof framing, shutters and the like, but their needs were significantly less. These statistics cannot be grafted onto ancient Italy wholesale but do provide some perspective about the nature of the Italian landscape before widespread industrialization. In sum, the survey of earthen architecture in Italy suggests a rough division between the north and south, with northern Italy using earth as daub to fill out structures that were primarily built out of timber, while southern Italians sought to economize on their use of timber by developing the pisé technique. Thus, when the pisé technique began to make its appearance in central Italy during the early Iron Age, it perhaps should be regarded as

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[406] Brown 1919, 11.

[407] Brown1919, 62. Several ancient authors, in particular Strabo, wrote about the abundant timber reserves around Rome, in Etruria and Umbria, and also in Liguria. See Meiggs 1992, 243-8.

an intrusion.   If this assessment is correct, it would have implications for the transition between the Orientalizing and Archaic complexes at Poggio Civitate.

Another trend that emerges from the survey of earthen architecture in Italy is the decoration applied to earthen architecture. In northern Italy during the Neolithic period, incisions into daub were used to decorate the exterior faces of buildings at Rocca di Rivola (Fig. 55) and Isera –La Torretta (Fig.59). Excavators looked to Bronze Age central Europe to find comparanda because of the geographical proximity of northern Italy to the region. Further west, though, similar methods of architectural decoration can be found in southern Spain. The late Bronze Age site of Cerro de la Encina in Granada produced many fragments of incised daub used to decorate the walls of buildings (Fig. 118).[408] Anne Chazelles-Gazzal cited the elaborated decoration of earthen walls by native Iberians in Spain as the discriminator between indigenous and Phoenician settlements, since both cultures used mudbricks and lime plaster to construct houses by the 8th c. BC. [409] The proto-Villanovan site of Vidolasco produced the incised terracotta fragment that could have been used as architectural decoration (Fig. 80 and Fig. 81) and decorative daub fragments appeared in Iron Age southern and central Italy at Torre di Satriano (Fig. 89), Luni sul Mignone (Fig. 91), and San Giovenale (Fig.113).   It is difficult, though, to draw direct correlations between different sites from pre- and proto-historic periods in Slovakia, Italy, and Spain. However, it is a trend that appears to manifest itself at indigenous sites throughout temperate Europe in cultures that primarily

[408] Arribas Palau et al. 1974, 38-40.

[409] Chazelles-Gazzal 1995, 55-56.

exploited timber and earth for architectural purposes.[410] To my knowledge, no comparable tradition in Greece or the eastern Mediterranean has been established. Therefore, where this decorative technique appears in Italy, first at Neolithic and Bronze Age sites in northern Italy and later at Iron Age sites in central Italy, it perhaps can be understood as a decorative technique developed in temperate Europe that was suited to the level of architectural technology.

A likely foreign influence can be seen with the introduction of mudbrick into central and southern Italy during the Orientalizing period. Mudbricks were commonly used in construction as early as the Neolithic period in Palestine, Anatolia, Egypt, and Mesopotamia.[411] Mudbrick was also used in Greece as far back as the Neolithic period but generally confined to southern and central areas of the Greek world. The use of mudbrick did not spread up into Macedonia and Thrace until the middle Bronze Age. The prehistorian Rene Treuil attributes the resistance of northern Greek areas to mudbrick to a clash between two architectural traditions, the mudbrick of the Near East and the wattle-and-daub of Europe (Fig. 119).[412] A similar 'resistance' can be envisioned during the Orientalizing period in Italy, although the active colonization of the western Mediterranean by both Greeks and Phoenicians results in a more complicated picture.

Phoenician colonists were active in Spain, Sardinia, eastern Sicily, and North Africa while Greek colonists settled Sicily and southern Italy. During the 8th c. BC,

[410] Decorative daub also appears at the 5th c. BC Golaseccan site of Brecciago near Como in northern Italy, Merlo and Fregerio, 1986, 56, 58.

[411] Van Beek 2008, 8-10.

[412] Treuil 1983, 268-74.

buildings at Phoenician colonies located along the southern coast of Spain such as Morro de Mezquitilla, Cerro del Villar, and Toscanos used mudbrick to build house walls.[413] Structures of the first Phoenician settlement of the 8th c. BC at Morro Mezquitilla had mudbrick walls covered with a pale-yellowish plaster made with lime that was painted red or yellow-green. The second Phoenician settlement still used walls of mudbrick but the construction techniques were different in that the mudbricks were placed on stone socles set in foundation trenches. In the opinion of the excavators, this shift in construction practice represented a consolidation of the Phoenician colony following an initial period marked by makeshift construction.[414] Enrico Dies Cusi cites the presence of rectangular plans with walls made of molded mudbrick covered with lime plaster as an archaeological indicator of Phoenician influence in Iron Age Iberia.[415] The Iberian peninsula, though, appears to have had its own tradition of mudbrick as evidenced by its incorporation into walls at sites during the late Bronze Age and early Iron Age before colonial contact, such as Cerro del Real in Granada and Vinarragel near Valencia (Fig. 120). The difference between indigenous and Phoenician construction, in the opinion of Chazelles-Gazzal, was not the use of mudbrick but rather the technique of placing mudbrick on top of a stone socle instead of directly upon the ground. This change was introduced by the Phoenicians.[416]

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[413] Dies Cusi 1995, 215-221, 228-32.

[414] Schubart 1985, 148-50.

[415] Dies Cusi 2001, 92-3. Mudbricks at Morro de Mezquitilla measured 52x36x12, those at Toscanos 40x20, the thickness was not known but guessed to be 12 cm.

[416] Chazelles-Gazzal 1995, 52-3.

Tracking the use of mudbrick in areas colonized by the Greeks is more muddled. The use of mudbrick in southern Italy is thought to have coincided with the arrival of Greek colonists during the 8th c. BC, but the archaeological record is equivocal. As noted on Table 1, the earliest building believed to have incorporated mudbrick into its structure was at Incoronata and Montagnoli. At the former site, the excavators believed the 8th c. BC oikos of the Saggio E was constructed with mudbrick, but the oikos only produced terracotta fragments that the excavators assumed were the remains of a mudbrick wall.[417] In Sicily, F. Spatafora cites the 8th c. BC circular hut at Montagnoli as evidence of the combination of indigenous and colonial architectural techniques because it was presumably built with mudbricks atop a circular plan.[418] In the field report, though, G. Castellana suggested only that mudbricks might have been used for the building's superstructure because decomposed clay was found above the stone socle.[419] Another possibility is that the superstructure was constructed of stones that were subsequently robbed and the clay present on top of the stone socle was simply used to fill spaces within the stonework, or the clay might have been post-depositional after the building's destruction. In any case, rectangular mudbricks atop a circular plan would be unusual. The earliest structure that actually produced indisputable archaeological evidence was the house of Saggio N at Incoronata, excavated by P. Orlandini, who recovered a number of mudbrick fragments from a destruction level dated to 640/630 BC (Fig. 121).[420] In her survey of the architecture of Apulia and Lucania from the 8th to the 5th c. BC, A. Russo-

[417] Lambrugo 2003, 30.

[418] Spatafora 1997, 153.

[419] Castellana 1988-89, 328.

[420] Orlandini 1986, 33.

Tagliente detected the presence of mudbrick beginning only in the 6th c. BC.[421] Likewise, in A. Liseno's recent survey of southern Italian architecture of the Orientalizing and Archaic period, the only other site besides Incoronata that used mudbrick before the 6th c. BC, Crispino-L'Amastuola in Messapia, [422] actually did not produce any evidence for mudbrick. The excavators assumed its presence above a stone socle.[423] Thus, while Spain displays clear archaeological evidence for the use of mudbrick and plaster via Phoenician colonization as early as the 8th c. BC, the appearance of mudbrick in southern Italy can only be attested beginning in the mid-to-late 7th c. BC.

In between Spain and southern Italy sits Etruria, which was never colonized but did begin incorporating mudbrick into construction at least during the mid-7th c. BC at Roselle. The early use of mudbrick by the Etruscans has long been a matter of discussion by scholars. In 1894, G. Sordini argued that the 6th c. BC stone socles at Marzabotto and Poggio Castiglione near Massa Maritima were topped by mudbrick. He did not recover mudbricks, though, only a layer of red earth above stone socles. Sordini believed this red earth was the remnant of deteriorated mudbricks. He also cited the Etruscan predilection of leveling the ground when constructing walls, which he believed suggested the use of mudbrick since the integrity of a rough stone wall would not depend on a uniform contact surface.[424] Disintegrated red earth similar to that found at Marzabotto and Poggio Castiglione was also found at Vetulonia, along with mudbricks measuring 0.45 x 0.3

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[421] Russo-Tagliente 1992, 86 and n.96.

[422] Liseno 2008, 116, Table 20.

[423] Maruggi 1996, 207.

[424] Sordini 1894, 114-15.

x.011 m. The date of the mudbrick wall from Vetulonia, though, is not clear.[425] The mudbricks from Vetulonia resembled those recovered from the 3rd c. BC mudbrick wall at Arezzo in that the excavators described them as 'semi-baked.'[426] Since Etruscans were familiar with firing ceramics, there is no reason why firing mudbricks to make them water-resistant would not have occurred to them. Unfortunately, it is impossible to know whether those mudbricks were fired as part of the production process or afterwards during a building destruction.

Although Etruria was not colonized, the shape of the bricks recovered from Etruria suggests its use was inspired by eastern prototypes. The earliest bricks in Italy appear to be mold-made and unlike Spain, there is no evidence of a Bronze Age tradition of mudbrick on the Italian peninsula or Sicily. In the Near East and Egypt, there had been almost 2000 years of hand-formed brick-making before molded mudbricks became common during the third millennium BC.[427] Vitruvius distinguished between the rectangular 'Lydian' mudbrick used by the Etruscans and the square mudbrick of the Greeks. Vitruvius was writing about the Greek mudbrick that he was familiar with during the 1st c. BC. Mudbricks in Greece, though, did not have a consistent shape and size throughout time and space in the ancient world. In their excavation report from Smyrna, Cook and Nichols wrote about the development of the Greek mudbrick from the Bronze Age through to the Classical era. After the 5th and 4th centuries BC, Greek

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[425] Falchi 1895, 280-1; bucchero was found along with the mudbrick, but so were several coins. Falchi's report was just a day-by-day account of his excavation so it is hard to establish any secure dates for individual finds.

[426] Pernier 1920, 176-79, 186-88; Pernier also points out that Vitruvius (*De Arch.* 2.8) had mentioned the mudbrick wall at Arezzo.

[427] Van Beek 2008, 9-10.

mudbricks did take on a square shape as Vitruvius noted, but at least from the Middle Helladic period onwards they had adhered to the rectangular shape commonly used in western Anatolia and Egypt. Early Greek mudbricks could be distinguished from the square variety commonly used in Mesopotamia and Persia during the Bronze and Iron Age.[428] Thus, the rectangular brick that appeared in Etruria during the 7th c. BC most likely was the result of eastern influence, but it cannot be definitively stated whether contacts from the Levant, Anatolia, or Greece inspired the adoption of this technology. The lack of definitive archaeological evidence for mudbricks in southern Italy before the late 7th c. BC suggests that the technology did not spread north into Etruria from Magna Graeca. Chazelles-Gazzal includes Etruria as an early adopter of mudbrick along with Spain and North Africa[429] during the 8th c. BC (Fig. 122), but she used a fragmentary 'mudbrick' recovered from a 1920 excavation at Veii conducted by E. Stefani as evidence of the precocious use of mudbrick in Italy. Stefani had initially reported he had found an 8th/7th c. BC mudbrick during his excavations in 1920, but then he amended his conclusion in the final report he published in 1922. On the contrary, he believed the ceramic fragments he recovered from the middle of the 8th/7th c. BC habitation at Veii were actually part of a firedog and had no relation to the building's superstructure.[430]

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[428] Cook and Nicholls 1998, 101-5; they also include various sizes recorded for mudbricks recovered from excavations in the East. For mudbrick recovered from the western Mediterranean archaeological contexts, seed Chazelles-Gazal 1997, Fig. 52 (France), Fig. 53 (Iberia), Fig. 55 (Etruria), Fig.56 (North Africa). No clear pattern emerges outside of the preference for the rectangular form throughout the western Mediterreanean.

[429] Chazelles-Gazzal 1995, 50-1; Fantar 1984, 285.

[430] Stefani 1922, 383. Pernier 1920, 189, n.1, had cited Stefani's find of an 8th-7th c. BC mudbrick based on personal communication before Stefani published his findings. Blake 1956, 270, n.30, then cited Pernier's 1920 report about the 8th c. BC mudbrick from Veii and in the process, Stefani's ultimate conclusion about the 'mudbrick' being a firedog somehow got lost.

Since the earliest mudbricks in Etruria appear to have been placed directly on the ground without a stone socle, Chazelles-Gazzal suggested that there could have been an indigenous tradition similar to that found on the Iberian peninsula [431] As noted above, a similar technique was common at late Bronze/early Iron Age sites in Spain before the arrival of the Phoenicians. Builders in Spain, though, were probably not greatly concerned with protecting mudbrick from the damp ground due to its low annual rainfall. Only Barcelona approaches an annual rainfall near 600 mm (596 mm), while southern and inland cities like Granada (416 mm), Alicante (312 mm), and Madrid (419 mm) are all semi-arid environments. [432] Cities in Etruria, however, all experience annual rainfalls in excess of 600 mm (see Table 2). Thus, builders in Etruria would most likely hesitate before placing mudbrick directly on the ground for fear that water intrusion would compromise the integrity of the wall it was incorporated into. In short, the use of mudbrick in walls at Poggio Civitate and Roselle is suggestive of the intrusion of eastern construction techniques, but it is surprising that the Etruscans did not take greater care in protecting the mudbricks from groundwater. As an adopted technology, the Etruscans might not have had first-hand experience with mudbrick construction.

The above survey and the table of construction methods subdivided chronologically and regionally give some idea of the construction techniques used for earthen architecture throughout Italy. Obviously, this survey is not comprehensive and future excavations that incorporate earthen architectural remains into field reports will contribute to a better understanding of regional differences and developments.

[431] Chazelles-Gazzal 1995, 57.

[432] Meteorological Office of Great Britain, 1972, Part 3, 119-30.

Nonetheless, it has been demonstrated that the evidence at Poggio Civitate stands at the end of a long tradition of earthen architecture in Italy. Chapter 4 will analyze and examine the material from Poggio Civitate and conclusions based on those analyses and this survey will be offered in Chapter 5.

CHAPTER 4:
RESULTS OF ARCHAEOMETRIC AND MORPHOLOGICAL ANALYSES

4.1 THERMOGRAVIMETRIC ANALYSIS

A key step in analyzing earthen architecture is the estimation of an artifact's firing temperature. Fragments that have exterior decoration can generally be ruled out as parts of an oven, kiln, or firedog, but those without decoration can come from any of those contexts. In order to assess firing temperatures and to classify the plaster used to decorate the earthen buildings as non-hydraulic or hydraulic, I conducted tests on 4 daub fragments, 3 plaster[433] fragments, 1 brick fragment, and 4 ceramic fragments (3 tile and 1 buccheroid sherd) from Poggio Civitate using a TA Instruments Q50 V20.10 Build 36 Model Thermogravimetric Analyzer. The TGA experiment was controlled by computer, with readings and results transmitted to and analyzed with the software package TA Universal Analysis 2000. The samples (~ 200-300 mg) were placed into a platinum pan suspended from an analytical balance. The balance sent the weight signal to the computer along with the sample temperature and the elapsed time while the TGA was programmed to heat the furnace to 1000°C at a rate of 10°C/min under nitrogen

[433] Plaster and mortar are essentially the same substances; the different nomenclature reflects different uses. Plaster is used to decorate or protect the surface of a wall while mortar is used to bind together wall components, see Blake 1959, 319.

atmosphere. In order to provide more clarity to the mineralogical processes occurring during the experiment, the effluent stream from the TGA was measured by a Vernier CO_2 sensor. The sensor measured gaseous carbon dioxide levels in the range of 0 to 10,000 ppm by recording the amount of infrared radiation absorbed by carbon dioxide molecules when taken into the sensor. The data was sent directly to the computer and analyzed using LoggerPro software. The recording of carbon dioxide emissions during the heating of samples helps to refine the estimate of firing temperature for the ceramics. As mentioned in Chapter 2, calcium carbonate ($CaCO_3$) begins to decompose into calcium oxide (CaO) and carbon dioxide around 750 to 880^{o}C.[434] If the Vernier CO2 sensor detected a significant uptick in carbon dioxide emission in this temperature range during the reheating of the ceramic, it would indicate that the ceramic had not reached that temperature in its original firing.

For select samples, the data will be presented in graphical form. The graphs display 'Percent weight-loss' on the y-axis against 'Temperature' on the x-axis. Since the TGA curve often shows a gradual slope, it is common practice to include the derivative of the thermogravimetric curve (DTG curve) on the graph since it can be more illustrative of the points in which the sample loses the most weight.[435] This curve measures the change in mass as a function of the change in temperature and is plotted on the second y-axis. Also, the weight losses for each sample will be presented in tabular form for different phases of heating. For the daub, mudbricks, and ceramics, the three phases of weight loss during heating which are most diagnostic with regard to firing

[434] Malainey 2002, 269; Papadopolou et al. 2006, 44.

[435] Heal 2002, 12.

temperature will be presented: 0-200^oC, 200-600^oC, and 600-1000^oC. For the plaster samples, the four phases of heating that provide metrics for the presence of chemically adhered water will be provided: 0-120^oC, 120-200^oC, 200-600^oC, and 600-1000^oC. These data should illustrate if there was a difference in firing temperature between the ceramics and daub at Poggio Civitate and whether the plaster applied to the buildings was hydraulic or non-hydraulic.

Results of thermogravimetric analysis on daub and mudbrick samples presented a contrast with the fired ceramics from Poggio Civitate. As can be seen in the graphs provided, the daub from OC1 experienced its greatest weight loss a little after the temperature rose to 600^oC (Fig. 123). The increase in weight loss was due to decarbonation, as is confirmed by the CO_2 emissions from the TGA circa 800^oC (Fig. 124). The tile sample recovered from the same building lost weight initially before 200^oC (Fig. 125), probably from adsorbed (evaporable) water, but then maintained a fairly stable weight until 1000^oC. The amount of CO2 emissions for the tile was negligible (Fig. 126), indicating that its original firing had surpassed 800^oC and decarbonation had been fully realized.

As can be seen in Table 3, the average total weight loss for daub and mudbrick samples (21.1%) was nearly three times as much as that for fired ceramics (7.1%). In particular, the fired ceramics lost proportionally less weight (average of 0.7%) when heated above 600^oC as compared to the daub and mudbrick, which lost the most weight (11.7%) at that temperature range. In short, the thermogravimetric analysis of earthen architectural components demonstrates that their firing temperatures were below 600^oC

and comparable to the firing temperatures estimated for architectural daub from other sites.

Table 3: TG–DTG weight losses of daub, mudbrick, and ceramics as a function of the temperature range (wt.%)

Sample	0-200^{o} C	200-600^{o} C	600-1000^{o} C CO^{2}	Total Weight Loss
Brick (OC2)	4.1%	2.6%	12.5%	19.1%
Daub (North Bldg)	4.7%	2.9%	5.5%	13.0%
Daub (OC1)	3.9%	3.3%	23.2%	30.4%
Daub (OC2)	11.9%	5.8%	10.4%	28.0%
Daub (OC2)	4.5%	3.2%	7.0%	14.7%
Average ± Std Deviation	5.8% ± 3.4	3.6 % ± 1.3	11.7% ± 7.0	21.1% ± 7.8
Tile (OC1)	6.9%	3.3%	1.0%	11.2%
Tile (OC1)	0.4%	0.5%	0.2%	1.0%
Tile (OC2)	5.6%	3.4%	0.9%	9.9%
Ceramic (OC1)	2.5%	3.1%	0.6%	6.1%
Average ± Std Deviation	3.8% ± 3.0	2.6% ± 1.4	0.7% ± 0.4	7.1% ± 4.6

The TGA results from the samples of plaster are similar to that of the daub (Fig. 127 and Fig. 128). The plaster, however, loses a good deal more weight due to decarbonation because of its composition, which is primarily lime. As can be seen in Table 4, each sample of plaster loses about a third of its weight in total. The weight loss for the plaster samples is broken down more discretely according to temperature than those for daub and ceramics in order to assess the hydraulicity of each sample.

Table 4: TG–DTG weight losses of plaster as a function of temperature range (wt.%)

Sample	30-120^o C Adsorbed H_2O	120-200^o C Hydrated Salts	200-600^o C Hydraulic H_2O	600-1000^o C CO_2	CO_2/Hydraulic H_2O ratio
Plaster (North Bldg)	4.7%	1.0%	4.3%	25.8%	5.98
Plaster (OC2)	2.7%	1.3%	2.3%	30.1%	12.95
Plaster (OC2)	2.5%	2.2%	2.6%	28.3%	10.70
Average ± Std Deviation	3.3% ± 1.2	1.5% ± 0.6	3.1% ± 1.1	28.0% ± 2.2	9.0 ± 3.5

As a measure of the significance of the CO_2/Hydraulic H_2O ratio, it is worth referencing the TGA experiments carried out on Roman-era mortars and limestone. Silva et al. ran TGA tests on a fragment of limestone along with two 2nd c. AD mortars, one taken from the Colosseum and another from a cistern located 30 km north of Rome in Albano Laziale. The limestone fragment had a CO_2/Hydraulic H_2O ratio of 78.2; the mortar from the Colosseum, 2.11; the plaster from the cistern, 0.29.[436] Table 5 below shows previous TGA results from non-hydraulic mortars composed of lime and hydraulic mortars mixed with artificial or natural pozzolans. Physically bound water is that water lost upon heating until 120^{o}C, structurally bound water from 200 – 600^{o}C, and CO_2 after 600^{o}C.

[436] Silva et al. 2005, 39-40.

Table 5: Chemical Characteristics of mortars/plasters[437]

Table 1
Chemical characteristics of historic mortars as deriving from thermogravimetric analysis

Mortar type	Physically bound water (%)	Structurally bound water (%)	CO_2%	CO_2/structurally bound water
Lime mortars	<1	<3	>32	10[a], 7.5–10[b]
Lime mortars with unaltered portlandite	>1	4–12	18–34	1.5–9
Hydraulic lime Mortars	>1	3.5–6.5	24–34	4.5–9.5
Natural pozzolanic mortars	4.5–5	5–14	12–20	<3
Artificial pozzolanic mortars	1–4	3.5–8.5	22–29, 10–19[c]	3–6

[a] Aggregates of calcareous nature.
[b] Aggregates of silicoaluminate nature.
[c] Byzantine "concrete".

Comparison of the results from Tables 4 and 5 demonstrate that the mortar samples from Poggio Civitate had hydraulic properties. It is possible that their hydraulicity was imparted from the use of a limestone with a high amount of silica and alumina impurities ('hydraulic lime mortar' type in Table 5), but limestones of this type are not common.[438] Alternatively, the addition of an artificial pozzolan in the form of crushed or powdered ceramics could have played some role in light of the standard deviations involved. This result is significant because most ancient mortars fall into the non-hydraulic category (typical lime) when tested using TGA.[439] Tests to obtain greater clarity in the components of a hydraulic plaster/mortar have been conducted by the researchers at the University of Palermo. There, hydraulic plaster/mortars formed using Portland cement, natural hydraulic lime, crushed brick, and volcanic pozzolans were subjected to TGA tests in order to determine if the mixtures behaved differently during

[437] Moropolou et al.2005, 297. Natural and artificial pozzolanic plaster/mortars are hydraulic; the presence of unaltered portlandite (the mineral form of lime) indicates that a non-hydraulic mortar did not fully carbonize, i.e. for some reason CO_2 from the atmosphere did not penetrate the matrix of the mortar, which can occur in mortar placed in interior walls. The plaster samples from Poggio Civitate were located on exterior surfaces.

[438] Reeves et al 2006, 435.

[439] Moropolou et al. 2005, 297.

testing. The TGA results for mortars formed using a natural hydraulic lime and crushed brick are shown in Table 6 below.

Table 6: TGA results of hydraulic mortars compared with Poggio Civitate plaster[440]

Mortar Sample	30-120° C Adsorbed H_2O	200-600° C Hydraulic H_2O	600-1000° C CO_2	CO_2/Hydraulic H_2O ratio	Hydraulic H_2O/ Adsorbed H_2O	CO_2/Adsorbed H_2O ratio
Natural Hydraulic Lime 1	0.7	2.7	19.9	7.4	4	29.7
Natural Hydraulic Lime 2	1.5	4.6	24.1	5.2	3.1	16.2
Average ± s.d.	1.1 ± 0.6	3.65 ± 1.3	22 ± 2.9	6.3 ± 1.5	3.5 ± 0.6	22.9 ± 9.5
Crushed Brick 1	1.2	3.2	15.5	4.8	2.6	12.4
Crushed Brick 2	1.7	2.5	15.5	6.2	1.5	9.3
Crushed Brick 3	1.8	3.1	19.8	6.4	1.7	11.1
Average ± s.d.	1.6 ± 0.3	2.9 ± 0.4	16.9 ± 2.5	5.8 ± 0.8	1.9 ± 0.6	10.9 ± 1.6
Poggio Civitate Plaster Averages	3.3	3.1	28.0	9.0	0.9	8.5

As can be seen in Table 6, the results obtained from the TGA tests on mortars formed with natural hydraulic lime versus those formed with an artificial pozzolan, crushed brick, vary greatly only in one parameter, the CO_2/Adsorbed H_2O ratio. The results obtained from the TGA tests of plaster from Poggio Civitate show greater conformance with hydraulic mortars formed using the artificial pozzolan of crushed brick. Whether the hydraulic properties of the plaster were obtained through the use of the marly limestone that surrounded the site or the incorporation of powered or crushed ceramics, it is likely that the builders at Poggio Civitate were cognizant of the superiority of their plaster to non-hydraulic plaster/mortars and of the different types of limestone available on and around the hill. Referring to the geological map of the area around

440 Adapted from Rizzo and Megna 2008, Table 1.

Poggio Civitate (Map 3), it can be seen that the Orientalizing Complex was within walking distance of high quality limestone outcrops (calcite is above 80% in the *calcari marnosi* deposits on Map 3) at Poggio Aguzzo, Montorgiali, and Poggio La Fornace that they could have exploited if their intention was to create a pure white lime plaster/mortar primarily suitable for decoration.[441]

The color of the plaster used by the builders at Poggio Civitate may also provide some insights, which ranged from a light gray (10YR 7/1) to a light brownish gray (7.5YR 7/1), suggesting a lower lime content than a pure lime plaster. The addition of a substantial amount of crushed ceramic would impart a reddish color, as seen in Roman *cocciopesto*. In Israel, the study of hydraulic plaster/mortar has relied upon their coloring. A method of classification for hydraulic mortars was developed by Yosef Porath of the Israeli Antiquity Authority based on his study of ancient aqueducts dated from the 2nd c. BC to the 7th c. AD. Plasters/mortars used on aqueducts could be classified into one of four types based on color: white mortar composed primarily of lime; gray mortar composed of lime and burnt organic material; uniform red mortar composed of lime and finely ground terracotta; and dotted red mortar, composed of terracotta not completely pulverized. White and gray mortars were used before and during the onset of the Roman takeover, while uniform red mortar appeared during the 2nd c. AD. Dotted red mortar is associated with the Umayyad period.[442] This plaster/mortar classification system developed in Israel is primarily chronological. No archaeometric tests were performed to establish that the mortars actually have hydraulic

[441] Signorini 1963, 77.

[442] Porath 2002, 27.

properties (although their incorporation into aqueducts suggests that the mortars were perceived to be hydraulic). In the Levant, the mortars that included crushed ceramics date from the Roman period and can be assumed to have been hydraulic. The white and gray mortars are more difficult to assess. The gray color of mortars in 3rd-2nd c. BC Israel was due to the addition of wood ash or crushed charcoal.[443] The utility of adding ash from organic combustion has been established by experiments by M. Goodman at the University of Pennsylvania. His tests, as compared to mortar without ash additives, determined that the incorporation of 10-20% wood ash into the mortar mix increased performance in workability, adhesion, stiffening rate, permeability, and crack resistance.[444] Goodman suggested an eastern origin for this technique based mainly on the results of petrographic analyses of cisterns at Carthage.[445] At Carthage, excavators analyzed thin sections of plaster taken from several Punic cisterns and compared them with that taken from Roman-era cisterns. The Punic cisterns were faced with a light gray (10YR 7/1) plaster that contained around 3-5% ash derived from burnt organic matter and an equal amount of crushed terracotta material set into a matrix composed of about 50% lime. The plaster from Roman cisterns ranged from an off-white (7.5 YR 8/0) to a grayish white (10YR 8/1) color and was composed of a large amount of crushed volcanic material with no organic additions.[446] These results indicate that settlers from the Levant (Phoenicians) at Carthage composed hydraulic plaster in a way different from settlers coming from Italy (Romans). The former colonists used organic ash and crushed

[443] Porath 2002, 26.

[444] Goodman 1998, 129.

[445] Ibid 10.

[446] Davis 1981, 43-7.

ceramics while the latter used volcanic pozzolans. Recent testing of the mortars used to line cisterns at the Phoenician/Punic colony of Tharros provided similar results. Most of the cisterns were lined with a gray mortar that included small fragments of ceramic material and granules of carbon material, presumably ash.[447] Thermogravimetric analysis of these plasters indicated that most had hydraulic properties.[448]

Researchers at the Iron Age Philistine site of Tell es-Safi claim to have found the earliest 'true' hydraulic mortar in the region, but TGA was not performed on the samples. Their conclusion relies mainly on mineralogical tests which show a high amount of silicates that they believe could have come from crushed ceramics.[449] They hypothesize that this technology could have been passed on to the Levant through Greece, where tests on mortars have shown that crushed and powdered ceramics were included in mortars used to line Bronze Age cisterns in Mycenae and Argos and a floor in Tiryns.[450] Natural pozzolans were included in mortars from the Minoan period in Crete.[451] Hydraulic mortars may have been developed much earlier in the Levant, however. Regev et al. do not reference the petrographic tests done on plasters and mortars from the Neolithic

[447] Bultrini et al. 1996, 124.

[448] Ingo et al. 2004, 60.

[449] Regev et al. 2010, 3007-9. These researchers also point out the difficulty in tracking down true hydraulic mortars in archaeological publications. Several reports claim that a mortar or plaster is hydraulic but no archaeometric tests have been performed to verify it.

[450] Chiotis et al. 2001, 329-31. Excavators at the Middle Minoan site of Kommos, Dandrau and Dubernet 2006, 239, determined that the plasters and mortars there had a high 'hydraulicity' based on petrographic and mineralogical analyses but Regev et al. 2010, 3001, point out that the high amount of silica present was probably due to the use of the local marly limestone (clay content 35-65%) used to create the lime, and not a deliberate attempt to fashion a hydraulic mortar.

[451] Maravelaki-Kalaitzaki et. al 2003, 654-7.

period in northern Israel.[452] These tests document the common practice of adding limestone aggregate and calcareous ash, a waste product left over after heating of the limestone, to mortar and plaster mixtures. Coincidentally, the addition of fly ash (ash left over from the burning of coal) as an artificial pozzolan is common in modern cement mixing, and it has been suggested by French researchers that the inclusion of ash into Neolithic mortars in northern Israel was a deliberate attempt to induce a pozzolanic reaction.[453] In any case, the experiments of Goodman mentioned above demonstrate the utility of the practice even if it did not act as true artificial pozzolan.

Outside of geography, no direct link can be attributed between the Neolithic Pre-Pottery cultures of the Levant and the Iron Age Phoenicians, but it is worth noting the apparent similarity in plaster and mortar preparation. Likewise, no direct link can be drawn between Iron Age Phoenicians and Bronze Age Minoans, and it is not clear that the technology of hydraulic plaster/mortar survived into the Greek Iron Age.[454] No petrographic examination was made of the plasters from Tell es-Safi so the presence of any small inclusions is unknown. The 'true' origin of hydraulic mortar is not likely to be found by archaeologists but current archaeometric tests suggest that the incorporation of ash to improve mortars was a Near Eastern technique developed during the Neolithic period, while the inclusion of crushed and powdered ceramics into mortar began as early as the Middle Bronze Age in the Aegean. While petrological and mineralogical analyses

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[452] Goren and Goldberg 1991; Malinowski and Garfinkel 1990; Gourden and Kingery 1975; Balfet et al. 1969.

[453] Balfet et al. 1969, 191-2; contra Kingery et al. 1988, 227.

[454] Besides the Bronze Age contexts in the Greek world, hydraulic mortars have been identified at Hellenistic Rhodes (Moropolou et al. 2000, 45-58) and Hellenistic Crete (Maravelaki-Kalaitzaki 2003, 651-61).

can be useful in confirming the presence of additives to a plaster/mortar mixture, only TGA can assess the permeability of a plaster/mortar.[455] Archaeometric testing to determine the hydraulicity of mortars is a fairly new field and a clear path of development through time and space has yet to be established. From the information available, though, it can be observed that the techniques of adding burnt organic matter and crushed ceramics to create hydraulic plaster/mortar mixtures were used by Phoenician colonists in the western Mediterranean from the 8th c. BC onward and the color and performance of the plasters under archaeometric testing in this study suggest a similar hybrid technique was used by builders at Poggio Civitate.

4.2 Elemental Analysis

The goals of the elemental analysis of earthen architectural samples was to help clarify the production processes involved in the manufacturing of earthen architecture and plaster at Poggio Civitate. I analyzed twenty-one samples using LA-ICP-MS from both the 7th and 6th c. BC occupations at Poggio Civitate. These included 6 samples of daub, 6 samples of plaster, 2 brick fragments, 6 fragments of terracotta tile, and 1 ceramic sherd (buccheroid). To conduct the tests, samples were placed inside a closed ablation chamber monitored by a video camera that allowed precise aiming of the laser. Three

[455] On the limitations of chemical and petrographic studies in determining the hydraulicity of ancient mortars, see Elsen et al. 2010, 136-8, who are particularly critical of the identification of any and all inclusions as intentional efforts to influence the hydraulic properties of a mortar since their presence could just as easily have been accidental. X-ray diffraction cannot detect the amorphous components that provide hydraulicity, such as volcanic ash from pozzolanic sands or the soluble silicates imparted from ground ceramics (Moropolou et al. 1995, 794). Petrographic examination offers more clarity, in that it can identify volcanic constituent (Silva et al. 2005, 36), or small fragments of crushed ceramic materials (Ingo et al. 2004, 54). Elemental analyses, as will be discussed below, can suggest the use of natural or artificial pozzolans if the silica content is relatively high (Maravelaki-Kalaitzaki et. al 2003, 656). In a recent work, Maravelaki-Kalaitzaki et. al 2011, 339, the authors suggest using chemical analyses developed for cement research to detect hydrated SiO_2 and CaO as a supplement to TGA. Their experiments suggest that the amounts of these hydrated oxides in a mortar correlate better with particular pozzolans than TGA.

different areas on each sample (smaller than 1000 x 1000 microns in length and less than 30 microns deep) were ablated using a high-energy laser and the particles produced during the ablation process were carried using an argon gas through a polymer tube from the ablation chamber into the inductively coupled plasma torch. The torch heated the plasma to 6000-10,000^{o}C and ionized the injected sample. The ions then moved into the mass spectrometer, where they were accelerated using high voltage and separated from one another using a magnet. Afterwards, the ions passed through a slit into the detector which recorded their atomic masses. [456] This process was repeated three times for each sample, along with samples of National Institute of Standards and Technology (NIST) Standard Reference Material (SRM) brick clay 679, glasses SRM 610, 612, and 614, and obsidian from Glass Buttes, Oregon. These samples have known elemental concentrations and allow the mass spectrometer to be accurately calibrated.

Although the LA-ICP-MS tests provide the concentrations of over 40 elements, statistical analyses were limited by the number of elements measured in the INAA tests conducted by Tobey et al. in 1986. Their data included the elemental concentrations for the principal components (elements that display the greatest variation in the population) that they identified: Dy, La, Eu, Ce, Mn, Na, Sm, Ce, Cr, Fe, and Co.[457] In order to develop ceramics groupings, Tobey et al. used the statistical computer program SAS (Statistical Analysis System) to run two clustering analysis algorithms. Principal component analysis followed by cluster analysis is the most commonly used statistical

[456] Speakman and Neff 2005, 1-2.

[457] Tobey et. al. 1986, 117.

procedure employed to analyze this type of data.[458] Cluster analysis takes a group of variables (in this case, the samples and their elemental concentrations) and breaks them down into subsets based on their relative similarity; this similarity can be measured in a variety of ways, but the standard procedure in archaeology is to program the statistical software to find the mean Euclidean distance (the straight-line or 'Pythagorean' distance in two-dimensional space) between variables and to construct clusters of similarity based on the average of all the distances between grouped pairs of variables (the average-linkage method) . This process continues iteratively until all pairs are agglomerated into one big cluster.[459] In the first iteration, Tobey et al. used the average-linkage method to first discern the number of viable discrete clusters in the data. They identified 5 rough groupings within the ceramic samples and used this number to run the second clustering algorithm, the k-means clustering method. This algorithm starts out with 5 clusters and then proceeds to assign samples to each cluster based on their proximity to posited cluster centroids.

The same statistical software and processes will be used in this study. However, the elemental data concentrations from the INAA tests of 1986, the LA-ICP-MS tests of 2009, and those obtained in this study will be normalized before submitting them to clustering algorithms. This is accomplished by converting the concentrations of each element in the samples into a logarithm (log-10 base). The transformation of elemental concentrations into logarithms became common practice in North American archaeology during the 1970s. A problem at the outset of the chemical grouping of ceramics was the fact that the concentrations of elements detected in ceramics varied greatly, i.e. potassium

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[458] Malainey 2002, 174.

[459] Stepoinaitas et al. 1996, 560.

(K) might register at 150,000 ppm for one sherd and 0.5 ppm for another. Large numerical spreads in elemental concentrations hindered the visualization and graphical representation of data groupings. If elemental concentrations were log-transformed, however, archaeologists observed that ceramic groupings based on elemental concentrations had a Gaussian (normal) distribution and this transformation enabled the graphical representation of groups. Furthermore, the transformation of the variable (elemental concentration) to a similar order of magnitude and comparable standard deviation was perceived as beneficial for statistical analysis.[460] However, this practice has recently come under some criticism as unnecessary or even inadequate, in some cases, when dividing ceramics into groups.[461] Although the theoretical underpinnings of the use of the log-transformation in analyzing elemental data have not been challenged, the groupings derived from the statistical analysis performed in SAS will be supplemented with a bivariate scatter plot of the principal components using Microsoft Excel. Once the values of ceramic samples are placed into the two-dimensional space of a scatter plot, 90% confidence ellipses will be drawn around each cluster in order to see if they overlap or disaggregate significantly.[462] If the clusters separate relatively cleanly on the scatter plot, it is an indication that the clustering algorithm successfully discerned separate groups among the samples. Scatter plots in archaeological provenience

[460] Bieber et al. 1976, 61-3.

[461] Tangri and Wright, 1993, Baxter and Freestone 2006; contra Aitchison et al. 2002

[462] I thank Dr. Sam Van Wassenbergh, University of Antwerp, for providing me with an Excel VBA Macro program to automate the drawing of the confidence ellipses.

investigations have proven useful in visualizing and confirming ceramic groupings obtained using statistical analyses.[463]

Of particular interest were the sources of clay used for the manufacture of daub and the components of the mortar used at Poggio Civitate. It is likely that the earth used for daub and mudbricks came from areas immediately adjacent to the buildings. In Shaffer's study, petrographic examination of the daub and various clay sources within the vicinity of Piana di Curinga located a daub source approximately 160 meters from the settlement.[464] The only other site to try to source daub was Acquarossa, where a single fragment of daub tested using X-ray fluorescence revealed a chemical signature matching that of the local clay.[465] Clay from the hill of Poggio Civitate was subjected to the INAA tests carried out by Tobey et al. in 1986. The principal objective of these earlier tests was to identify a local clay source for the ceramics found on site, but the tests were inconclusive. Tobey et al. tested 133 ceramics and 15 clay samples using INAA and then subjected the eleven elements (Dy, La, Eu, Ce, Mn, Na, Sm, Ce, Cr, Fe, and Co) identified as principal components to statistical analysis. In the first iteration of statistical analysis, they attempted to define groups within the ceramic assemblage. They focused on the value of the square of the correlation coefficient, R^2, provided by the first clustering algorithm to make their determination of preliminary groups. The correlation coefficient , R^2, varies from 0 to 1 and measures the proportion of variance within a data set accounted for by the clusters. As the number of clusters increases, the value of R^2

[463] Michelaki and Hancock 2011, 4.

[464] Shaffer 1984, 529.

[465] O. Wikander 1993, 169.

increases. The increase in R^2 reflects the greater success of the clustering algorithm in distributing samples into separate clusters based on similarity.[466]

Table 7: Statistical data for average linkage clustering algorithm from 1986 INAA study[467]

Number of Clusters	Normalized Average Linkage	R^2
15	.650	.919
14	.672	.906
13	.752	.901
12	.773	.883
11	.806	.854
10	.863	.808
9	.870	.799
8	1.027	.792
7	1.118	.761
6	1.140	.715
5	1.240	.706
4	1.465	.400
3	1.521	.331
2	1.817	.076
1	3.328	0

Referring to Table 7, Tobey et al. noticed that R^2 significantly increased as the clustering algorithm organized samples from 4 into 5 clusters. This increase in R^2 could indicate that the 5 clusters identified by SAS were fairly compact and coherent. They then ran another clustering algorithm, the k-means clustering method, and programmed it to distribute the samples among 5 different clusters. The five clusters that the average linkage clustering algorithm identified can be visualized in the dendrogram for clustering provided by Tobey et al. (Fig. 129). The results of the k-means clustering algorithm were displayed on a bivariate plot using two principal components (the particular elements

[466] Tobey et al. 1986, 117; SAS Institute Inc. 1985, 272.

[467] Adapted from Tobey et al. 1986, 117

used for the plot were not specified) (Fig 130). Cluster 1 was composed of a single piece of greyware, so it is not really a cluster, just an outlier. Cluster 2 contained nearly all of the tile samples and the majority of the coarseware and impasto samples. Cluster 3 was composed mostly of orangeware, bucchero, greyware, and some fine orangeware samples. Cluster 4 had a majority of the fine orangeware, and cluster 5 contained a variety of samples to include tiles, coarseware, impasto, orangeware, and a single piece of bucchero. The clay samples were not included in this statistical exercise. After establishing groups for the ceramics, they ran another average-linkage clustering algorithm that included the clay samples and discovered that there was no statistical correlation between the ceramic assemblages and the clay group (Fig 131). Ultimately, the elemental analysis determined that the ceramics at Poggio Civitate could not be sourced to the clay beds tested on the hill.[468] In his LA-ICP-MS study on terracotta tiles, W. Gilstrap had suggested that perhaps limestone temper in the terracotta tiles and coarseware had thrown off their elemental concentration by introducing an abundance of Ca into the clay matrix.[469] V. Steponaitas and M. Blackman have developed a formula for Mississipian wares that takes into account the tamping down of elemental concentrations in ceramics tempered with shell, which has a high concentration of Ca.[470] Examination of the mean elemental concentrations of tile samples versus that of the clay samples tested by Tobey et al. in Table 8 does not necessarily support this view, however.

[468] Tobey et al. 1984, 119-22.

[469] Gilstrap 2009, 1.

[470] Stepoinaitas et al. 1996, 558-9.

Table 8: Mean elemental concentrations from 1986 INAA study[471]

	Dy	Mn	Sm	La	Na	Eu	Ce	Cr	Sc	Fe	Co
Tile	3.5	1300	2.4	10	21000	0.85	33	700	30	49000	55
s.d.	1.4	1200	0.75	5.1	1600	0.25	12	130	5.8	5900	28
Clay	8.5	3000	9.3	43	1300	1.9	89	150	33	120000	48
s.d.	1.6	770	2.1	11	240	0.39	20	37	6.5	29000	15

The concentrations for Na, Cr, and Co are telling. The mean concentration of Na for a tile sample was 21000 ppm, while the Na concentration for clay was only 1300 ppm. The mean concentrations in the clay are smaller than those found in the tiles for the elements Cr and Co also. If a substantial amount of limestone temper had been added to the clay to create tiles, it would be reasonable to expect the majority of the other elements' concentrations to have been tamped down because of the introduction of excess Ca into the matrix.

To improve on the study conducted by Tobey et al., the tiles tested by Gilstrap and the daub samples tested in this study were incorporated into the statistical analysis and the data were log-transformed. SAS was used and the data were subjected to the same two clustering algorithms used by Tobey et al., CLUSTER and FASTCLUS, which used average-linkage and k-means clustering techniques, respectively. In the first iteration, a similar increase in the correlation coefficient was observed, but in this instance the increase registered as clusters were increased from 5 to 6, as can be seen in Table 9.

[471] Adapted from Tobey et al 1984, 122.

Table 9: Data generated by SAS average-linkage clustering algorithm

Number of Clusters	Normalized Average Linkage	R^2
15	0.6672	.752
14	0.74	.741
13	0.748	.721
12	0.7825	.676
11	0.8144	.672
10	0.848	.665
9	0.8651	.642
8	0.8673	.636
7	0.9365	.628
6	0.9872	.619
5	1.0356	.328
4	1.108	.309
3	1.2998	.057
2	1.5367	.043
1	1.7149	0

Inspection of the dendrogram generated by the SAS average-linkage clustering algorithm (Fig. 132) does not differ significantly from that of Tobey et al., although there appear to be three main groups (underlined by different colors) and then some outliers to the far right. A subsequent k-means clustering algorithm programmed to search for 6 clusters was then run on the data and it generally confirmed the visual impression given by the dendrogram, with the majority of samples falling among three separate groups (Table 10).

Table 10: Cluster assignments using k-means clustering algorithm with mean and standard deviations of elements (in ppm)

Cluster	#		Dy	Mn	Sm	La	Na	Eu	Ce	Cr	Sc	Fe	Co
1	64	Mean	2.9	1304.5	2.8	11.7	18642.5	1.0	34.0	756.4	32.2	57922.3	51.9
		s.d.	1.8	856.1	0.8	4.2	5915.4	0.2	13.6	337.3	6.9	16492.6	20.8
2	21	Mean	2.7	1559.6	3.4	17.7	16255.6	1.2	49.8	691.5	31.4	59932.1	46.2
		s.d.	1.7	864.9	0.9	9.7	9303.1	0.5	26.5	375.3	9.2	14236.2	15.9
3	2	Mean	3.7	33.3	4.6	27.5	8935.0	0.9	60.5	315.0	20.5	47500.0	23.0

Cluster	#		Dy	Mn	Sm	La	Na	Eu	Ce	Cr	Sc	Fe	Co
		s.d.	1.1	25.7	0.1	1.5	1665.0	0.0	4.5	155.0	3.5	4500.0	4.0
4	3	Mean	1.1	372.7	1.5	8.5	31609.1	0.6	18.4	614.5	20.2	32469.5	29.7
		s.d.	0.9	248.6	0.5	1.7	12820.4	0.2	5.7	119.2	3.1	3974.9	12.3
5	82	Mean	5.0	620.7	5.5	33.0	8859.8	1.1	70.0	245.2	20.0	51200.0	22.4
		s.d.	1.8	362.6	1.3	8.1	3513.4	0.3	15.8	140.0	5.0	7966.4	8.3
6	4	Mean	2.1	1695.7	4.4	29.6	265.2	1.3	85.5	239.1	14.7	73854.7	29.5
		s.d.	0.5	374.4	0.3	6.6	206.3	0.2	14.0	48.7	2.9	4006.6	2.8

Cluster 2 (Green) was composed of the clay and daub samples, indicating they were both sourced from the hill of Poggio Civitate. Among the two ceramic groupings, Cluster 1(Red) comprised the tiles and almost all the coarseware, along with about half the orangeware and half of the impasto samples. Cluster 5 (Blue) was composed of the other half of the orangeware and impasto samples, nearly all of the bucchero save one sample and all of the fine orangeware, and two pieces of coarseware. The other three clusters included a piece of bucchero and orangeware (Cluster 3), three tiles (Cluster 4), and three pieces of plaster and a piece of daub (Cluster 6) and were treated as outliers. The main difference between this elemental study and the one conducted by Tobey et al. is the cleaner breaks provided for different ceramic classes. This is illustrated in the bivariate plot (Fig. 133) of the three groups for the first two principal components, La and Fe. The points of each group are outlined by 90% confidence ellipses with the clay/daub group in green (Cluster 2), the tile/coarseware group in blue (Cluster 1), and the bucchero/fine orangeware group in red (Cluster 5). There is some overlap of the three clusters in the middle but the ellipse centroids are far enough apart to recognize a significant disaggregation among them. The coarseware and tiles (Cluster 1) were most likely sourced at Poggio Civitate but the clay source has not been located. Cluster 5, since it was composed mainly of the finer wares – bucchero and fine orangeware – may

have been imported. Unsurprisingly, the daub was sourced from clay on the hill of Poggio Civitate (Cluster 2). Unlike the case at La Muculufa in Sicily, it appears that ceramic production and architectural practice remained separate processes despite the fact that presumably much of the ceramic production at Poggio Civitate was devoted to architectural embellishment.

One of the advantages of testing ceramics with LA-ICP-MS is that the procedure is able to detect nearly every element, with the notable exception of oxygen. When data from the test is calibrated, each element is converted into its oxide state in order to get a more accurate picture of its representation within the clay matrix. This procedure, developed by B. Gratuze, assumes that LA-ICP-MS accounts for 100% of the material in the sample and presents each element as a ratio based on total capture of the ceramic's elemental signature. There is some error in this procedure since a few elements not measured are unaccounted for (sulphur, chlorine), but it has provided the best results in efforts to quantify the data produced by LA-ICP-MS.[472] Thus, the LA-ICP-MS tests conducted on tiles, daub, mudbrick, and plaster in this study provided a good characterization of all the components used in their manufacture. This data is presented in pie charts in order to provide greater clarity (Fig. 134-137) and in the table below (Table 11).

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[472] Speakman and Neff 2005, 6-7. The inability of LA-ICP-MS to detect sulphur could be a drawback if one were trying to distinguish between a gypsum or lime plaster/mortar. Gypsum, however, is relatively soft, sets quickly, and absorbs water, making it of limited use in an architectural context in a temperate climate (Kingery et al. 1988, 221). The robustness of the plaster at Poggio Civitate suggests a lime plaster. Moreover, the absorption of water by gypsum would have been indicated by a sharp drop in weight at the outset of heating during the TGA tests.

Table 11: Composition of major element oxides in samples according to LA-ICP-MS

Sample		Na_2O (%)	MgO (%)	Al_2O_3 (%)	K_2O (%)	CaO (%)	SiO_2 (%)	TiO_2 (%)	Fe_2O_3 (%)
Tiles	Mean	2.75	4.10	20.27	1.82	4.97	50.27	0.76	14.27
	s.d	2.6	3.0	3.2	1.2	2.9	5.2	0.4	4.6
Daub	Mean	0.32	0.61	17.06	3.68	20.33	40.74	1.02	15.43
	s.d	0.2	0.1	5.3	1.9	12.9	6.12	0.4	2.1
Plaster	Mean	0.04	0.43	10.49	1.32	55.29	21.41	0.44	10.06
	s.d	0.1	0.2	0.9	0.9	2.42	1.43	0.1	1.8
Mudbrick	Mean	1.43	0.81	18.72	4.59	10.60	44.81	1.23	17.13
	s.d	1.56	0.05	3.40	0.30	6.76	5.41	0.25	2.59

As can be seen in Table 11, silicates comprised the largest portion of the tiles, daub, and mudbrick at Poggio Civitate. The difference in the elemental composition of the plaster and the daub samples appears to be one of magnitude, which is not surprising since the earth mixed into quicklime to make plaster probably came from the hill. As anticipated by the formula of Steponaitas and Blackman mentioned above, the high proportion of Ca (over 50%) in the plaster tamps down the concentration of the other elements in the matrix. In their study of the Iron Age plaster from Tell es-Saif, Regev et al. point to the ratio of silica to alumina, two of the main constituents of clay, as an indicator of the addition of extra silicates to a plaster or mortar. In this case, the ratio in the daub (40.74/17.06= 2.38:1) is larger than that in the plaster (21.41/10.49= 2.04:1). If the plaster and daub were mixed from the same clay source and extra silicates were added in the form of crushed ceramics to form the plaster, Regev et al. suggested there would be a higher silica to alumina ratio in the plaster/mortar.[473] It must be observed, though, that

[473] Regev et al. 2010, 3004.

the concentrations of SiO_2 and Al_2O_3 in the daub samples have relatively high standard deviations. This could be the result of the small sample size but, at the same time, the mixing of daub was probably not conducted according to a rigid formula, so it is not certain that a larger sample size would provide significantly smaller standard deviations.

The high proportion of Ca in the plaster samples, as seen in Figure 137, places it between a pure lime plaster and an advanced hydraulic mortar of the Roman period, which can have lime concentrations as low as 25%. The results from the plaster at Poggio Civitate, which has a mean CaO content of 55.29% and silica content of 21.41%, do not neatly correspond to the four categories of plasters/mortars defined by Maravelaki-Kalaitzaki et al. in 2003 based on their study of ancient and pre-modern Cretan mortars. A typical, non-hydraulic lime mortar on Crete had an average CaO content of 44.04% and a silica content of 6%; a natural hydraulic mortar, 41.44% and 12.44%; a crushed brick mortar, 34.28% and 26.77%; and a pozzolanic mortar 26.54% and 33.18%, respectively.[474] At about 50% lime, the components of the plaster at Poggio Civitate appears to have more in common with values obtained in the testing of mortars used at the Phoenician colonies of Tharros[475] and Carthage.[476] Thus, in composition, it appears the hydraulic plaster at Poggio Civitate resembled those used in Phoenician colonies rather than early Greek hydraulic plasters/mortars of the Bronze Age.

4.3 Morphological Analysis

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[474] Maravelaki-Kalaitzaki et al. 2003, 656.

[475] Ingo et al. 2004, 54, Fig. 3.

[476] Davis 1981, 44.

Before discussing the daub and mudbrick fragments recovered from Poggio Civitate, it is necessary to briefly discuss the excavation history of the site. The earliest excavations during the 1960s concentrated on a plateau at the northeastern edge of the hill called the Piano del Tesoro. Any trench opened on this plain was designated a 'Tesoro' trench and numbered sequentially (Fig. 138). There have been over fifty trenches opened on the Piano del Tesoro and they are referred to by abbreviated alphanumeric designators (i.e. T-1 through T-50). Trenches were also opened to the west of the Piano del Tesoro and those trenches were designated Civitate A (CA) or Civitate B (CB), with Civitate A being immediately adjacent to the Tesoro trenches and the trenches of Civitate B further west.[477] Trenches opened to the south of the Piano del Tesoro were designated area Civitate C (CC) and those that cut into the agger closing off the western side of the Piano del Tesoro were also given a separate designation (AG). During the 1970s, as the Tesoro and Agger trenches reached the floor of the Archaic complex, excavations that continued below the floor of the Archaic complex were designated 'Rectangles' because the rooms of the Archaic complex were rectangular (Fig. 139).[478] Thus, Orientalizing period material on the Piano del Tesoro initially came from trenches identified as R1 through R21. Earthen architecture was retained in the storerooms of Vescovado from trenches R5, located at the northeastern corner of OC1, and trench R13, the western extent of OC3. Also during the 1970s, trenches 18 and 19 north of the Archaic building uncovered the remains of the Northern building which Phillips and Nielsen determined, based on pottery finds, was constructed before the end

[477] Phillips 1967, 137-8.

[478] Phillips 1971, 260.

of the 7th c. BC, perhaps during the interim between the destruction of the Orientalizing complex and the construction of the Archaic complex.[479] Excavations on the southern portion of the Tesoro plain during the 1980s and 1990s uncovered OC2. The length of OC2 was divided into two large trenches, T-25 and T-26, which uncovered the western end and the eastern expanse of the building, respectively (Map 4). These two trenches retained the largest amount of earthen architecture during excavations at Poggio Civitate. In presenting the results of the morphological analysis, the data obtained for OC2 will be presented first since it is the most expansive. Finds retained by the trench supervisors and stored in Vescovado from T-18 and T19 (North Building), R-13 (OC3), and R-5 (OC1) will then be presented. Comparison of the data from the areas of the different buildings of the Orientalizing complex with data from other sites will be conducted in order to better ascertain the architectural techniques used by the builders at Poggio Civitate.

A comprehensive listing of each fragment of earthen architecture recovered from trenches dated to the 7th c. BC can be found in Appendices D through G. The following data were recorded for each individual fragment of daub and mudbrick:

> <u>Length (cm)</u>: for daub with circular impressions, this dimension was measured parallel to the impressions. For daub without impressions and mudbrick fragments, this dimension reflected the maximum extent of the fragment.
>
> <u>Height (cm)</u>: for daub with circular impressions, this dimension reflected the maximum extent as measured perpendicular to the impressions. For daub without

[479] Nielsen and Phillips 1983, 10.

impressions and mudbrick fragments, this dimension reflected the minor extent of the fragment.

Thickness (cm): for daub with circular impressions, this dimension reflects the extent of the thickest portion of the daub not including the depth of the impression.

Fabric: The overwhelmingly dominant fabric of earthen architecture at Poggio Civitate was designated Type A, which normally fired to pink (5YR 8/4) but also exhibits a reddish grey color (5YR 5/2) on the interior of larger pieces not completely fired. The clay appears to have been well-mixed and maintains a uniform color throughout the matrix, but there are many inclusions. Within the daub measuring less than 5 cm in thickness, mica inclusions are frequent and measure up to 3 mm in diameter. In larger pieces of daub and bricks, rounded stones measuring up to 5mm and angular stones measuring up to 10 mm are present. A few fragments were comprised of a fine, powdery clay with few inclusions that fired to a pale brown (10YR 8/3).

Decoration: the presence of a plaster coating or finish was noted.

For daub with wattle impressions (diameter up to 3 cm), further data were collected:

Number: Number of wattle impressions.

Diameter of impressions. In the case of small circular impressions left by wattles, the entire diameter of those circular impressions was normally preserved in the daub.

Space between circular impressions (cm). In instances where there were several wattle impressions on a single fragment of daub, the distance between the impressions was recorded.

Plane: When there was more than one wattle impression, it was noted whether those impressions ran on a single plane next to one another (parallel) or if their direction would have intersected with one another to form a woven lattice.

Finished Edge: Many fragments of daub with wattle impressions had flattened/finished edges on one side, perhaps from contact with a wooden board, terracotta tile, or mudbrick. In these cases, the direction of the wattle impressions in relation to the finished edge was noted.

In the case of daub fragments with impressions in the daub, the type of impression was noted along with its size:

Type of impression: Circular/Curvilinear/Flat.

Diameter/Width & Length: Larger circular impressions often preserved only a portion of the timber member's diameter. In these cases, an estimation technique used by archaeologists studying daub at the south Italian site of Trasano was used. There, the diameter of circular members was deduced from the length of the semicircular impressions left on the daub. Most impressions appeared to delineate an internal arc of about 78 degrees, leaving an impression whose length represented about a fifth of the entire diameter of the circular member in the daub (Fig. 36).[480] This formula could then be used to arrive at a rough approximation

[480] Tasca 1998b, 81 and Fig.1.

of the diameter of larger circular members whose entire diameter could not be readily ascertained from impressions on the daub:

$$\frac{\text{Length of Arc}}{\text{Circumference}} = \frac{\text{Angle of internal arc } (78^{o})}{360^{o}}$$

$$\frac{\text{Length of Arc}}{\text{Circumference}} = 0.217$$

$$\text{Circumference x } 0.217 = \text{Length of Arc; } [C = \Pi \text{ x Diameter}]\ldots$$

$$(\Pi \text{ x Diameter}) \text{ x } 0.217 = \text{Length of Arc}$$

$$\text{Diameter x } 0.681 = \text{Length of Arc}$$

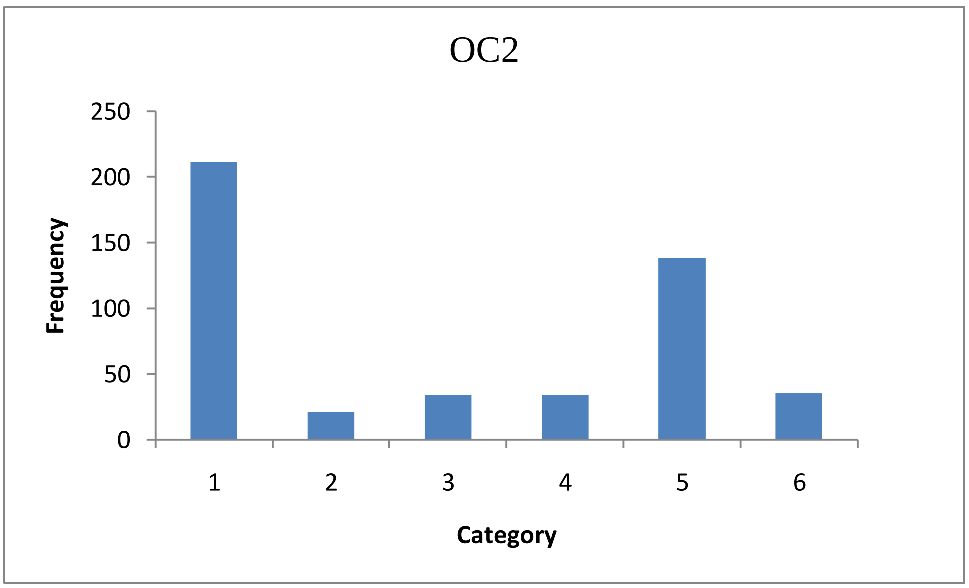
$$\text{Diameter} = \frac{\text{Length of Arc}}{0.681}$$

For circular impressions, the impression length was recorded. For analysis below, the estimated diameter was used. For daub fragments with flat impressions, the width of an impression ran perpendicular to the length of the impression and represented its minor extent, unless otherwise noted.

4.3.1 Morphology of Earthen Architecture from OC2 (T-25 and T-25)

A total of 409 daub and 35 mudbrick fragments were recovered from the area of OC2, weighing 151 kg and 41.5 kg respectively. The majority of material was recovered from the eastern part of the workshop in Trench T-26. Some daub was recovered in topsoil or as high as 30 cm below ground level, but most samples appear to have been found in levels associated with the debris of the workshop, at a depth ranging from 75 to 130 cm below ground level. Individual daub fragments range from 10 grams to 2.0 kg in weight, but most are of moderate size and weigh anywhere from 50 to 80 grams. Mudbrick fragments retain at least two finished sides and appear to have been mold-made. Mudbrick widths varied between 6 and 12 cm, with a mean thickness of 7.4 cm. Referring to Table 12, Type 1 daub (Fig. 140), having circular impressions from single wattles or multiple wattles running side-by-side in a parallel direction, made up the largest portion of the daub recovered from OC2.

Table 12: Histogram of earthen architecture types



The smallest number of daub fragments from OC2 displayed impressions of a woven lattice of wattles (Type 2) (Fig. 141). In one instance, a horizontal wattle or lashing can be seen running beneath two larger wattles perpendicularly (Fig. 142), but daub fragments preserving the impressions of wattles intersecting on multiple planes were uncommon. Thirty-four fragments displayed larger circular impressions (Type 3) indicating that the daub was pressed up against a round timber (Fig. 143). In some instances, the striations made on the timber after the bark had been stripped off appeared in the daub (Fig. 144). Of type 4 fragments of daub, six pieces displayed curvilinear impressions and 27 had flat impressions. Curvilinear impressions and some flat impressions resulted from daub used as filler between cover and pan tiles on the terracotta roof (Fig. 145). Other flat impressions might have been caused by the pressing of daub against mudbricks (Fig. 146). No flat impressions displayed a wood-grain impression to suggest its use against a split timber. Type 5 daub fragments are the second largest group from OC2. Many of these fragments were retained because they had plaster on them but there is not enough evidence to assign them to any of the other groups. Mudbrick fragments were classified as such if they displayed at least two flat surfaces forming a corner (Fig. 147 and Fig. 148).[481]

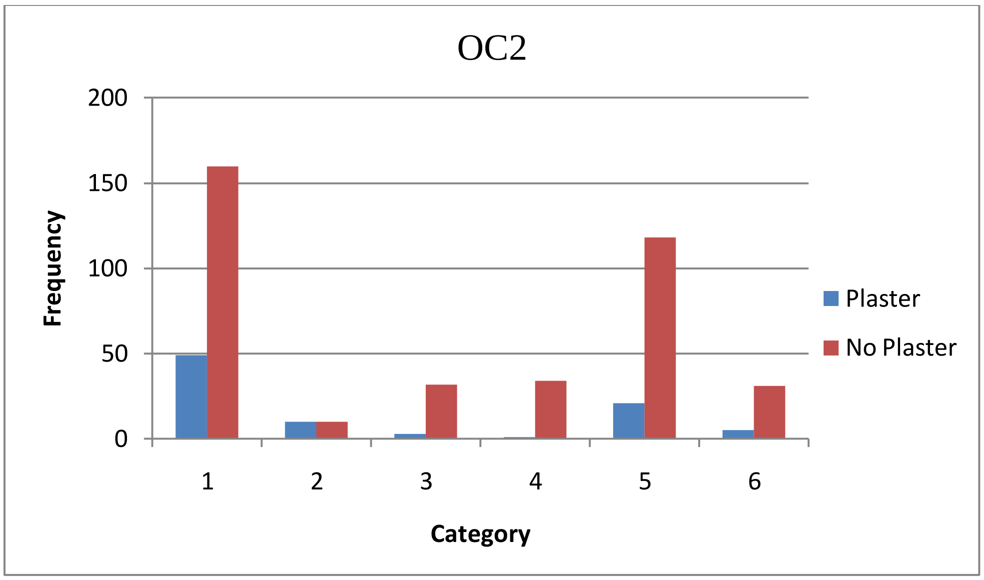
The evidence for several different types of construction techniques in one area makes interpretation of the particular methods used for OC2 difficult. Although approximately 200 kg of daub and mudbrick fragments may seem like a fair amount, if the walls of OC2 were two meters high and 0.35 meters thick, the amount of daub recovered from the area of the building would equal less than 1% of the mass of the building's walls. This should not be surprising. During the controlled destructions of earthen buildings where the materials was collected soon after the building's collapse, no more than 3% of the mass of the walls could be accounted for from the daub recovered.[482] As a discriminator, the presence of plaster on a fragment can help in understanding a fragment's location in the building. Table 13 shows the number of

[481] In Fig. 147 can be seen four slight impressions on the face of the mudbrick fragment. The trench supervisor, Abby Collins, suggested it may have been a paw print from an animal, though the fragmentary nature makes it hard to discern. Still, the presence of impressions on the surface of the otherwise well-formed mudbrick suggests that the surface anomalies were introduced during the process of sun-drying.

[482] Shaffer 1983, 91-93; Bankoff and Winter 1979, 13.

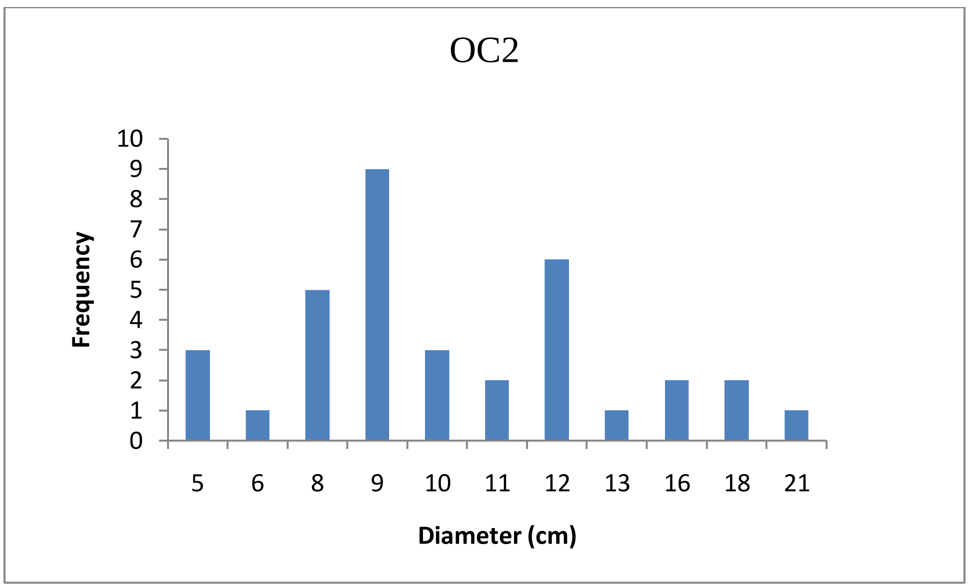
fragments that had plaster attached to their surface, indicating their location on an exterior. An exterior surface does not only include the outer walls of the building. Interior walls might also have been decorated and plaster could also have been used to cover the roofing structure in areas not protected by terracotta tiles.

Table 13: Decorated (plastered) and non-decorated (non-plastered) fragments



About a third of Type 1daub and one-half of Type 2 daub were decorated with plaster. For types 3 and 4, which displayed impressions of timbers, terracotta tiles, or mudbrick impressions, only four fragments had any decoration. Five mudbrick fragments (Type 6) displayed plaster decoration out of a total of 35. It appears that wattled daub had the highest likelihood of being decorated and thus being a part of an exterior surface, while it was uncommon for daub fragments with timber or ceramic impressions to have been part of a visible surface. Mudbrick fragments had a slightly higher likelihood of being decorated with plaster than daub with circular, curvilinear, or flat impressions. This evidence suggests that the earthen architecture of types 3 and 4 usually came from the interior of walls or, in the case of the curvilinear fragments, beneath roofing tiles. In order to get a better understanding of the function of Type 3 daub in the building, it is useful to look at the histogram of timbers sizes derived from the length of the circular arcs measured on the daub fragments in Table 14. Type 3 fragments had an average thickness of 5.74 cm and most of the impressions delineated timbers less than 12 cm in diameter.

Table 14: Timber sizes based on daub impressions from OC2 (Type 3)



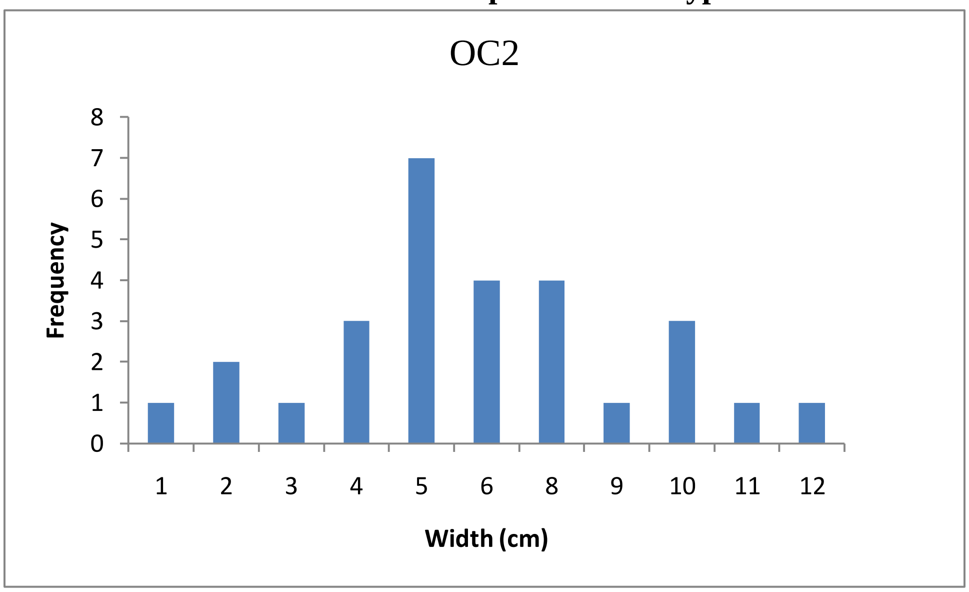
At Ficana, the excavators recognized two classes of vertical 'poles,' those measuring between 6 to 8cm in diameter and those between 18 to 30 cm, with about twice as many of the former type. There is not as clear a division for timber sizes at Poggio Civitate, but the majority of the 35 round impressions cluster around the average diameter, 9.5 cm. One fragment shows a circular impression of a timber around 8cm in diameter running parallel to 3 woven wattle impressions (Fig. 149). This timber was most likely part of a wall and functioned as a horizontal tie between larger vertical timbers that comprised the skeleton of a wattle-and-daub wall. Horizontal timbers probably include the smaller timbers ranging from 5 to 9 cm in diameter, and vertical timbers in the skeleton of a wattle wall likely included larger timbers ranging from 10 to 13 cm in diameter. There are also a few impressions delineating timbers ranging from 16 to 21cm in diameter. The daub fragments displaying these large timber impressions include the only type 3 daub pieces decorated with plaster. These fragments also display impressions of wattles that run on a separate plane and appear to be bending around the daub fragment, at first running parallel to the timbers and then turning perpendicular to the direction of the timber impression (Fig. 150 and 151). It is not clear what role these pieces might have played in the superstructure of OC2, but they perhaps might have been internal corner pieces. As can be seen in the side view of Figure 152, the attitude of the large timber impression rises at an angle of about 15 degrees in relation to the plastered front surface. A gradual slope of about 15 degrees would provide a stable bedding for the gabled terracotta tiled roof and the appearance of wattles running parallel to the direction of the timber, wrapping beneath perpendicularly and then disappearing, could indicate the junction between internal wattle-and-daub screen walls and a thicker bearing wall.

With regard to Type 4 impressions on daub resulting in curvilinear and flat impressions, N. Winter was the first to suggest that the curvilinear shaped pieces of daub were pressed beneath cover tiles and between pan tiles.[483] Obviously these daub fragments would not have been visible and would not have been decorated with plaster. Five of the 27flat impressions can be associated with the curvilinear fragments of daub,

[483] Winter 2009, 54.

having been imparted by the pan tiles they were pressed between as packing on the terracotta tiled roof. Of the remaining 22 flat impressions, the average width of a flat impression was 6.1 cm and an average length of 10.65 cm. The distribution of the width of flat impressions is shown in Table 15.

Table 15: Width of flat impressions on Type 4 daub



As mentioned above, since no wood grain could be discerned in the flat impressions on daub, it is assumed that they were pressed against terracotta tiles or mudbricks. It is also possible that these flat impressions were imparted by wooden boards that had been smoothed, but that would require a substantial amount of effort. The earliest planes - the tool used to smooth a rough wood surface – come from Pompeii.[484] Roger Ulrich believes the proliferation of finely paneled furniture doors in Greece beginning in the 5th c. BC may provide indirect evidence for the use of the plane but, prior to the classical

[484] Goodman 1964, 40.

period, wooden panels seem to have been smoothed by the laborious process of rubbing split planks with stones and sand.[485] Perhaps the best evidence for woodworking techniques during the Iron Age comes from tumulus chamber MM at Gordion in Phrygia. The tumulus chamber there was constructed and lined with wooden beams that had been squared with an adze. The walls of the tomb chamber were further smoothed down by sanding.[486] More likely at Poggio Civitate, the flat impressions on daub indicate junctures between wattle-and-daub and mudbrick walls. As suggested above, this may have occurred where non-load bearing interior walls met load-bearing exterior walls or, alternately, in exterior walls that were constructed of both wattle-and-daub and mudbrick. Such a scenario may be suggested by a fragment that appears to have two roughly finished sides and a third with a wattle impression (Fig. 153 and Fig. 154). The two flat sides would suggest classification as a mudbrick fragment (Type 6), but the fragment's length (20.5 cm) and the undulations visible on one of the flat surfaces in Figure 143 suggest the fragment was not mold-made. Furthermore, on the back side of the fragment in Figure 154 a potential wattle impression runs lengthwise from right to left. It is possible that one flat side was smoothed by hand while the other resulted from its placement upon a flat surface. The fragmented side with a potential wattle impression would represent the interior of a wattle-and-daub wall that was set above or adjacent to mudbricks.

The possibility that wattle-and-daub was either integrated into or adjacent to mudbricks in the construction scheme of OC2 is buoyed by the frequent occurrences of daub with finished edges. The finished edges are flat impressions in and of themselves

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[485] Ulrich 2007, 41.

[486] Liebhart 1988, 126-7.

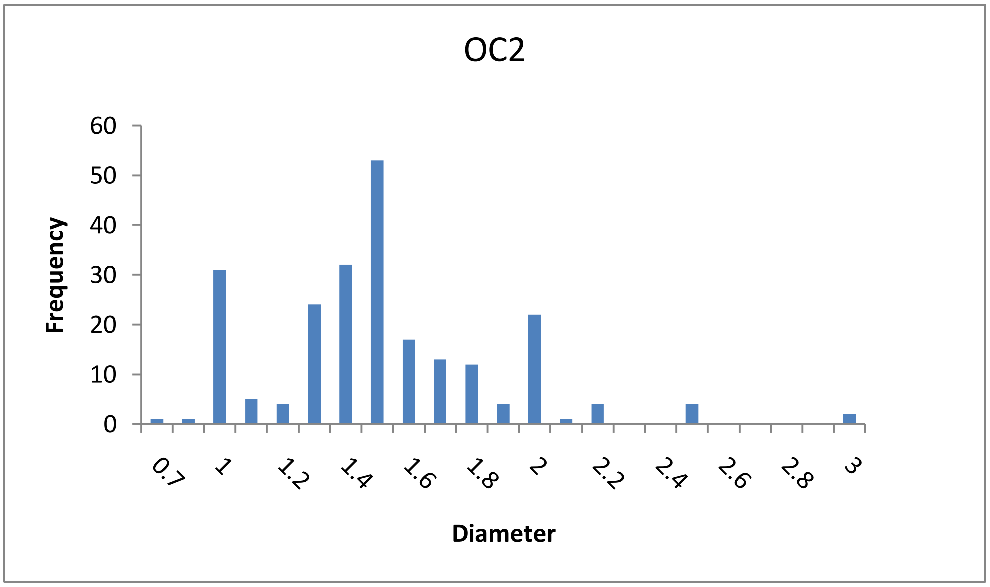
but are classified separately because they are associated with multiple wattles and include the length or width of the entire fragment. There is not a great deal of diagnostic value in daub fragments with single wattle impressions, but fragments with multiple wattle impressions can give an idea of the interior structure of a wattle-and-daub wall or roof . Almost half (44%) of type 1 daub fragments had multiple wattle impressions, and of those, 42% had finished edges, with a third of them being parallel to the finished edge and two-thirds perpendicular to the finished edge (See Fig. 140 for an example). By definition, all type 2 daub fragments had multiple impressions since the wattles appeared to have been woven together. Of these, 43% had finished edges, with two-thirds of them being parallel to the finished edge (See Fig. 155 for an example) and a third perpendicular. Wattles could have been woven vertically but, as discussed in Chapter 3, daub probably has a better grip on horizontal wattles. This is the disposition of wattles often depicted in reconstructions (see Fig. 14, 50, 105, 110). The finished edges that they ran into could have been mudbrick socles or mudbrick pillars, in the event that walls were composed of a mix of mudbricks and wattles. Alternatively, the finished edges might have represented junctions between the two different wall types.

The location of daub fragments without finished edges is not clear but Shaffer's study at Piana di Curinga might provide some help. There, he classified daub fragments with parallel impressions as roofing daub or a lathing surface for wall exteriors.[487] The roof of OC2 was covered by terracotta tiles, but it is possible that a mudbrick or woven wattle-and-daub wall could have a lathing of wattles covered with a thin layer of daub and plaster. The average thickness of type 1 daub fragments with multiple wattles and plaster was 3.52 cm, which was actually smaller than type 1 fragments with multiple

[487] Shaffer 1983, 437-40.

wattles and no plaster (3.68 cm). This is contrary to expectations. A layer of plaster should result in a larger average thickness, as was the case with type 2 daub fragments. In general, the wattles used at Poggio Civitate were on the small side. Most wattles at Piana di Curinga had a diameter greater than 3.5 cm; those that Shaffer classified as roofing or wall lathing daub were usually around 1cm in diameter, similar to the wattles classified as roofing material at Favella and Broglio di Trebisacce. The average wattle diameter for OC2 did not exceed 2 cm. For type 1 daub fragments, the average wattle size was 1.55 cm; for type 2, 1.38 cm.

Table 16: Histogram of wattle diameters



As can be seen in Table 16, the wattle diameters generally break down into three rough groups that cluster around 1 cm, 1.5 cm, and 2 cm. Tables 17 and 18 present daub fragments broken down into three groups according to their diameters (0.7 to 1.2 cm, 1.3 to 1.7 cm, and 1.8 to 3.0 cm). Referring to Table 17, about two-thirds of the fragments with larger wattles (1.8 to 3.0 cm) displayed multiple wattle impressions, but few of them were woven together. The smaller wattle diameters were the most likely to be woven together because of their small size. Table 18 illustrates that, among the three groups of wattle sizes, it was more common for smaller wattles to have had finished edges.

Table 17: Type 1 and 2 daub fragments by wattle diameter and orientation

Wattle diameter	Number of fragments	Decorated with Plaster	Fragments with multiple impressions	Woven	Parallel
0.7 - 1.2	43	26.8%	39.0%	38%	63%
1.3 - 1.7	139	23%	50.4%	14%	86%
1.8 - 3.0	49	30.6%	59.2%	10%	90%

Table 18: Type 1 and 2 daub fragments by wattle diameter and finished edges

Wattle diameter	Number of fragments	Finished Edge	Parallel	Perpendicular
0.7 - 1.2	43	41.4%	47%	53%
1.3 - 1.7	139	30.1%	31%	69%
1.8 - 3.0	49	10.1%	60%	40%

These two tables demonstrate that smaller wattles were more likely to be woven together and to run into a flat edge, i.e. terminate presumably at the face of mudbrick. Larger wattles generally ran parallel to one another and the fragments rarely had a finished edge. The reasons for this are not immediately clear.   It is possible that smaller wattles were used to construct the interiors of hybrid mudbrick and wattle-and-daub walls. Smaller wattles might also have been used to construct interior screen walls that ran into exterior mudbrick bearing walls.   With regard to larger wattles, if they were used as lathing for exterior walls as suggested by Shaffer at Piana di Curinga, it could explain their tendency to run parallel to each other and to not run into mudbrick, along with the smaller average thickness of the daub fragments that they are associated with.

Also worthy of mention are two triangular daub fragments found in the area of OC2. Nielsen suggested that one fragment might have come from the corner of a gabled roof because of its triangular shape (Fig.156).[488] On one side, several wattle impressions approximately 1 cm in diameter ran parallel to one another, while the opposite side was decorated with plaster (Fig. 157). Along the sides, the fragments preserves two smooth, finished edges. On the underside of the fragment, the wattle impressions extend slightly beyond one of the finished edges. Despite its peculiar triangular shape, the steep pitch (35 degrees) outlined by its finished edges would likely have been too steep for a terracotta tiled roof. The pitch of modern terracotta tiled roofs generally does not exceed 20 degrees in order to ensure that the tiles do not slide down the roof due to their own weight.[489] If the terracotta tiles were nailed to the rafters below, a steeper pitch could be achieved, but only four fragmentary pan tiles recovered from the area of OC2 displayed evidence for a nail hole to secure them to the wooden rafters below.[490] At Poggio Civitate, over 200 nails were recovered, most being made of bronze and two-thirds coming from the Orientalizing context. Almost all of these were used for decorative purposes, however, with the exception of five spikes up to 7 cm in length that were associated with the 6th c. BC complex.[491] Furthermore, the fact that the wattles extended

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[488] Nielsen 1991, 25.

[489] Damgaard Andersen and Toms 2001, 255.

[490] Winter 2009, 127.

[491] Warden 1985, 104-5.

beyond the flat impressions along the side of the fragment indicates that the wattles continued to run beneath. If the triangular fragment came from the corner of a gabled roof, there would be no room for the continuation of wattles. Furthermore, it would be odd for wattles to be arranged vertically. Both triangular daub fragments were decorated with plaster and had finished edges delineating a triangular shape, but the second fragment (PC 85-94) displayed wattle impressions horizontal to the finished edges (Fig. 158).

There are no comparanda for these triangular daub fragments. The only discussion of triangular daub that I have been able to find comes from a report on Iron Age buildings in Finland, but these pieces are fairly nondescript and lacked wattle impressions or decoration. The Finnish excavators believed their triangular fragments resulted from the use of earth to fill corner joints formed in log houses.[492] If the triangular fragments at Poggio Civitate were used in a wall, they might have resulted from earth used to daub a wall cross-braced with dressed wooden timbers, though the lack of flat impressions with an obvious wood grain frustrates this explanation. Another possibility is that they were part of a decorative scheme. Italians used daub decoratively from the Neolithic through to the Iron Age at several sites mentioned in Chapter 3 (Trasano, Rocca di Rivoli, Isera-La Torretta, Vidolasco, Torre di Satriano, Luni sul Mignone, and San Giovenale). A possible comparison can be drawn to the use of decorative daub at the Bronze Age site of Trebatice, Slovakia, which was referenced by excavators at Rocca di Rivoli. There, the excavators imagined that the front of a structure might have been plastered with daub decorated with triangular motifs above a

[492] Uino and Linturi 1986,179-81.

doorway or roof (Fig. 159). Although no evidence for thresholds was found at OC1, doorways would most likely have been located on the narrow sides.[493] The shape and thickness of these fragments also brings up another possibility. It is not known how the earliest iteration of the decorative terracotta roofs at Poggio Civitate protected or hid sloping rafters at the front of the gabled roof. The earliest terracotta roofs at Acquarossa and San Giovenale used revetment plaques for this purpose, but revetment plaque fragments that might be associated with the Orientalizing period at Poggio Civitate lack defined contexts.[494] It is possible that builders at Poggio Civitate closed off the ends of OC2 using walls of wattle-and-daub topped by a hipped roof covered in daub. The triangular fragment that Nielsen suggested might have been used in the corner of a pediment becomes noticeably thicker on one end when viewed in profile (Fig. 156). Excavators at Rocca di Rivoli and Broglio di Trebisacce suggested daub of a similar profile at their site might have been used on a sloping roof (Fig. 57 and Fig. 69). On the other triangular fragment (Fig. 158), its finished edges beveled outward on the bottom and inward on the top: a detail which could suggest its use on some kind of slope. The finished sides could have resulted from the use of daub next to roofing tiles or small squared timbers used along the hipped roof. In short, though, until more convincing comparanda are discovered for the triangular fragments at Poggio Civitate, their role in the architectural scheme will remain speculative.

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[493] Prayon 1975, 122, observes that from the evidence of groundplans and urns, doorways appear to have been routinely located on the narrow ends of Etruscan buildings.

[494] Winter 2009, 89, 92, 94.

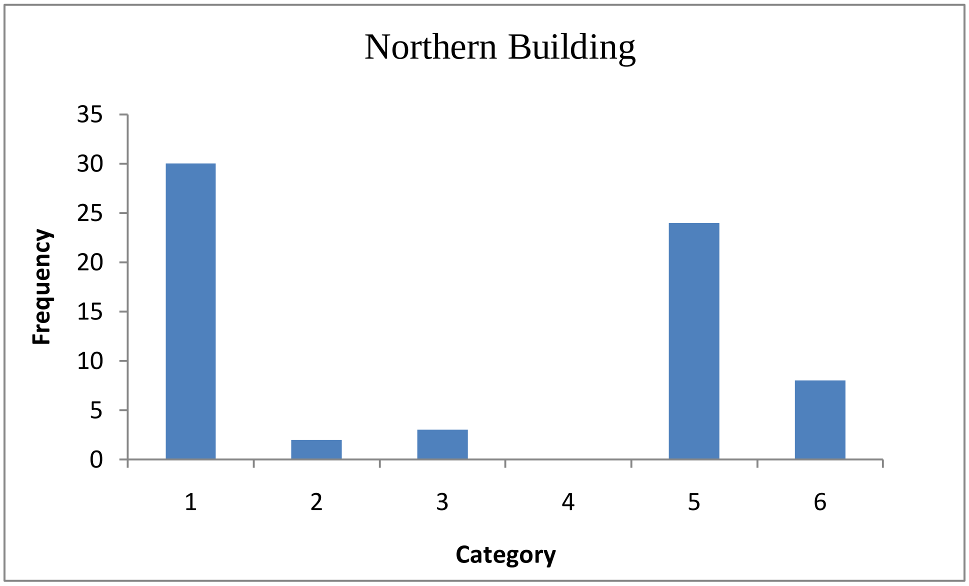
4.3.2: Morphology of Earthen Architecture from the Northern Building (T-18 and T-19)

Trench T-18 produced the majority of fragments associated with the Northern Building (60 fragments at 52.2 kg). T-19 produced several large daub fragments (7 pieces at 19.7 kg). The morphology of the earthen architecture from the Northern building differs from OC2 in quantity and is distinguished by the lack of type 4 fragments with curvilinear or flat impressions (Table 19). This is notable since the context of the fragments of terracotta roofing decoration found in the vicinity of the building is unclear [495] and the building is believed to have been constructed during the interim between the destruction of the Orientalizing Complex and the construction of the Archaic complex.[496] Otherwise, the distribution of fragments is similar to that of OC2. Type 1 fragments comprised the largest portion of the finds and mudbrick fragments were a bit more numerous, comprising 12% of the earthen architecture fragments as compared to 8% for OC2. Type 2 daub fragments number only two and there were only three fragments with impressions of circular timbers.

[495] Winter 2009, 66, assigns roofing material from T-17, the agger, and dumps to either subsequent repairs of the roof of OC1 or the roof of the Northern Building and classifies it as Roof 2-21.

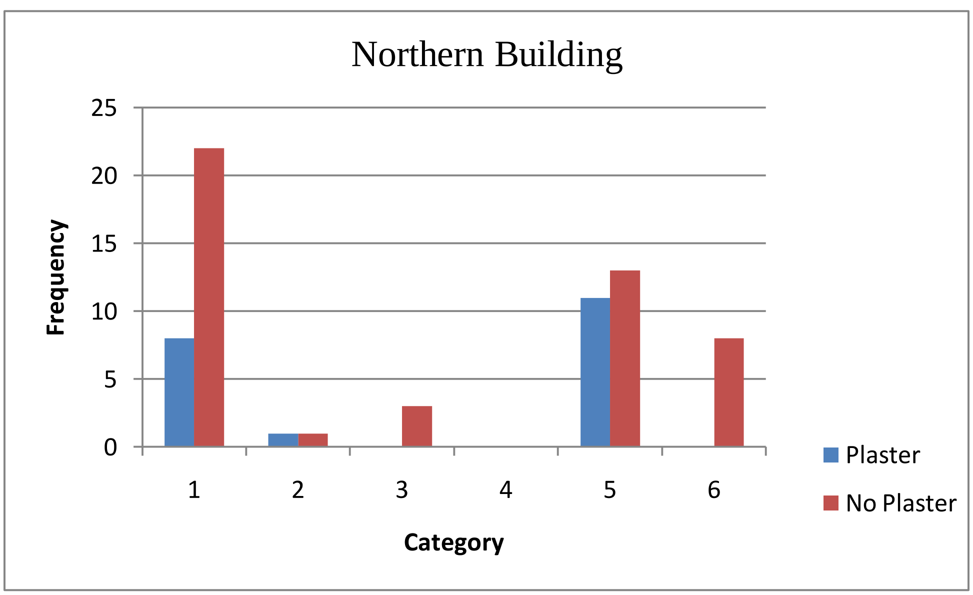
[496] Berkin 2003, 18.

Table 19: Histogram of earthen architectural types



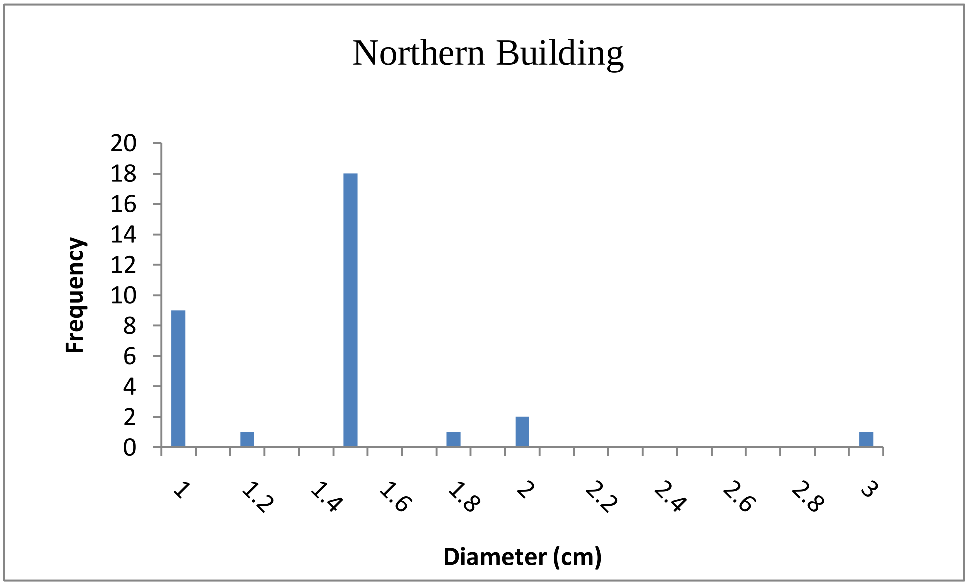
A similar proportion of fragments from the Northern building displayed plaster decoration (Table 20). About half of the type 5 fragments had plaster decoration. None of the mudbrick fragments had plaster decoration. As in OC2, wattled fragments appear to have composed the exterior surface of the building.

Table 20: Decorated (plastered) and non-decorated (non-plastered) fragments



Although there were a smaller number of fragments with wattles, their sizes broke down into the same three rough categories identified at OC2 (Table 21). There was a group concentrating around 1cm, a larger group clustering around the average wattle diameter, 1.43 cm, and then a few wattle with larger diameters from 1.8 to 3 cm.

Table 21: Histogram of wattle diameters

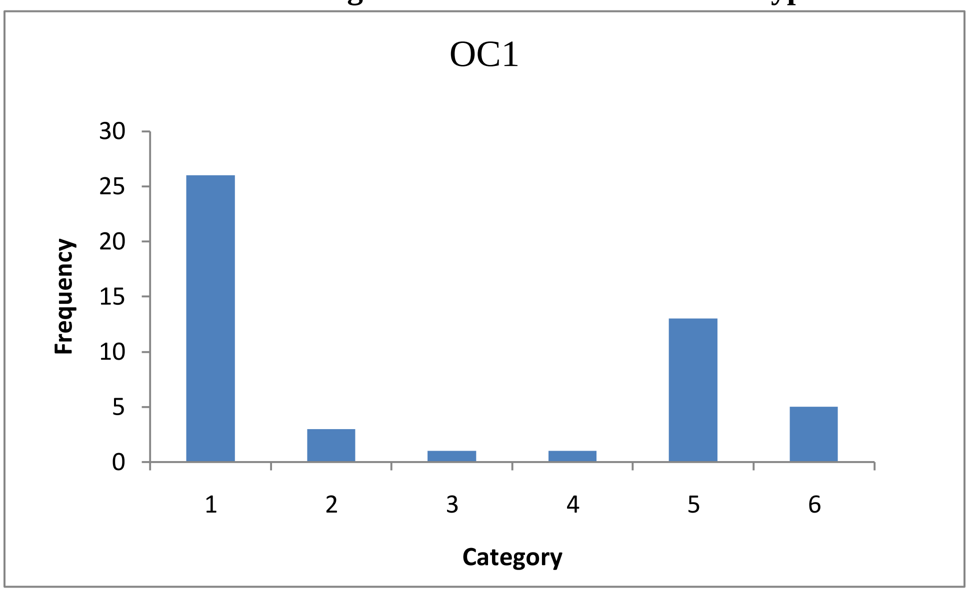


Unlike the wattled fragments at OC2, however, none displayed finished edges either parallel of perpendicular to their direction. A possible explanation for this difference might lie in the lack of evidence for terracotta roof decoration. The walls of the Northern building could have been constructed solely of mudbrick and covered with a simple roof of reeds (wattles) and daub. The wattles had a small average diameter and the absence of finished edges could indicate that there was no junction between ceramics and daub in this building, as was surmised in OC2.

4.3.3 Morphology of Earthen Architecture from OC1 (R5)

The earthen architectural fragments from trench R5 represent the finds from the northeastern corner of OC1. As with the Northern Building, the amount of fragments recovered is far smaller than that from OC2 and numbered only 49. However, these fragments were usually fairly large (total weight of 138.5 kg) and often decorated. The distribution of fragment types is somewhat similar to OC2 and the Northern Building, with type 1 and type 5 fragments comprising the largest categories (Table 22).

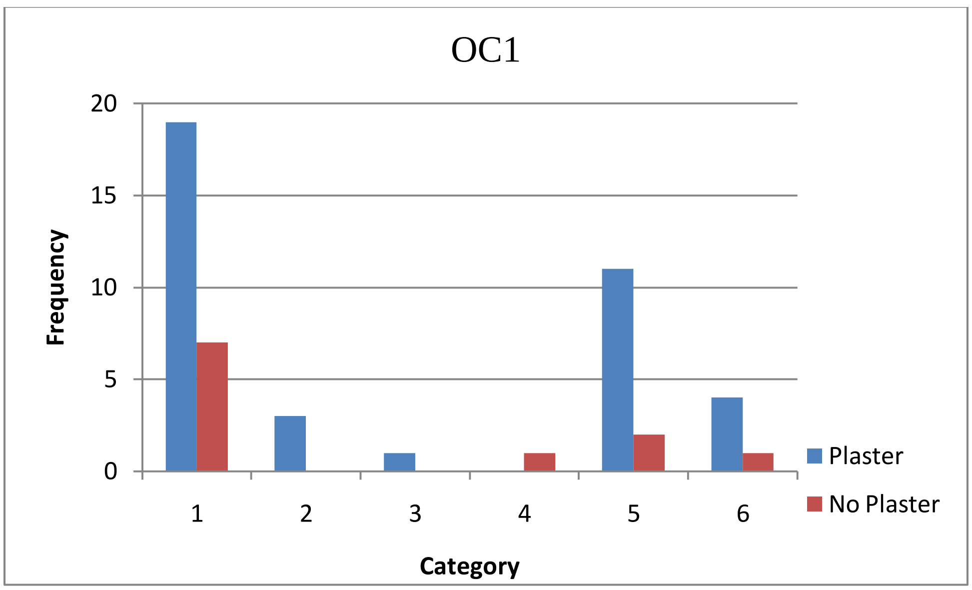
Table 22: Histogram of earthen architectural types



Types 3 and 4 only recorded one fragment each, and the former fragment in category 3 provided a curved circular impression that might not have been structural. This impression was actually in a fairly thick piece of daub that exhibited one roughly flat side (Fig. 160). The impression formed a kind of 'lazy U' on the daub and varied in width, delineating a shallow arc ranging from 3 to 5 cm in length. This fragment has no plaster or decoration and there is no comparanda that I can find. At least for building OC1, the daub fragments displayed no impressions of structural timbers.

In contrast to the other buildings of the Orientalizing period, the majority of fragments recovered from OC1 had plaster on them (Table 23). This is most likely due to the different recovery procedures in place for OC1 during the 1970s versus the other buildings during the 1990s through 2000s. During the latter period, daub without decoration was often retained in the excavation's storeroom.

Table 23: Decorated (plastered) and non-decorated (non-plastered) fragments

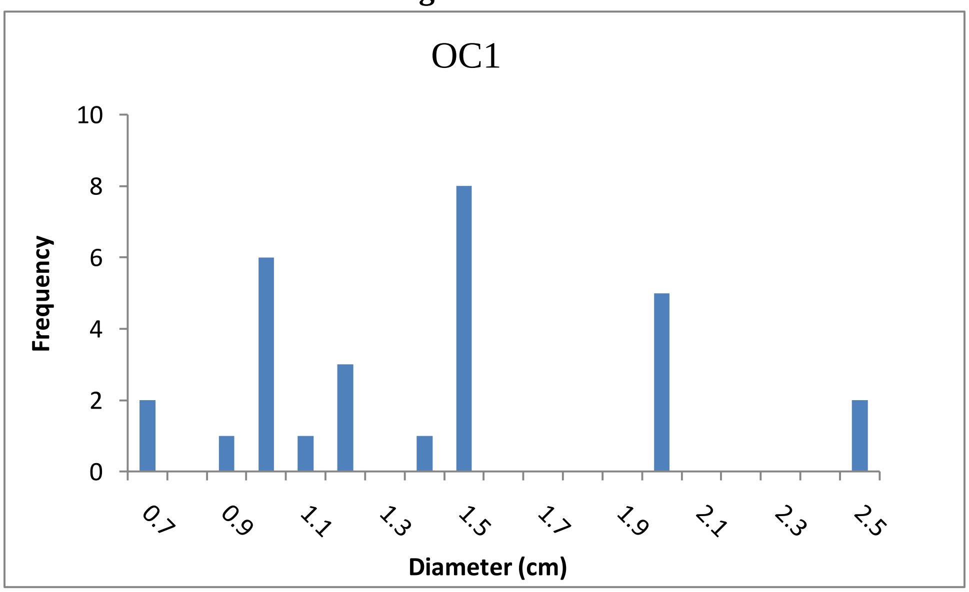


The application of plaster on fragments from OC1 displayed some differences. On most fragments, a fairly thick layer of grayish-white plaster was applied (Fig. 161a), similar to that found on the fragments from OC2. On a few fragments, though, the plaster covering was very thin and appeared to have a reddish hue to it in places (Fig. 162a). This could have been due to the application of paint to decorate certain portions of the exterior walls.

Tiles and acroteria from OC1 preserved evidence of red paint on their surfaces, as did roofing ceramics from OC2 and OC3.[497]

The overall thickness of the daub with wattles (Types 1 and 2) was 5.1 cm, somewhat thicker than that from OC2 (4.35 cm). There were only three type 2 fragments, but they had a substantially higher average thickness (7 cm) than the type 1 fragments (4.8 cm).[498] Similar to the other Orientalizing buildings, the average wattle diameter for OC1 was fairly small, measuring 1.43 cm (Table 24). The average wattle diameter for the three type 2 fragments was considerably higher (1.83 cm) than that for the type 1 fragments (1.38 cm). This was in contrast to OC2, where the average wattle diameter for type 2 fragments was smaller than that for type 1 fragments.

Table 24: Histogram of wattle diameters



[497] Winter 2009, 51-4.

[498] The average overall thickness of type 1 and type 2 daub from OC2 were similar (4.31 cm vs. 4.42 cm).

Similar to OC2, there appear to be three rough groupings of wattle sizes (Table 25). Most fragments have multiple impressions. A little less than half of the fragments with wattles measuring 1.3-1.7 cm had plaster decoration, perhaps suggesting they were most likely to be used for interior screen walls that were not decorated. The larger wattles have the highest tendency to be woven together, in contrast to the practice at OC2. All of the fragments with large wattles had plaster decoration.

Table 25: Type 1 and 2 daub fragments by wattle diameter and orientation

Wattle diameter	Number of fragments	Decorated with Plaster	Fragments with multiple impressions	Woven	Parallel
0.7 - 1.2	13	85%	62%	13%	87%
1.3 - 1.7	9	44%	67%	0%	100%
1.8 - 3.0	7	100%	86%	33%	67%

Some of the largest wattle impressions (2.5 cm) belonged to the thickest wattle-and-daub fragment found at Poggio Civitate. As can be seen in Figure 163, the fragment displayed two layers of large wattles interweaving with one another. A small amount of plaster is visible on its face (Fig. 163a), indicating it was an exterior wall fragment. The fragment most likely intersected with a mudbrick wall or mudbrick pillar since the wattles run perpendicular to a finished edge (Fig 163b). The possibility that hybrid walls built of mudbrick and wattle-and-daub is suggested by the daub fragment depicted previously in Fig. 163. This fragment displayed finished edges both parallel and perpendicular with the running wattles and might have occupied the corner above a mudbrick socle and adjacent to a mudbrick pillar. As with OC2, none of the finished edges displayed the impressions of wood grain so it is more likely that the daub fragments ran into another finished surface, likely mudbrick but also possible stone. With only the latter exception, wattles ran perpendicular into finished faces (Table 26).

Table 26: Type 1 and 2 daub fragments by wattle diameter and finished edges

Wattle diameter	Number of fragments	Finished Edge	Parallel	Perpendicular
0.7 - 1.2	13	1%	0%	100%
1.3 - 1.7	9	11%	0%	100%
1.8 - 3.0	7	57%	13%	100%

Contrary to the evidence from OC2, it appears that OC1 daub fragments with larger wattles were more likely to be woven and occupy a position adjacent to a finished surface, i.e. mudbrick. While in OC2 larger wattles might have been used as lathing for the exterior surface of mudbrick walls, larger wattles were obviously incorporated into the wall structure of OC1. Mudbricks were also incorporated into the walls, with trench R5 providing the most complete fragment from the Orientalizing period (Fig. 164). This mudbrick fragment had intact sides delineating a length of almost 24 cm and width of 10 cm. These dimensions comport well with those found on mudbricks at Roselle, which had finished sides ranging from 7-12 cm in width and 25-32 cm in height. The large fragments of wattle-and-daub and mudbricks recovered from the area of OC1 strongly suggest some type of hybrid wall construction. A hybrid wall construction was suggested at the contemporary site of Acquarossa[499] in southern Etruria (Fig. 105) and also later in time at the Etrusco-Celtic site of Monte Bibele, located about 30 km

[499] Although both Poggio Civitate and Acquarossa (Winter 2009, 54-8) are the earliest sites in Etruria displaying evidence for terracotta tiled roofs with figural decoration, it is difficult to compare the two sites beyond the scope of architectural terracottas since only the tiles have received extensive study and publication (Damgaard Andersen 1997, 359).

southeast of Bologna. This mid- 4^{th} c. BC site included several rectangular structures built on the slope of a hill. The excavators offered reconstructions for a few buildings that were somewhat novel. The buildings were envisioned as having shed roofs supported by vertical posts set on top of the ground that were bracketed by hybrid wattle-and-daub and rubble walls (Fig. 165). Given the slope of the hill, shed roofs would have better facilitated the movement of water off the hill than gabled roofs. Portions of the rubble walls were finished on three sides and a fair amount of daub with timber impressions was found among the building debris, leading them to envision rubble walls topped with wattle-and-daub set against three rows of interior timber posts (diameter circa 15cm) that held up the roof.[500] Such a scenario is not all that different from the evidence for the construction practices for OC2. Evidence for mudbrick and daub for the buildings of the Orientalizing complex potentially makes the hybrid wall conception applicable to each structure at Poggio Civitate.

4.3.4. Morphology of Earthen Architecture from OC3 (R13)

From the area of OC3, only 3 mudbrick fragments were retained (8.3 kg). One mudbrick fragment (Fig. 166) was intact enough to discern its thickness (7cm), which was a bit smaller than the one relatively intact mudbrick fragment from OC1.

4.4 Engineering Assessment of Earthen Architecture at Poggio Civitate

Although not very common, civil engineering principles have been used to validate architectural reconstruction of prehistoric buildings in Italy. Two studies that have relevance to the Orientalizing Complex at Poggio Civitate are the structural analyses

[500] Vitali 1988, 112-16.

of the roof of the large Iron Age building at Luni sul Mignone by O. Nystrom, and that of the temple of Apollo at Portonaccio by J. M. Turfa and A. Steinmayer. Both analyses have come under criticism, however, because of the sizes of timbers that they incorporated into their reconstructions. At the former site, archaeologists envisioned a timber A-frame covered with thatch at a slope of 60 degrees to the ground that rose 13m above a dugout floor and 8.5 meters above the top of the exterior walls (Fig. 94).[501] Scholars, though, have expressed skepticism with regard to its practicality because a structure of that size would have required Iron Age builders, presumably pastoralists, to acquire several timbers at least 9 meters in length.[502] At the latter site, dated to c. 500 BC, Turfa and Steinmayer suggested that a timber truss supported the terracotta tiled roof of the temple. In their estimation, the trusses would have had horizontal tie-beams measuring 0.66 x 0.85 x 19 meters.[503] A beam of this size would have weighed somewhere around 6000 kg - the weight of a small truck - prompting H. Damgaard Andersen to suggest that the beams in their reconstruction would be unnecessarily large and far too heavy to be practical.[504]

Taking each analysis in turn, there are other reasons why these engineering analyses may be misleading. At Luni sul Mignone, the excavators provided calculations demonstrating that the A-Frame they envisioned could withstand wind speeds of up to 90

[501] Hellström 1975, 65-72.

[502] Lollini et al. 1969, 180-81.

[503] Turfa and Steinmayer 1996, 16, assume the beam was equal to the height of the terracotta revetment and the width of column capitals recovered with the temple. The calculation of a beam's weight is based on the density of Douglas Fir, 530 kg/m^3.

[504] Damgaard Andersen 1998, 122.

m/s: [505] about twice as much as buildings today are designed to withstand in the eastern US. For instance, the design wind speed for structures in a hurricane danger zone such as Brooklyn, NY is 51.9 m/s.[506] The calculations for the structure at Luni sul Mignone only take into account the integrity of the timber A-frame but neglect a more critical feature for any lightweight timber frame under wind loading conditions: foundation anchoring.[507] In their reconstruction, there was no allowance made for anchoring the timber frame on either side. One side rests on the rock face above the dugout and the other on a low rubble wall. As noted by the excavators, though, there are no posthole cuttings on the edge of the dugout or anywhere in the vicinity.[508] Thus, it is not clear how the building would be anchored in order to resist the rotational force generated by the wind loading. The low rubble wall on which one side of the timber A-frame terminated would be particularly vulnerable. The steep angle of the reconstructed roof (60 degrees) prevents stacking stones above the base of roofing timbers to hold them down. In short, the larger problem of the A-frame envisioned by the excavators at Luni sul Mignone is not so much the size of timbers required, but rather the lack of any evidence for a stable foundation that might have prevented the overturning of the A-frame in the face of significant wind loading.

For the temple of Apollo at Portonaccio, Turfa and Steinmayer suggested a timber truss had been used by the Etruscans in order to take up the horizontal thrust

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[505] Hellström 1975, 106. .

[506] *ASCE 7-10,* Table C6-3, 315.

[507] Butler 2002, 49.

[508] Hellstrom 1975, 69.

generated by a heavy terracotta tiled roof. The rationale is based on their interpretation of the plan of the building and the comparison of Etruscan and Greek buildings with terracotta tiled roofs. The plan typically presented of the temple is square measuring about 18m on each side. It is divided into two parts by a tufa wall running width-wise, separating a deep pronaos from triple cella in the rear of the temple (Fig. 167). The division of the rear of the temple into three cellas by the excavators is not accepted by Turfa and Steinmayer because the tufa blocks that outline the interior walls were not found *in situ*.[509] In their support, the original state plan provided by the excavator, S. Stefani, depicts jumbles of stones in the rear of the temple along the lines of interior walls, but they were not set in place (Fig. 168). In addition, there was no evidence in the pronaos for postholes or column pads that might have been aligned with interior cella walls, as is usually depicted in plans of the temple.[510] Given the limitations of the evidence for the interior articulation of the temple, Turfa and Steinmayer believe that the temple had no interior supports. Many Greek temples lacked interior supports, but they used cut stones in their walls that could absorb the side-load generated by terracotta tiles sloping down a roof. The Etruscans, on the other hand, presumably used mudbrick or earthen walls on top of tufa foundations. Turfa and Steinmayer rejected the possibility that earthen walls could have resisted the lateral load of tiled roofs by themselves because of the potential for erosion and the possibility that they would displace, or creep, over time. They also dismissed the possibility of 'top-sill' beams running on top of the earthen walls, jointed together like a grid to resist any outward pressure from the tiled

[509] Turfa and Steinmayer 1996, 9.

[510] Stefani 1953, 35-7.

roof.[511] The only possibility that remains, in their opinion, would be a truss with a horizontal tie-beam running the length of the building jointed to the descending rafters of the gabled roof in such a way that it took up any outward force by itself and did not transfer it to the walls (Fig. 169). Turfa and Steinmayer supplemented this scenario with calculations of the roof load and the resulting lateral load that the tie-beam would be expected to take up. If each truss in the building had to shoulder 6000 kg of weight, then half of that would be distributed to each side of the gabled roof. The resulting lateral or 'side' load of that 3000 kg would equal 850 kg. The large cross-section of the tie-beam (0.66 x 0.85m) that they envisioned, placed in tension by the outward force of 850 kg, would only have experienced a loading of about 0.15 kg per cubic centimeter; far below the allowable loadings permitted for structural timbers today (21 kg/cm^2 for cypress and 57.4 kg/cm^2 for oak).[512] Turfa and Steinmayer arrive at this number by assuming that the entire cross-section of the tie-beam would take up the tension generated by the sloping rafters. In their illustration of the jointing between the rafters and tie-beam, however, it appears that only a small portion of the tie-beam would interact with the rafter (Section AA in Fig. 169). The drawing is not scaled so it is unclear how large they believe the cross-section of the tie-beam inserted into the rafter would have been, but it is obvious that the ability of the tie-beam to resist tension would have been significantly degraded because of the smaller cross-section in contact with the rafter.[513] A more general

[511] Turfa and Steinmayer 1996, 33-4.

[512] Ibid 16; calculations are not provided, but the formula they use is f(stress)= P(force)/A(area) = 850 kg/5600cm^3 = 0.15 kg/cm^3.

[513] A large cross section would not be needed to meet the guidelines for allowable tension parallel to the grain for modern structural timber, but it would have to be fashioned in such a way that the bearing surface of the tie-beam made full contact with the rafter. A 7 x 7 cm cross section on a cypress beam would be sufficient to resist 850kg of tension. In general, timber design guidelines strongly recommend against

problem with the tie-beam joint of Turfa and Steinmayer, besides its small size, would be its delicate nature. As they acknowledged, trusses depend on precise sawing in order to ensure efficient jointing.[514] It is not clear that the Etruscans would have had the tools necessary to construct such a complicated joint in a timely and efficient manner. The integrity of the proposed roof at the temple of Apollo at Portonaccio would ultimately depend on dozens of these joints being fashioned without defect.

In his analysis of the long houses of Neolithic Hungary, W. Startin ruled out the possibility of a truss construction for the roofs because of the absence of two tools: a saw with 'set' teeth, and the auger. A truss relies on accurate jointing and pegging and without these two tools, in his view, it would have been impractical to fashion the types of joints necessary to construct an effective truss.[515] Metal saws date back to the Copper Age in Egypt and Mesopotamia but they were primarily small pull-saws used in cabinetry and furniture making. During the late Bronze Age, large saws that resemble modern ones appeared in Crete, measuring up to 170 cm in length, which might have been used for sawing soft stone or wood.[516] Even these large saws from Crete, though, probably acted only in one direction because of the disposition of their teeth. [517] The teeth are the

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notching the ends of a timber beam because it results in a decrease in its strength and a reduction in the area resisting shear forces, which a beam of this size would be particularly vulnerable to. Timber is decidedly weaker resisting shear parallel to the grain. The allowable tension parallel to the grain for a timber is usually about ten times greater than its allowable shear (*AITC Timber Construction Manual* 1994, 5-123, Table 8-6).

[514] Turfa and Steinmayer 1996, 18-20.

[515] Startin 1978, 146.

[516] Goodman 1964, 111-3.

[517] Bartlett Wells 1974, 2-8; with regard to 'set' teeth on ancient saws, Meiggs 1982, 347, claims that one of the saws from Crete had 'set' teeth, not along the entire length, but at intervals. He attributes this observation to Winters 1974, 163, who wrote a non-academic book about forestry and woodworking.

key to an effective saw and their strength and orientation determine the saw's ability to cut wood efficiently and accurately. In order to allow the blade of a saw to pass through timber without getting stuck, the teeth of the saw need to be set in opposite directions and flared out. This setting allows the teeth to produce a cut (kerf) wider than the saw blade that permits the blade to pass through the timber unhindered. The first archaeological evidence for a saw with set teeth and literary references to teeth-setting on a saw only appear during the Roman period.[518] From the Etruscan period, few examples of saws exist and those that do appear to be fragments of small frame saws, most likely used for small-scale board manufacture.[519] At Poggio Civitate, only three metal (iron) tools were recovered among the many metal finds, none of them saws. One tool was a butt-socketed axe 10 cm long from the Archaic period complex. The 7th c. BC finds included an iron sickle 38cm long and an adze with a curved tapering blade.[520]

Evidence for the auger – the only boring tool that can be turned continuously in one direction – also does not appear until the Roman period.[521] From Egyptian times onward, the much less effective bow drill was used to carve shallow holes in wood and is the only drill that Greek and Roman carpenters are depicted using. Unlike the twisted bit

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Meiggs goes on to cite Bartlett Wells for illustrations and discussion of the 'set' teeth of the Bronze Age saws from Crete. To the contrary, however, Bartlett Wells 1974, 8, writes 'As can be expected at this early date, the teeth of these saws are not raked in either direction.' Evely 1993, 26, concurs with Bartlett Wells on the rudimentary nature of the Cretan saws.

[518] Goodman 1964, 116-7, cites a Roman handsaw from the site of Hohenrain-Ottenhause in Switzerland but does not give a date for the saw. He refers to Pliny's discussion of the orientation of saw teeth in *NH* 16.227 as the earliest discussion, but Meiggs 1982,347 cites Theophrastus (*HP* 5.6.3) of the late 4th-early 3rd c. BC, as does Ulrich 2007, 46.

[519] Goodman 1964, 113.

[520] Warden 1985, 91-2.

[521] Goodman 1964, 160-66; Ulrich 2007, 18-21.

of the augur, the square bit of the bow drill does not clear out the hole being drilled. This does not present a problem for the shallow holes bored into wood used in furniture or boat construction, but for deep cuttings into timber of the sort imagined by Turfa and Steinmayer, an auger would be preferable since the turned bit lifts up cuttings as it sinks down into the wood.[522] The absence of these tools from the repertoire of the Etruscan craftsman does not exclude the possibility of a truss at the temple of Apollo at Portonaccio, but it does make the scenario advanced by Turfa and Steinmayer somewhat unlikely. If the Etruscans had wanted to use a timber tie-beam to take up the outward thrust of a tiled roof, they would have needed to devise a simpler solution for connecting the tie-beam to the rafter.

The flaws of these engineering analyses in support of architectural reconstructions that do not have archaeological evidence to support them bring up a broader point that has been the subject of significant debate in North American archaeology: are engineering analyses useful in reconstructing ancient buildings? In 1969, J. Marshall offered a reconstruction of a Hopewell culture 'house,' presumably 40 feet in diameter based on the location of postholes, built c. 200 AD in southern Illinois (Fig. 170). Pottery and 128 postholes were found within the area of the house. Marshall devised a formula based on the lateral strength of columns which he called the strength-resistance index (the square of the diameter of the posthole multiplied its depth) to assess the function of each posthole. If postholes had a high score (above 2000), it was classified as a posthole for a column. Of the 128 postholes, 32 scored above 2000 and the majority of them circumscribed a plan for a quasi-circular structure. Since several postholes were slanted

[522] Hocker 2004, 303; Ulrich 2007, 30-1.

inward and 40 feet (about 12 meters) was deemed too far to span with timbers, Marshall suggested the columns formed a ring of support for a canvass roof held up by ropes.[523] This analysis was criticized on several counts. First, it was not clear what a column's strength-resistance index had to do with its role in holding up a canvass roof held in place by the tension developed in ropes, presumably lashed to the columns somehow. His index was simply a measure of the lateral resistance of a column with no relation to tension.[524] From an archaeological standpoint, no allowance was made for the secondary processes that usually alter the landscape of prehistoric sites. The slant in the postholes that Marshall identified in several postholes and used as evidence to suggest that columns were inclined inwards toward one another might have been the result of disturbance or post-depositional processes instead of construction technique. Along the same lines, postholes are often the only evidence for a building's phase after it has been razed and rebuilt upon. In such a case, it is naïve to assume that all structural information is available to the archaeologist, as if they had come upon an undisturbed level with floor and wall-outlines intact. Whatever reconstructions are offered, it is important to take into account those architectural elements that might not have left behind archaeological markers.[525] Although critics encouraged the line of research that Marshall was pursuing, after his publication on the Hopewell 'house,' engineering analyses have generally not been incorporated into North American archaeological investigations.[526]

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[523] Marshall 1969, 168-9.

[524] Loten 1970, 2001.

[525] Vencl 1971, 451-54.

[526] A recent contribution though is Zink 2009.

As pointed out by Shaffer in the introduction to his study on huts in Neolithic Piana di Curinga, instances when engineering analyses have been employed in support of reconstructions seem to occur at sites where archaeological evidence for architecture is lacking. In the process, engineering analyses may detract from archaeological investigation by closing off the pursuit of other possibilities. Not considered by Marshall, but certainly feasible given the large distances separating the posts, is the possibility that there was no roof for any Hopewell 'house.' Instead, Shaffer believed the evidence pointed to a series of postholes demarcating a fenced -in enclosure. Furthermore, engineering analyses may distort the guiding principles of prehistoric builders by imparting the modern goal of efficiency upon premodern processes of construction. Citing the work of A. Rapoport, Shaffer observed that in non-modern cultures, social considerations often outweigh physical ones when it comes to architectural form.[527]

Shaffer's main point – that engineering analyses can forestall architectural solutions based on actual archaeological evidence – also applies to the Etruscan sites previously discussed: Luni sul Mignone and Portonaccio. At the former site, daub was found in the debris stratum but was nowhere included in the reconstruction of the building. As mentioned above, postholes were not found in places one would have expected if the reconstruction of the A-frame was valid, and postholes that did not correspond to the architectural scenario were explained away as aborted attempts to provide supports for a possible raised floor.[528] At the latter site, the evidence for interior

[527] Shaffer 1983, 48-9; also Ammermann et al. 1988, 136.

[528] Hellström 1975, 67. See chapter 3 for a broader discussion of the evidence from Luni sul Mignone.

walls found by the original excavators was substantial. Stefani found two stone collapses running the length of the interior of the cella that were roughly linear and not related to the two outer walls of the temple.[529] Furthermore, the debris recovered from the temple pronaos included the marble fragments of two capitals and column plinths.[530] The reconstruction put forth by Stefani might not have been perfect, but they were reasonable given the evidence available to him. Central supports would have obviated the need for a truss and the lateral force exerted on the walls would have been greatly reduced, thereby eliminating any need for a truss. The main reason to build a roofing truss for the Temple of Apollo at Portonaccio would have been to provide unobstructed space in the middle of the building. If the roofing structure of the temple of Apollo at Portonaccio had interior supports, the space would have been obstructed with or without a truss. Furthermore, the construction of a truss to provide uninterrupted space in the interior of the cella would have imparted a substantial amount of risk. In Turfa and Steinmayer's scenario, the stability of 6000 kg horizontal tie-beams would have depended entirely on the timber joints at either end of the building.

Nonetheless, civil engineering principles can be put to use in architectural reconstructions devised by archaeologists by focusing on discrete parts of the reconstruction based on actual archaeological data and using resources developed for quick reference in the field of engineering and architecture to test their viability. In the section on morphological analysis, the material from OC2 provided the most complete accounting of architectural techniques used in the Orientalizing buildings at Poggio

[529] Stefani 1953, 105-7.

[530] Ibid 46.

Civitate. There are two particular architectural features of OC2 discussed above whose feasibility can be tested using data from the field of civil engineering: (1) the use of timbers 18 cm in width at an angle of 15 degrees to the horizontal as roofing rafters and (2) exterior wall construction using mudbrick. Since we have an idea about the dimensions of the structural members involved and an estimate of the loading upon the roof provided by Turfa and Steinmayer, guidelines currently used by engineers can provide a check on the feasibility of these techniques. As discussed above, two pieces of daub (Fig. 145 and 146) displayed timbers with diameters of about 18cm set at a slope of roughly 15 degrees to the horizontal which might have served as interior daub fragments set at the junction between the roof, the exterior wall, and an interior screen wall. In this scenario, the 18 cm diameter timbers would have served as the sloping rafters upon which the terracotta tiles would have been laid (see Fig. 171 for a hypothetical reconstruction of an early terracotta tiled roof). Turfa and Steinmayer calculated a roof loading of 85 kg per square meter of roof.[531] In order to calculate the amount of weight that would have pushed down on the rafters of OC2, it is necessary first to determine the tributary area supported by each rafter. Column pads were spaced 2.75 meters from one another in both directions, making each rafter support approximately 2.75 meters of roof (with the exception of the rafters at the ends of the building, which would only support 1.375 meters of roof). The width of the tributary area would then equal 2.75 meters (the tributary area of each pair of rafters is shown graphically on the plan of OC2 in Figure 172). In order to know the length of the tributary area supported by each rafter, it is necessary to know their lengths. This can be calculated if the triangular gabled roof is

[531] Turfa and Steinmayer 1996, 3.

imagined as two right triangles set back to back. The minor angle of the right triangle is defined by the angle that the presumed rafter made with the horizontal (15 degrees). Since the space between the exterior supports and the internal columns was 2.75 meters, given a pitch of 15 degrees the length of the roofing rafter would be approximately 2.85 to 3 meters long.[532] Thus, a linear load of 233.75 kg/m was acting on each rafter for a total loading of about 700 kg.[533]

Since the roof had a central support in the form of a ridge beam set atop an interior column, the rafters can be evaluated as simple beams despite the fact that they rise at an angle between the exterior and internal supports.[534] In theory, all forces set atop the rafters will resolve themselves vertically and no lateral load will be transferred to the walls.[535] Modeled as simply supported beams, it is possible to use the safe loading tables provided in *Wood Structural Design Data* to evaluate whether rafters 18 cm in diameter spanning roughly 2.85 meters would be capable of sustaining a total loading of 700 kg. These tables provide safe load values for commonly used structural timbers that are simply supported over a variety of spans.[536] The structural timber which most resembles the 18cm rafter in question is a 6” x 6”, approximately a 15.25 x 15.25 cm in metric units.

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[532] Cosine 15^{o} = 2.75 meters / length of rafter.

[533] 85 kg/m^2 multiplied by the width of the tributary area (2.75 m) and the length of the rafter (2.85 m).

[534] Turfa and Steinmayer 2002, 4, suggest that OC2 used a tie-beam truss to hold up the roof based on the conclusions they reached about the temple of Apollo at Portonaccio. In this case, however, there is no doubt about the presence of a central support. A horizontal beam could still be used, but it would prevent direct support of the ridge beam, unless another smaller timber was placed in between the apex of the gable beneath the ridge beam and supported in the center of the horizontal beam. A structure such as this would not function as a truss and would require the builders to construct dozens of joints that would not be needed if the central support just ran up to the ridge beam directly.

[535] Underwood and Chiuni 1998, 327.

[536] The *WSDD* uses imperial units, e.g. 2 x 4”, 4 x 4”, etc.

A span of 2.85 to 3 meters equates roughly well with the 10' span safe load tables, which recommend a safe load ranging from 754 to 1677 kg, depending on the allowable bending stress of the timber in question.[537] Thus, a rafter 18 cm in depth for OC2 should have been well capable of sustaining a total loading of 700 kg. This exercise demonstrates that an 18 cm rafter would be within the realm of possibility as a choice for a rafter to support the terracotta tiled roof.

As mentioned above, despite the fact that the rafter is set an angle between its two supports, it behaves as a simply supported beam. The roofing load would theoretically be distributed equally between the two supports, i.e. the ridge beam supported by the center column and the outer column supported on the exterior column pads. There are two reasons - besides the presence of the large amount of earthen architecture documented above - to believe that the exterior supports for OC2 included not only the exterior columns, but also a mudbrick or mudbrick/wattle-and-daub wall. The first reason is the series of small stone pads set 0.35 meters outside the line of exterior column pads on the northern side (Fig. 173). Given the dimensions of the mudbricks found at Roselle and Poggio Civitate, this distance could incorporate the width of a single course of mudbricks. A comparable line of small stone pads were not found on the southern side of OC2, but that side of the building was not preserved as well as the northern side. In line with the suggestion of Shaffer regarding parallel wattles on thin pieces of daub at Piana di Curinga, a lathing of wattles and vertical posts could have been supported on the

[537] *WSDD* 1986, 74. The calculation of the allowable bending stress can be a complicated procedure that involves several modification factors based on the type, quality, and moisture content of the timber used, along with its loading conditions and location. The assignment of an allowable bending stress in order to reach greater precision for an allowable loading on the timber would require assumptions for which there is no reliable data.

small column pads and provided a better gripping surface for the application of daub and mortar for the exterior of the mudbrick wall.

The second reason is due to the action of a simply supported rafter in gabled roof. In theory, all loads from the roof would be resolved vertically but, in practice, some lateral load will be transferred to the walls since the rafters in such a scheme have a tendency to rotate inward about their top-most joints (Fig. 174).[538] A robust mudbrick wall would prevent any inward rotation of the rafters on OC2 and explain why the columns for the building were set on top of column pads instead of being set into postholes beneath the ground in order to resist lateral loading.[539] If the rafters came to rest atop the exterior mudbrick walls, they would transfer a concentrated load of about 350 kg (half of the total load –700 kg) onto the mudbrick. Structural theory for earthen structures is not a well-developed field in civil engineering, but the National Bureau of Standards conducted tests on mudbrick and rammed earth (pisé) walls at the end of the Great Depression in an effort to gauge the potential of earthen structures to function as low-cost construction alternatives. These tests assessed the structural, heat-transfer, and water permeability properties of individual specimens and built walls alike. The mudbrick molds measured approximately 30 x 40 x 14 cm – not all that different from the sizes of mudbricks used by Etruscans. To assess wall strengths, 1.2 and 2.4 meter long mudbrick and rammed earth walls were constructed. The mudbrick walls were set into a lime-mortar and stacked 20-21 courses high and one course wide, while the rammed earth

[538] Amrbrose and Vergun1987, 194-5.

[539] The mudbrick walls tested by the National Bureau of Standards were able to resist lateral loads up to 0.03 kg/m^2 (Whittlemore et al. 1941, Table 10), about of fifth of the lateral loading calculated by Turfa and Steinmayer for the temple of Apollo at Portonaccio. The mudbrick wall’s lateral strength was not high but likely sufficient to restrain any rotation by the rafters.

walls were compacted by hand between wooden forms. Individual specimens and the walls themselves were subjected to concentrated, compressive, and transverse loading to find their maximum resistance capacity. The mudbrick walls tested by the National Bureau of Standards were only one course thick (30 cm). Their tests found that an approximately 2 meter-high mudbrick wall could support a concentrated load of at least 454 kg while maintaining its structural integrity.[540] It appears that the 350 kg load generated by the terracotta tiled roof of OC2 would be able to be absorbed by a mudbrick wall without any risk of collapse. This exercise does not prove that OC2 was built with mudbrick walls and 18 cm diameter rafters, but rather demonstrates that their incorporation into the architectural scheme was a physical possibility. Other scenarios could be imagined and explored. Timbers with an 18 cm diameter that appear to form a 15 degree oblique angle could have served as cross-bracing for an interior wall and the timber rafters may have terminated into some kind of connection with vertical timbers set on the exterior column pads. Although the morphology of the particular pieces examined and the difficulty of fashioning timber connections of the sort imagined by Turfa and Steinmayer make these possibilities less likely, new evidence regarding daub or timber from other Iron Age sites could offer different perspectives and prompt a reevaluation of the architectural scheme.

4.5 Summary of Results of Analyses of Earthen Architecture at Poggio Civitate

[540] Whittlemore et al. 1941, 2-3, 16-7, Table 10.

The evidence for earthen architecture at Poggio Civitate represents a mix of construction techniques. Every building provides evidence for the incorporation of mudbrick, but each building differs in the amount and morphology of the daub that was recovered. The most pronounced differences were between the evidence from OC1 and OC2. The area of OC1 produced some wall fragments with wattle impressions that were almost 20 cm thick, while the majority of daub fragments with impressions from OC2 hovered around the average of 4.34 cm, with none being thicker than 9 cm. The decoration of the earthen walls of OC1 and OC2 also differed. OC1 produced wall fragments with a very thin application of plaster that might have served as a base for painted decoration, while the decoration from OC2 normally consisted of a thick layer of grey-white plaster that provided no evidence of further decoration. Also found in the area of OC2 was a fragment of daub with grooved ridges (Fig. 175), reminiscent of the daub decoration at Rocca di Rivoli and Vidolasco.[541] The daub fragments from OC2 also provided much more evidence for the incorporation of round timbers than any other structure of the Orientalizing period, which could be due to different construction techniques but also could have been the result of the more comprehensive recovery program of recent excavations. Nevertheless, based on the evidence at hand, some general observations can be made. Mudbrick was incorporated into every structure in some manner, most likely in the lower part of walls. The perception that mudbrick should not come in contact with the ground was not shared by the Etruscans. Both at Arezzo[542] and Roselle[543], archaeological evidence demonstrates that the Etruscans had no

[541] Catalogue number PC20040161.

[542] Pernier 1920, 182.

compunction about using mudbrick as a socle course directly on the ground surface. The builders at Poggio Civitate might have been more willing to use mudbrick as a socle course, and perhaps for entire walls, with the knowledge that the plaster applied to the exterior had hydraulic properties. The walls at OC1 not only used plaster for protection but also as a base for painted decoration. The earthen walls at OC1 were also more robust than those used for OC2, but the reason is not clear. It is possible that mudbrick comprised the greater portion of the walls for OC2 but evidence did not survive. Unfortunately, excavations in OC1, OC3, and the Northern Building did not provide any information about possible interior supports. For OC2, the stone pads uncovered during its excavation suggest that three rows of columns supported the roof. It originally had been suggested that this building could have been constructed without walls,[544] but such a scenario is highly unlikely given the amount of earthen architecture recovered and the necessity for the building to have some mechanism to resist lateral loading.

Since OC2 provides the most evidence for its superstructure, a hypothetical reconstruction has been offered in Figure 176. The building is reconstructed with three vertical timbers posts having a diameter of about 30 cm set inside hybrid wattle-and-daub/mudbrick walls in a manner somewhat similar to the reconstruction from Monte Bibele. Since the daub fragments tend to have parallel impressions and are fairly thin, they may have served as an exterior lathing to a core mudbrick wall set outside the exterior columns. The main purpose of the mudbrick walls would be to resist any rotation on the part of the rafter due to gravity or wind loads. Daub fragments from OC2

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[543] Laviosa 1961: 41; tav. 5 a, b.

[544] Nielsen 1987, 91; Nielsen 1991, 256.

that displayed woven wattle impressions might have been part of cross-walls on the short side of the building which served no structural purpose. The 18 cm diameter rafters, set at a gentle 15 degree slope from the ridge beam, would have terminated above the mudbrick walls. The top face of the mudbricks would not have provided a suitable seat for the sloped rafters, so it is possible that the fragments displaying timber impressions at a 15 degree angle to the horizontal discussed above would have performed that role. The transition from a mudbrick to a wattle-and-daub wall might have occurred midway, as at Monte Bible, or above the socle in manners different from the two meter high mudbrick walls depicted in Figure 176. Hybrid mudbrick/wattle-and-daub walls are suggested in this reconstruction because mudbrick fragments, although not as numerous, constituted a significant amount of the evidence for earthen architecture recovered from the Orientalizing complex. It should also be noted that modern ethnographic studies on wattle-and-daub structures in Africa suggest that the line of a wattle-and-daub wall very likely might leave no archaeological indicator. In Roderick McIntosh's study of mudwall decay in West Africa, wattle-and-daub walls were set above the foundations of the huts on a raised bank of earth (Fig. 177). The thin vertical wattles that were set into the raised bank of earth were able to support the daub wall without the aid of large vertical timbers set into postholes along the wall's length.[545]

Other scenarios for which archaeological evidence is lacking can be imagined, however. Patricia Arcelin and Oscar Buschsensthutz detailed the different manners in which long-houses were constructed in temperate Europe before the Roman period and offered a reconstruction of a typical structure that presented a ground plan similar to that

[545] McIntosh 1974, 162-4.

of OC2 (Fig. 178).[546] Lateral load was resisted in European long-houses by sinking the exterior vertical posts on each end of the building deep into the ground. As noted above, though, there are no postholes in the area of OC2. It does not appear the full length of OC2 was uncovered during excavation, so it would be possible that the vertical posts for the end of the building were set into postholes which were not discovered. The posts on each end of the building would then serve as rigid frames that could withstand some lateral loading. Problems with this scenario include the increased weight of the roof on OC2 compared to the thatched roof of a longhouse, and the lack of any evidence to allow for rigid framing in the central portion of the building. Another possibility to resist lateral loading would be to construct a tension joint at the apex of the gabled roof. If the rafters were lashed or notched together above the ridge beam, they would essentially be bound by a tension joint and thereby relieve the walls of the hut from the lateral pressures generated by the roofing structure. This possibility was briefly considered by Turfa and Steinmayer in their article on the roof of the temple of Apollo at Portonaccio, but they dismissed its feasibility because they thought a mortise-and-tenon joint cut into a ridge beam would fail due to shear (Fig. 179).[547] The joint could actually have been located above the ridge beam, though, having been made between the two rafters via lashing or notched together. If this were the case, the builders at Poggio Civitate might have continued using wattle-and-daub for buildings with terracotta tiles roofs because the manner in which they traditionally built structures with pitched roofs did not rely on the exterior walls to absorb the lateral loading of the roofs. A practical construction detail

[546] Arcelin and Buchsenschutz 1985, 20-22.

[547] Turfa and Steinmayer 1996, 32.

such as this could have provided the inspiration for the elaborate acroteria used in Etruria.[548]

It must be noted though that walls would not have had to run the entire length of the building to provide lateral stability for OC2. Several rows of unfired cover tiles were found beneath the debris of the building on the hard-packed floor of OC2, along with a stack of fired pan tiles (Fig. 181). The cover tiles were presumably set out to dry beneath the roof of OC2 in the center of the building. Impressed into some cover tiles were human footprints, perhaps left by workers as they scrambled to get out of the building before its destruction (Fig. 182).[549] The location of terracottas in the process of manufacture in the center of the building suggests that the long walls were pierced by doorways or entrances to allow both ventilation and access. Since OC2 was the southern-most building on Poggio Civitate and had the closest access to the river Crevole (see Map 3),[550] it could have served as a monumental entranceway for those disembarking from the river and making their way up to site.

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[548] Phillips (1985, 11-12) and Rystedt (1983, 161) have suggested that the elaboration of roofs of central Iron Age hut urns might have some relation to the acroterial decoration at Poggio Civitate and Acquarossa. Damgaard Andersen (1992, 29) and Muller-Karpe (1959, 89-96) thought the ends of the rafters of the roof on the hut-urns were manipulated for iconographic purposes. G. Gierow, 1966, 34, 73-5 ,on the other hand, rejected any symbolic meaning for the roofing rafters depicted on Italic hut-urns. In his opinion, the tops of hut-urns were nothing more than faithful renditions of the typical roofs of huts that used criss-crossing beams above the ridge pole in order to weigh the thatch down. Gierow essentially did not believe that they were rafters. Bartolini 1987, 142, believes the ends of the beams/rafters were decorative. Whether or not the criss-crossing beams/rafters had a decorative purpose, they do appear to sit above the roofs of the hut-urns (Fig. 180) and thus would not represent structural members of the roof, as suggested by Gierow.

[549] Nielsen 1987, 91-4; Nielsen and Tuck 2001, 37.

[550] OC2 was originally called the Southeast building because during the earliest excavations because magnetic north was thought to run in the direction of 'Northern' Building (see the north arrow in Map 4). As pointed out by N. DeGrummond 1997, 26-7, the 'Northern' Building truly lies to the northeast and the 'Southeast' Building lies more to the south of the Archaic complex.

CHAPTER 5: CONCLUSIONS

5.1: SOURCES FOR TECHNOLOGICAL CHANGE

To restate, the two main research questions that the survey of construction techniques in earthen architecture and the archaeometric and morphological analyses sought to answer were as follows:

1) Did the construction techniques at Poggio Civitate represent a break from the vernacular architectural tradition and, if so, how?

2) What foreign influences were present in construction materials or techniques?

This study suggests that the construction techniques used at Poggio Civitate in conjunction with the adoption of terracotta tiled roofs incorporated foreign influences, but those techniques were tempered and filtered through an indigenous prism. The use of a plaster with hydraulic properties and rectangular mold-made mudbricks were new developments most likely inspired by eastern contacts, but the Italic/European technique of wattle-and-daub wall construction persisted in concert with these new technologies. In assessing the source of foreign influences, the balance of evidence suggests the builders at Poggio Civitate during the 7th c. BC developed their hybrid architecture based on their familiarity with Near Eastern construction practices, not those used by Greek colonists.

Plaster/mortar with hydraulic properties is attested at Phoenician colonies in the western Mediterranean during the Orientalizing period; no comparable evidence exists in the areas colonized by the Greeks during the same time. Rectangular mold-made mudbricks appeared as early as the 8th c. BC in Spain, but the earliest evidence for mudbricks in Magna Graeca comes from a context contemporaneous with Poggio Civitate. This conclusion, based on the evidence of earthen architecture on site, stands at odds with the widely held belief that the primary influence on Italian architectural techniques came from Greece and could suggest a different origin for the technology of terracotta tiled roofing.

The recent study on the morphology of Proto-Corinthian terracotta roofing tiles by P. Sapirstein reached a comparable conclusion. From a morphological point of view, he believed that the best archaeological evidence for the origin of terracotta roofing tiles came from Etruria. His reasoning was based on the simplicity of Etruscan roofing tiles, as compared to those from the earliest dated contexts in Greece: Olympia and Corinth.[551] The terracotta tiled roofs at the latter sites had more developed tiling systems, to include corner tiles designed for the transition to a hipped roof in their earliest iterations. At Poggio Civitate, only basic components for the construction of the tiled roof - ridge tiles, cover tiles, pan tiles, a lateral sima -were present at the Orientalizing Complex. However, the evidence for earthen architecture at the site demonstrates that the use of terracotta tiles at Poggio Civitate was part of a larger package of technological changes introduced into Etruria that appears to have had its origin in the eastern Mediterranean. The original path of diffusion imagined for the technology of terracotta tiles to Etruria started at

[551] Sapirstein 2008, 354.

Corinth and 'island-hopped' to Corfu, then Sicily, and finally onto peninsular Italy. The evidence from Poggio Civitate and also Tarquinia[552] suggests that the transfer of construction technology into peninsular Italy was not so linear. Maritime trade appears to have enabled the transfer of goods and technology from the eastern edge of the Mediterranean to Etruria without any Greek filter.[553]

The rapid movement of this technology in the Mediterranean during the Orientalizing period can also be seen in Anatolia. There, a tiled roof from the Artemision at Ephesus was locally produced and at least contemporary with those at Corinth in Greece.[554] This new understanding of terracotta roofing technology demonstrates that different types of terracotta tiled roofs appeared in northern Italy, Greece, and Anatolia within a short span of time and largely independent of one another.[555] Poggio Civitate may not represent the origin of the technology Mediterranean-wide, but at the moment it does stand at the beginning of the development of this technology in its region, as opposed to the evidence from Corinth and Ephesus. Charlotte Wikander has objected to suggestions that the Etruscan terracotta tiled roofs originated without any connection to Greek roofs[556] because every early Etruscan terracotta tiled roof excavated so far has decorative features in the form of revetment plaques, simas, or antefixes; no simple roof

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552 Bonghi Jovino 1991 on the 7th c. BC 'edificio beta' at Civita.

553 A similar transfer has been suggested by Strøm 1971, 201-16, who considers the production of gold and silver jewelry during the Orientalizing period in Etruria to have been a collaboration between Syrian and Etruscan craftsmen with no Greek intermediaries.

554 Bammer 2004, 69-76; Schädler and Schneider 2005, 47.

555 Sapirstein 2008, 343, thinks the roofing tiles at Ephesos had some relation to those on the Greek mainland but were local productions.

556 Ridgway and Ridgway 1994, 8; Nielsen 1987, 119.

of pan tiles and acroteria has been documented up to this point. This study concedes Wikander's point,[557] but the evidence from the earthen architecture at Poggio Civitate suggests that the influences active in the diffusion of the technology to northern Etruria originated further east than mainland Greece. In the case of Poggio Civitate, the most significant foreign influences in construction appear to come from the Near East.

The influence of Phoenician traders in Italy during the Orientalizing period has been the subject of recent studies[558] and is underscored by R. Fletcher's quantitative study of Iron Age imports into Italy. His research illustrates that most of the imports into Etruria during the latter half of the 8th c. BC came from the Levant (Map 5). In the first half of the 7th c. BC, imports from the Levant still comprised the majority of imports into Etruria and Latium (Map 6) but during the second half of the century, goods from Greece began to gain a larger portion of the market (Map 7).[559] This trend can also be seen in the imports into the area around Poggio Civitate during the first half of the 7th c. BC (Map 8), wherein Levantine imports comprised a large portion of the material recovered from Populonia and Vetulonia, as compared to the first half of the 6th c. BC (Map 9), when it appears Levantine imports have been crowded out by imports from the Greek world. [560] Looking at import data for all of Italy during 7th c. BC (Map 10) and comparing it to data from the 6th c. BC (Map 11), it can be seen that Levantine imports clustered in northern Italy during 7th c. BC and then all but disappeared during the 6th c. BC as Greek imports

557 Wikander 2001, 272.

558 E.g., the collected essays in Riva and Vella 2006.

559 Fletcher 2007, 56-8.

560 Ibid 66-8.

came to dominate the market. Northern Italy - Etruria in particular - might have been attractive to traders because of its mineral wealth,[561] but Fletcher is skeptical that Levantine traders were drawn to northern Italy for this reason since no evidence exists for the exploitation of mines in Etruria before the mid-6th c. BC.[562] While the motivations of Levantine traders remain obscure, it is clear that Etruscan elites desired and sought eastern goods from the Near East. Albert Nijboer has suggested this acquisitive desire on the part of the Etruscan elite was rooted in their intent to imitate and associate themselves with Phoenician traders,[563] who, according to the Phoenician archaeologist Maria Eugenia Aubet, enjoyed a high social status.[564]

5.2: Motivations for Technological Change

The intrusion of Near Eastern techniques of construction can help to explain how the technology of roofing structures changed in Italy, but the reason why this change took place remains elusive. If one takes a broad view of the development of construction technology, the moment in time when builders in Italy should have adopted architectural terracottas for roofs would have coincided with the Roman development of concrete in the late 3rd/early 2nd c. BC.[565] Concrete walls could be manufactured quickly and

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561 Sherratt and Sherratt 1993, 369; Boardman 2001, 35.

562 Fletcher 2007, 126-7; also Warden 1984, 357-60.

563 Nijboer 2008, 451.

564 Aubet 1993, 92-113; 2006, 105, believes that Phoenician traders were usually members of wealthy aristocratic trading families. She bases this view off papyrii documents, particularly the story of Wen-Amon dated to 1070 BC. Wen-Amon was an Egyptian priest who was sent to Phoenicia to obtain lumber. Aubet points out that in his story, trade was controlled exclusively by the Phoenician 'princes' and the gist of the story regarding trade with the Phoenician city-states suggested that trade was the tightly controlled purview of a mercantile elite.

565 Blackman 2008, 644.

cheaply with unskilled personnel and easily handle the increased loading introduced with a terracotta tiled roof. It is in this regard that assigning 'agency' to objects – in this case, buildings decorated with architectural terracotta – could assist in explaining the precocious adoption and innovation of this new technology in Etruria. Tuck's recent research has advanced in this direction by attempting to tie the iconography of the lateral simas and acroteria of the Orientalizing Complex to wider political developments in central Italy.[566] As mentioned in Chapter 1, Tuck suggested the female and feline antefixes and lotus palmette acroteria used to decorate the roofs of the Orientalizing buildings would combine to represent to the viewer a key attribute of the eastern Potnia Theron: fertility and fecundity. Also associated with the Orientalizing levels were the 'canopic' antefixes that depicted a bearded male and were assumed to have alternated along the lateral sima with the female antefixes. Phillips called these male antefixes canopic because of his belief that they resembled the masks placed upon the canopic funerary urns from Chiusi.[567] Tuck suggests that the placement of the male antefix alongside the potnia theron was part of a program advanced by a local chieftain to associate himself with the Italic equivalent of an eastern fertility deity. In this way, the

[566] Tuck 2006, 132-3.

[567] Phillips 1984, 415-16; 1986, 153-4. Phillips also suggested the male antefixes were terracotta representations of the bronze masks that were affixed to canopic urns. Based on a terracotta house model dated to the 4^{th}-3^{rd} c. BC in the museum of Capua that depicts a male protome at the end of the ridge pole, Phillips suggested that the bronze canopic masks of local chieftains were fashioned while they were still alive and then nailed to front of the house on a rafter or ridgepole (the bronze masks often have several holes in them, presumably so that they could be affixed to either the urn or perhaps, in Phillips' scenario, a house). Thus, the placement of a male antefix along the lateral sima at Poggio Civitate would mimic a local practice and link the iconography of the building to its local patron. Besides the problem of linking a late southern Italian house model with a roof in 7^{th} c. BC Etruria, a practical issue presents itself. The placement of a mask made of precious metal to the roof of a house would expose it to corrosion and/or theft by passers-by.

local elite could cement their positions atop society by presenting their rule as sanctioned in a *hierogamos*, a divine marriage between a mortal man and a female deity.[568]

The imperative for a sophisticated hierarchical form of societal organization becomes evident when considering the amount of effort required in constructing the Orientalizing Complex. An understanding of the quantities of earth required and the amount of manpower involved can be gathered from the results of several studies in experimental archaeology in Italy, Denmark, and Greece. G. Shaffer built two wattle-and-daub walls in his study of hut construction at Piana di Curinga and found that it took 77.76 man-hours to construct one cubic meter of wall volume, to include making the wattle frame and mixing water, chaff, and the dry daub together and then applying the mixed daub to the wattles frame.[569] For each cubic meter of wall, 1413.6 kg of dry daub were required.[570] At the Orientalizing complex, taking into account the ground plans of the three buildings OC1, OC2, and OC3 and assuming 2m high walls 35 centimeters thick, the volume of the earthen walls altogether approaches 190 m^3.[571] If we assume earth would have been moved in buckets and that the average 10 kg bucket has a volume of about 8500 cubic centimeters,[572] builders at Poggio Civitate would have had to acquire over 22,000 buckets of dry daub weighing nearly 270, 000 kg to construct the earthen walls for all three buildings. In his study, Shaffer is not explicit on the timber supplies he

[568] Tuck 2006, 134-5; 2010, 213-18.

[569] Shaffer 1984, 118.

[570] Ibid 124.

[571] OC1 measured 36.2 x 8.5 m, OC2, 23.3 x 9.2 m, OC3, 51 x 6.6 m. The pisé walls of the Archaic complex were 0.9 meters thick.

[572] An average 10 kg bucket would have a diameter of about 20 cm and a height of 26 cm.

used for the walls, but Danish archaeologists constructed an entire house made of wattle and daub measuring 6.1 x 4.6 m and found that the 20 cm thick and 2 meter high walls required over 8000 kg of daub, 48 wooden posts up to 2.5 meters tall, and 2000 wattles.[573] Since the entire volume of the walls of the Danish house was only about 9 cubic meters, the 190 cubic meters of earthen walls at Poggio Civitate would need timber and wattle supplies over 20 times greater if all the walls were constructed out of wattle-and-daub, and that estimate neglects the larger timber supports needed for a terracotta roof. According to Shaffer's work rate, the construction of the walls for buildings of the Orientalizing Complex would require nearly 15,000 man-hours; or 50 people working 10-hour days, 7 days a week, for over a month. If mudbricks were incorporated into the construction scheme, that may have reduced the amount of labor required. V. Walsh constructed a small 2 x 3 m mudbrick house in Cyprus as part of her 1979 study on the Late Bronze Age structures in Nichoria, Greece. As a point of comparison, setting aside the quarrying of earth which Shaffer did not include in his calculations, it took Shaffer 77.76 man-hours to construct a cubic meter of a wattle-and-daub wall versus 88.5 man-hours for Walsh to construct a cubic meter of mudbrick wall. However, of those 88.5 man-hours, 29.7 were spent collecting and laying a stone socle.[574] At Roselle and Arezzo, the only places where mudbrick walls have been found *in situ* in Etruria, there was no stone socle. Thus, if the time spent constructing a stone socle is subtracted from Walsh's time estimate for a cubic meter of mudbrick wall, it would take 58.8 instead of 88.5 man-hours for construction, or almost 20 man-hours less per cubic meter than

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[573] Coles 1967, 13; Hansen 1962, 128-31.

[574] Walsh 1980, 17, 162-7.

constructing a wattle-and-daub wall according to Shaffer's estimates. Given these requirements, the incorporation of mudbrick into the construction scheme at Poggio Civitate could have reduced the amount of time spent in constructing the walls, but the construction of the complex would still represent an advanced level of communal organization.

In Tuck's opinion, the practice of legitimizing aristocratic rule at Poggio Civitate by claiming divine heritage was not fundamentally different than the mechanism of political manipulation practiced in Rome between the King Servius Tullius and the Italic goddess Fortuna as envisioned by Patricia Lulof,[575] and the program is reminiscent of the mythical founder of Rome, Aeneas, who was the product of a mortal-divine relationship. This rationale behind the iconography of the terracotta tiled roof and the buildings themselves would be the logical end of the process of emulation and imitation envisioned by Nijboer at the onset of the Orientalizing period. Etruscan elites at first sought out exotica from Levantine traders and then, at least at Poggio Civitate, began to produce the exotica themselves. Finds recovered from the debris levels of the Orientalizing complex included locally produced luxury items such as carved bone, antler, and ivory.[576] Bronze and copper objects, mostly utilitarian, were also worked on site in the vicinity of OC2.[577] Fine gold and silver jewelry[578] were found in the debris of OC1 which was based on prototypes from Egypt and the Near East,[579] but it is not known if they were locally

[575] Lulof 2000, 215.

[576] Nielsen 1983, 1984.

[577] Warden et al. 1982, Warden 1985.

[578] DePuma 1981, 78-89.

[579] DePuma 1985, 93.

produced. Although it is not possible to definitively know the intentions of the individuals who constructed the Orientalizing complex, the archaeological evidence indicates a primary function of the Orientalizing buildings was to consolidate craft activities in a central location and produce objects based on eastern prototypes. The construction of the entire complex and the co-location of craft activities on site suggest that the buildings themselves served as mechanisms of organization and control.

5.3: Circumstances Enabling Technological Change in Orientalizing Italy

The notion that the technology of terracotta tiled roofs could have been initially developed on the peripheries of the Mediterranean by the peoples of the Near East and Etruria might seem odd, yet it would be in line with the concept of diffusion as a *conjoncture* advanced by Lewthwaite to explain the Bell Beaker phenomena. In his view, pottery types and styles of northern Europe enjoyed distribution as far south as southern Iberia because maritime trade routes were beginning to open up after a long period of retrenchment during the Neolithic period. This phenomenon set the stage for the Mediterranean-centric Bronze Age with more trade and greater material homogeneity.[580] A similar phenomenon can perhaps be imagined in the western Mediterranean during the Orientalizing period. During this time, technology and material began to move again via open maritime trade routes and allowed the transfer of technology, ideas, and material culture to move along asymmetric axes and develop in disparate areas. Ideas and material did not have to 'island-hop' from one end of the Mediterranean to another. This does not suggest that there was some genetic link

[580] Lewthwaite 1987, 49-52; also n. 74 above.

between the peoples of the Near East and Etruria, as has been suggested recently by DNA studies.[581] On the contrary, this model of development in the early Iron Age and Orientalizing period could help explain the apparent puzzlement on the part of some early historians on the origins of the Etruscans. Herodotus believed the Etruscans were migrants from Lydia,[582] while Hellanicus of Lesbos[583] and Anticleides[584] thought they were an ancient wandering people from northern Greece called the Pelasgians who came to settle in Etruria. Only Dionysius of Halicarnassus identified the Etruscans as natives of Italy.[585] The peculiarity of the Etruscans to early historians could be due, in part, to the fact that those living during the classical period inhabited a world where material culture was much more homogenous. By the end of the 6th c. BC, Greek material culture had overtaken all of Italy (Map 11)[586] and by the 2nd c. BC, the Romans had quashed any further Levantine influence in the western Mediterranean with the destruction of Carthage. The presence of the Etruscans on peninsular Italy, with their unique customs

[581] The earliest DNA studies were on human samples, including Francalacci et al. 1996 and Moggi-Cecchi et al. 1997. A more recent study purporting to establish a genetic link between Etruscans and Near Easterners is Vernesi et al. 2004, which was criticized by Bandelt 2004, Malyarchuk and Rogozin 2004 (reply Barbujani et al. 2004), and Turfa 2006 (reply Barbujani 2007). Since then, researchers have suggested that mitochondrial testing on Tuscan cattle establishes a genetic link between Etruscan and Near Eastern cattle, and therefore possibly people, in Achilli et al. 2007 and Pellechia et al. 2007. This study has been criticized by Perkins 2009, who offers a general overview of the competing arguments. Magness 2001, however, has suggested that the burial customs in southern Etruria suggest small groups of Near Eastern immigrants could have immigrated into southern Etruria and become part of the Etruscan elite.

[582] Hdt. 1.94.

[583] Dion. Hal. 1.28.

[584] Strab. *Geog*. 5.2.4

[585] Dion. Hal. 1.25-30.

[586] Fletcher 2007, 115-8.

and material culture, might call for some dramatic explanation in the mind of the ancient historian.[587]

The lack of technological change in the classical world and by extension, an overall homogeneity in material culture, was a key theme in the work of the ancient economic historian, Moses Finley. His work had significant influence on classical studies and contributed in large part to the neglect of the study of technological development in the ancient world, at least in the opinion of the Roman archaeologist Kevin Greene.[588] Finley believed technology did not appreciably advance during the classical period because no profit motive existed as it is understood in modern capitalist terms. He recounted the story told by Pliny the Elder,[589] Petronius,[590] and Cassius Dio[591] about a Roman citizen approaching the emperor Tiberius with a new 'invention' - unbreakable glass. After presenting his new invention to the emperor, he was promptly executed because Tiberius feared this new material would challenge the value of gold. Finley had no opinion on the veracity of the story but thought it illustrated the ancient mindset about technological progress and economic reward. The ancient authors expressed no surprise that the inventor had brought the technology to the emperor instead of trying to exploit it for his own fortune. In Finley's view, technological progress has only become a goal of society with the rise of the modern market economy while in the

[587] On the efforts of ancient writers to cast the Etruscans as distinct from Greek and Romans, often in unflattering terms, se Firpo 1997, MacFarlane 1996, and Bittarello 2009.

[588] Greene 1994, 22-3.

[589] Pliny *NH* 36.56.195.

[590] Petron. *Sat.* 51.

[591] Cass. Dio 57.21

ancient world, other values held sway.[592] Greene has countered that Finley's view of ancient technological progress was too pessimistic. Glass technology, for instance, had been widely exploited[593] and important technological advances had been made in the fields of agriculture, food processing, mining, and pottery during the Roman period.[594]

Greene is undoubtedly right in his criticism, but Finley's argument did not rest on this story alone and Greene may be missing the larger point that Finley was trying to make. Technological progress certainly took place during the classical period but efforts to fundamentally change the manner in which people lived – the technology that formed the backdrop of the *longue duree*, in Braudelian terms – could not be sustained in the Greek and Roman worlds. Finley referred to the behavior of the governments of the Ptolemies in Egypt and the late Roman emperors as instructive. In the former case, the Ptolemies had unlimited authority in their state and were able to transform Egypt in a short time from a technological backwater to the technical and scientific rival of Greece. Despite obvious economic incentives, it never occurred to the Ptolemies to push beyond the existing plateau of technology achieved by the Greeks in agriculture or industry. Technology may have stagnated in Ptolemaic Egypt due to the lack of any profit motive, but even the imperative of survival could not compel technological change in the late Roman Empire. Roman emperors of the 4th c. AD had to be aware that their borders were no longer secure, but they were incapable of structurally changing agricultural or

592 Finley 1973, 147.

593 Greene 2000, 46.

594 Greene 2000, 35-9. 2008, 62-65, wherein he provides an overview of several recent studies on Greek and Roman technological innovations.

industrial processes within their realm to free up personnel and resources for defense.[595] Finley's general concept of technological stagnation during the classical period may have found some support in the research of Serafina Cuomo, who in her recent book *Technology and Culture in Greek and Roman Antiquity,* suggests that craftsmen were purposely marginalized in the classical world by the aristocracy. In her opinion, craftsmen possessed learned knowledge whose progression and potential to initiate change represented a threat to elites, who relied upon inheritance and the *status quo* to maintain their social positions.[596]

The preceding discussion of technological change in the Roman period is offered in contrast to the situation in the 7th c. BC Mediterranean. The complete transition from a European-centric to a Mediterranean-centric mode of life (in the vocabulary of Lewthwaite) after the destruction of Carthage and the rise of Roman hegemony might have actually inhibited the advance and development of technology. The open lines of communication afforded by a Mediterranean-centric *structure* could be considered a double-edged sword for technological change. Maritime trade enabled rapid and widespread technological diffusion but the rise of a hegemonic power, such as the Romans after the 2nd c. BC, could use those lines of communication to propagate a homogenization of thought and material culture and thereby inhibit technological development. Thus, the Orientalizing period might have been a particularly auspicious time for the invention and innovation of terracotta tiled roofs throughout the Mediterranean. In the absence of any dominant central power, elites throughout the

[595] Finley 1973, 148-9.

[596] Cuomo 2007, 167-8.

Mediterranean during the Orientalizing period were able to experiment with a variety of new technologies without interference or compulsion. This, of course, is a hypothesis about the circumstances behind technological change in the 7^{th} c. BC Mediterranean that would need to be tested by investigations into other fundamental technological changes in the premodern world. Even if circumstances for technological change can be established as favorable, it is still a socially-embedded process. Ultimately, the adoption and development of terracotta tiled roofs at Poggio Civitate depended on an elite who perceived some advantage in its development and implementation.

5.4: Directions for future research

This study has attempted to use archaeometric techniques and materials science to describe the innovation of terracotta tiled roofs at Poggio Civitate during the 7^{th} c. BC. These techniques can be implemented at other pre- and proto-historic sites in Italy in order to gain a better understanding of the phenomenon. Even cursory morphological analyses of architectural evidence recovered from pre-and proto-historic archaeological sites could help to fill out the genealogy of earthen architecture in Italy begun in this study. Component analysis of plasters/ mortars and daub using thermogravimetric and elemental investigative techniques offers significant promise in understanding the development of architectural technology in the ancient world. In particular, the testing of plasters/mortars from Etruscan and Greek colonial sites of the $7^{th}/6^{th}$ c BC would help to illustrate the extent to which Italians were influenced by foreign manufacturing techniques. Since Poggio Civitate was an inland site, it is reasonable to assume that some contemporary Etruscan settlements on the Tyrrhenian seacoast and along the Ombrone river valley should display evidence for foreign construction techniques, as seen at Roselle. The possibilities and limitations that these new construction techniques afforded can be assessed by consulting the references used by architects and engineers as demonstrated in Chapter 4.

The explanatory models provided by the Annaliste and Neo-Darwinian approaches, along with ‘Thing theory,’ have provided a provisional rationale for the causes of technological change at Poggio Civitate during the Orientalizing period but for proto-historic and historic archaeological sites for which a large amount of data is available, there is potential to explore other approaches. A more detailed understanding of the social dynamics behind technological change in Orientalizing Italy might be gained by adopting a wider ‘Mediterranean’ perspective. Proto-historic sites in Greece and Spain also encountered and developed new technologies during the Iron Age. The circumstances in which small, inland sites similar to Poggio Civitate incorporated new materials and construction techniques into their built environment could provide useful paradigms through which our understanding of the dynamics of technological change at Poggio Civitate could be expanded.

Figures referenced in Text

Unless otherwise noted, all photos and drawings are the author's own.

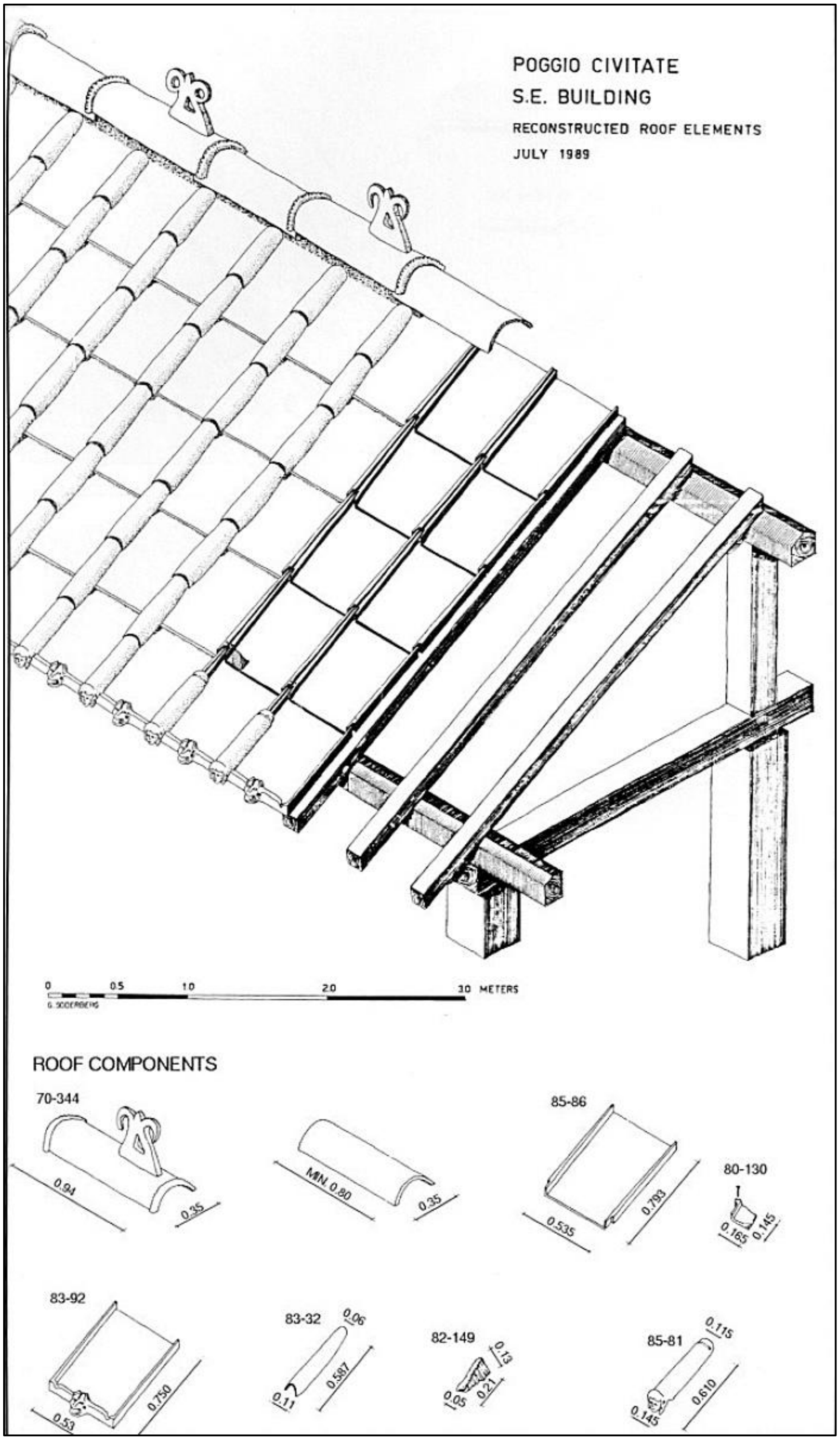


Figure 1: Reconstruction of architectural terracottas used on roof at Poggio Civitate (Nielsen 1998, 97)

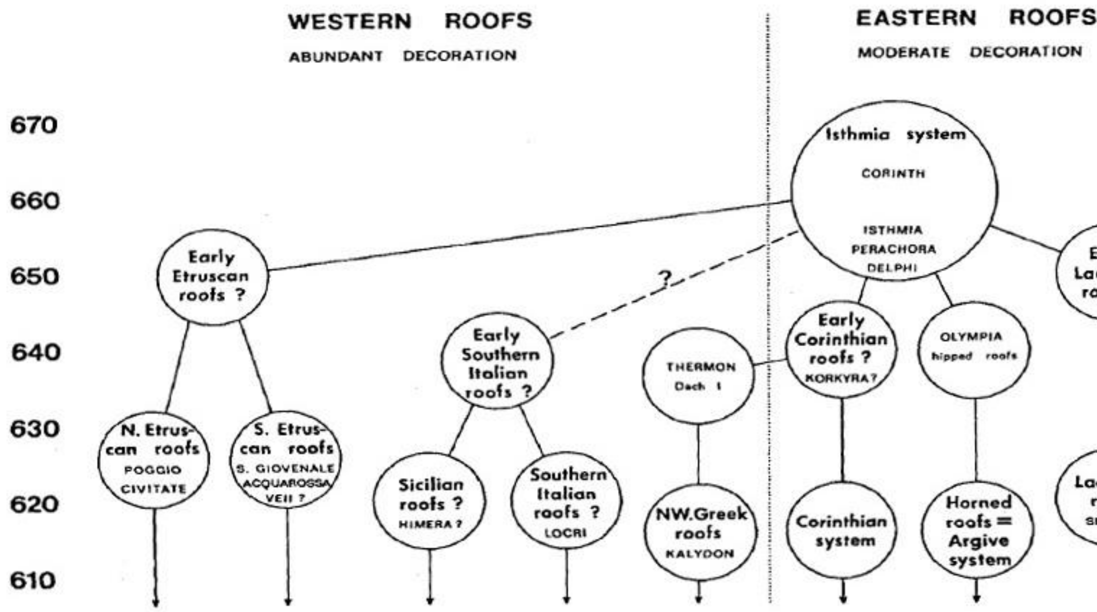


Figure 2: Hypothetical development of terracotta roofing tiles (O. Wikander 1992, 160)

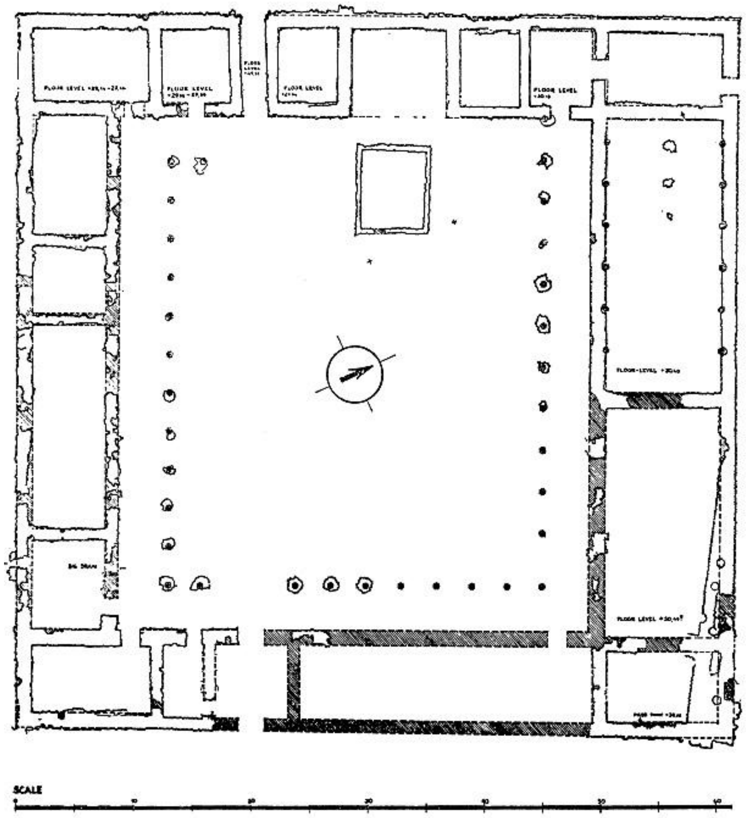


Figure 3: Poggio Civitate - 6th c. BC Archaic complex (Phillips1972, 250)

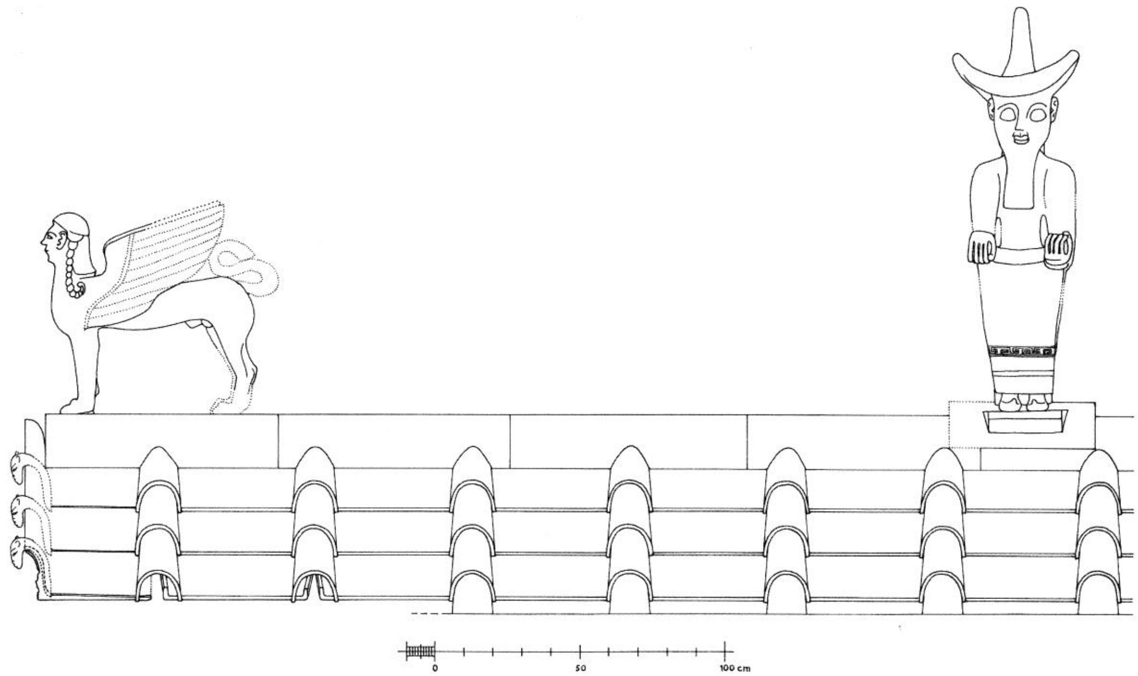


Figure 4: Poggio Civitate - Archaic roof (Winter 2009, 156)

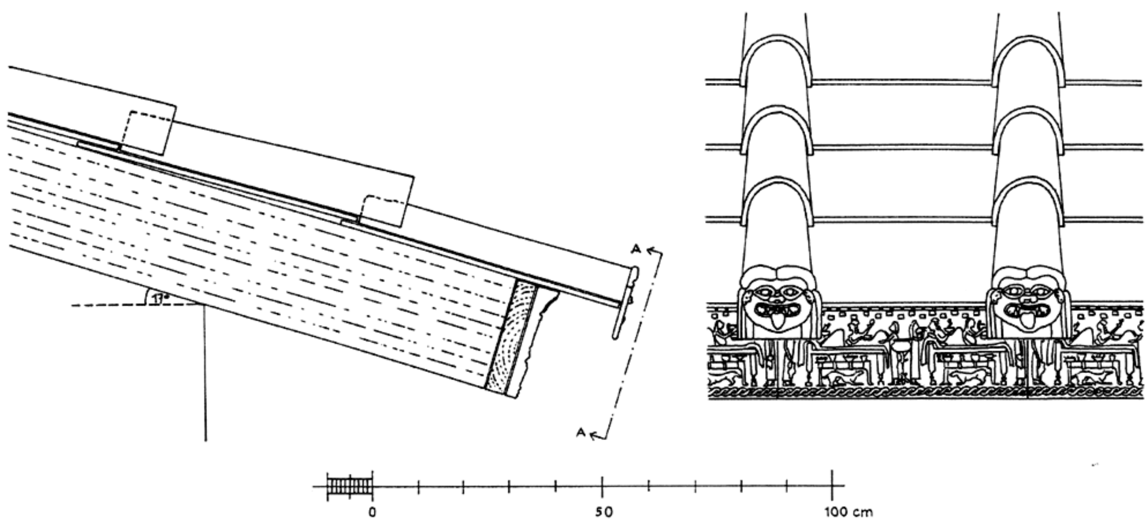
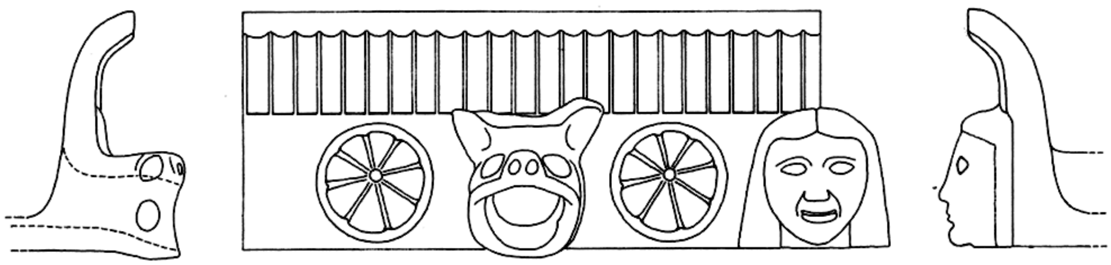
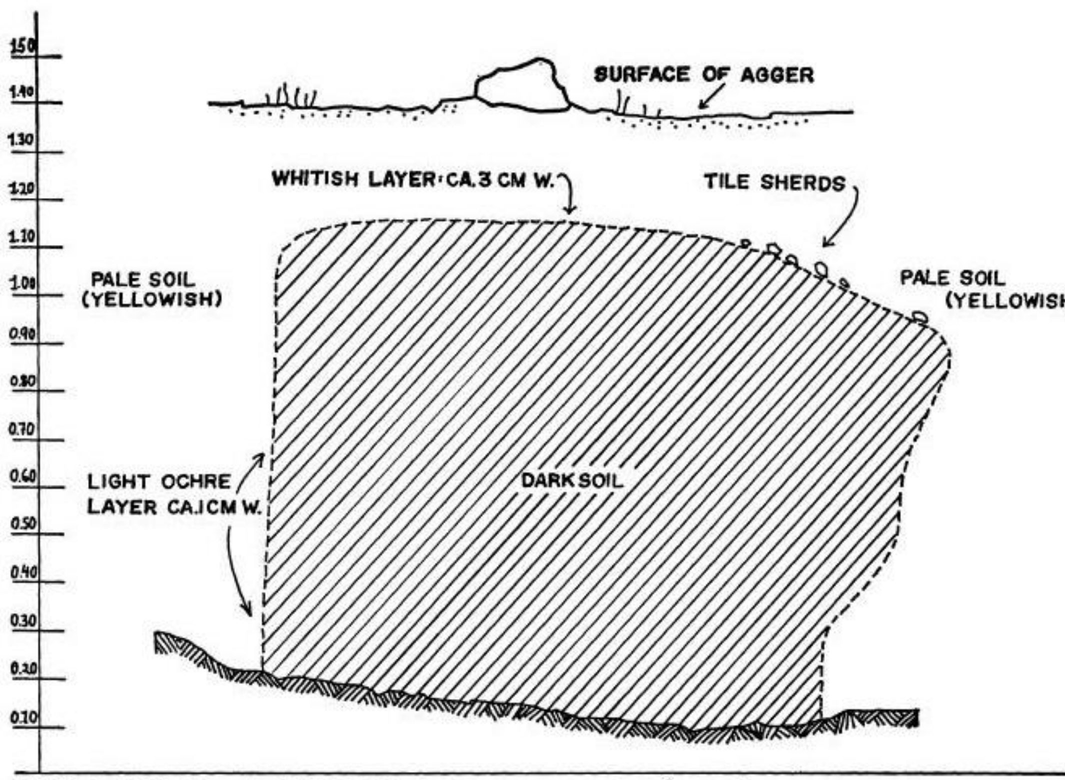


Figure 5: Poggio Civitate - Archaic roof revetment (Winter 2009, 154)



Ill. 3.2.2. 3.B.1.b. Lateral sima, Poggio Civitate (Murlo) 68-482.

Figure 6: Poggio Civitate Archaic roof lateral sima (Winter 2009, 164)



MURLO. POGGIO CIVITATE. PIANO DEL TESORO. PISÉ WALL
PRESERVED IN THE N.W. CORNER OF THE AGGER.

Figure 7: Poggio Civitate - Cross-section of Agger (Phillips 1969, 337)

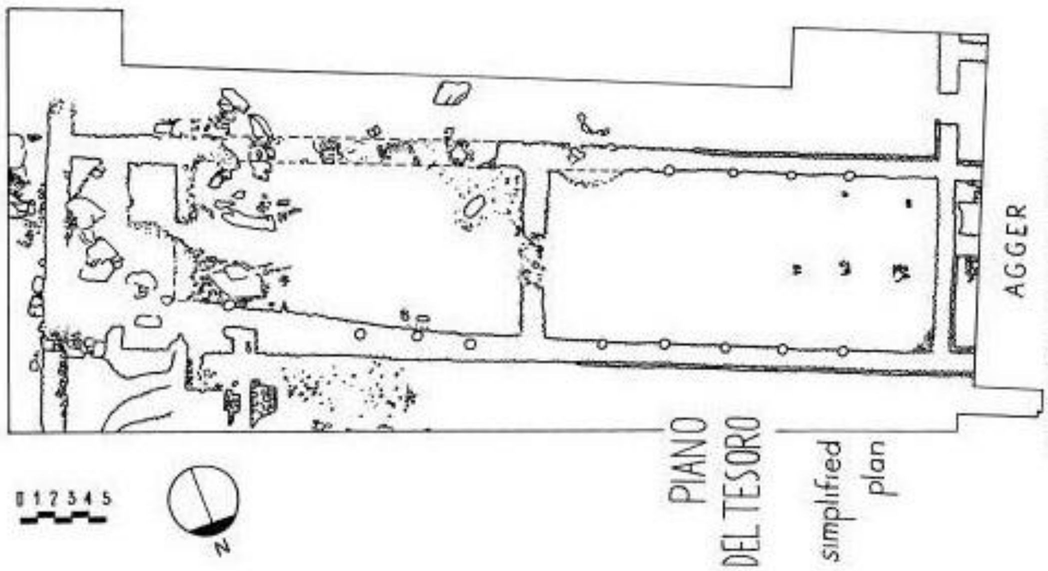


Figure 8: Poggio Civitate - Northern wing of 6^{th} c. BC complex (Phillips 1967, Plate 45)

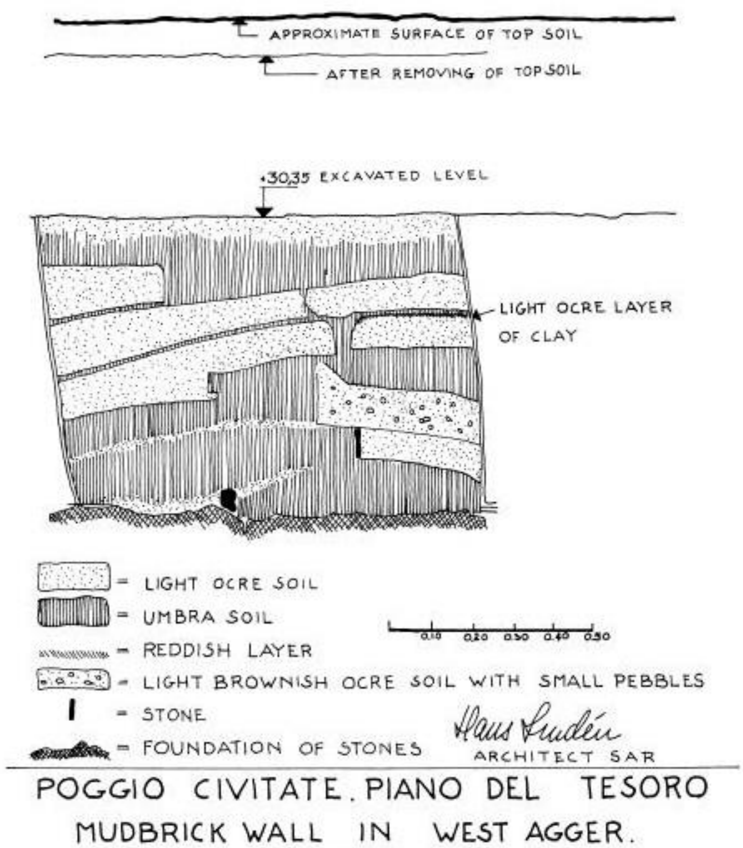


Figure 9: Poggio Civitate - Interior wall of 6^{th} c. BC complex (Phillips 1970, Fig. 9)

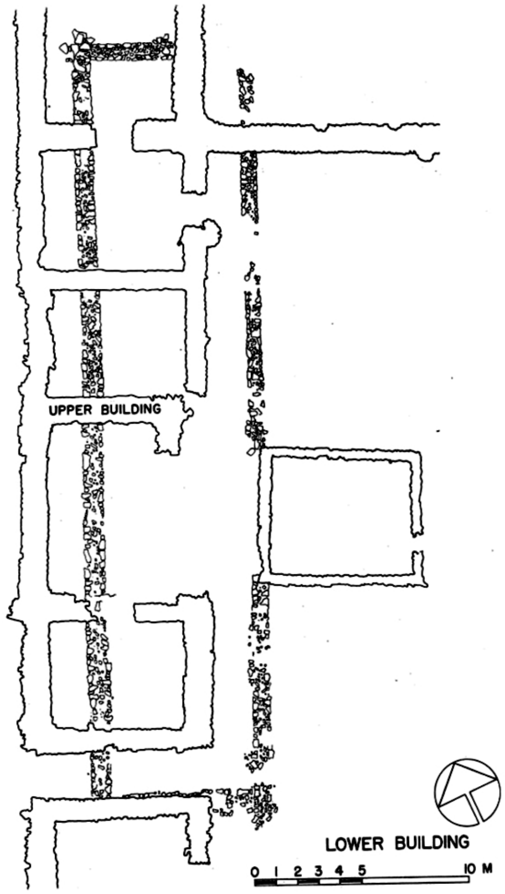


Figure 10: Poggio Civitate - 7th c. BC Lower Building (Nielsen and Phillips 1983, 6)

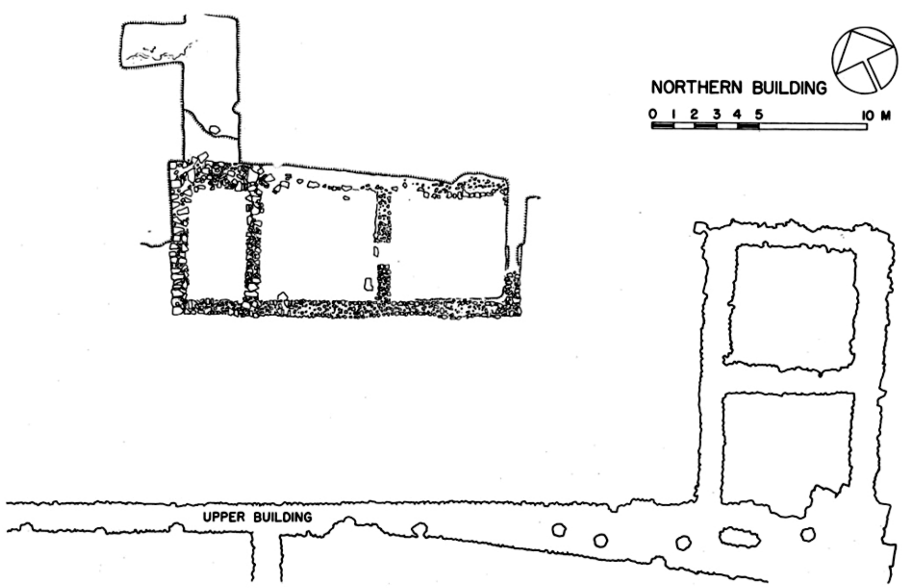


Figure 11: Poggio Civitate - 7th c. BC Northern Building (Nielsen and Phillips 1983, 11)

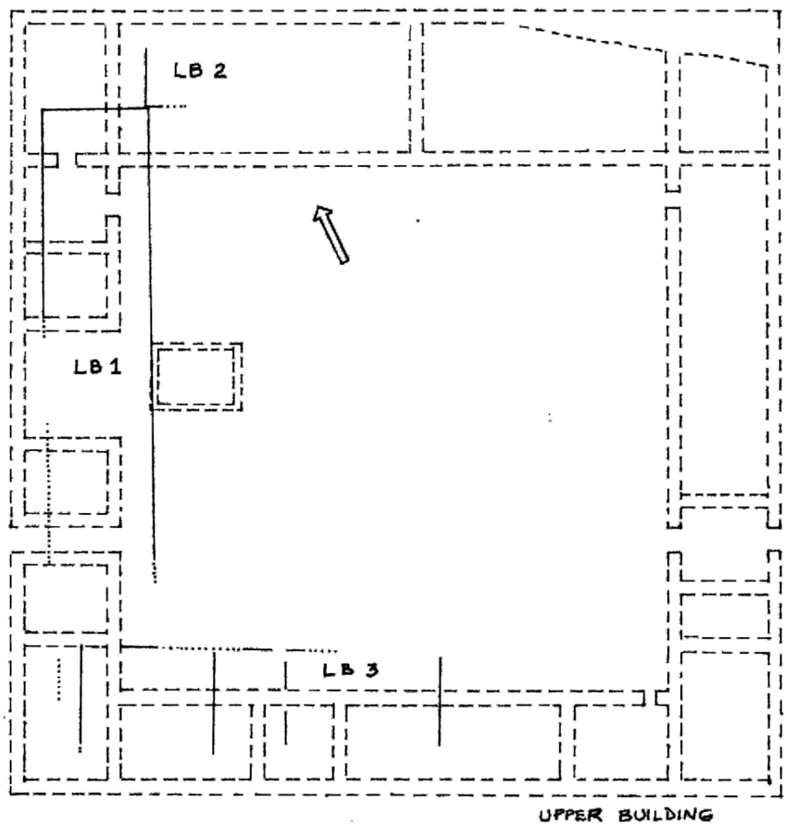


Figure 12: Poggio Civitate - 7th c. BC buildings according to Rystedt (Rystedt 1983, 87)

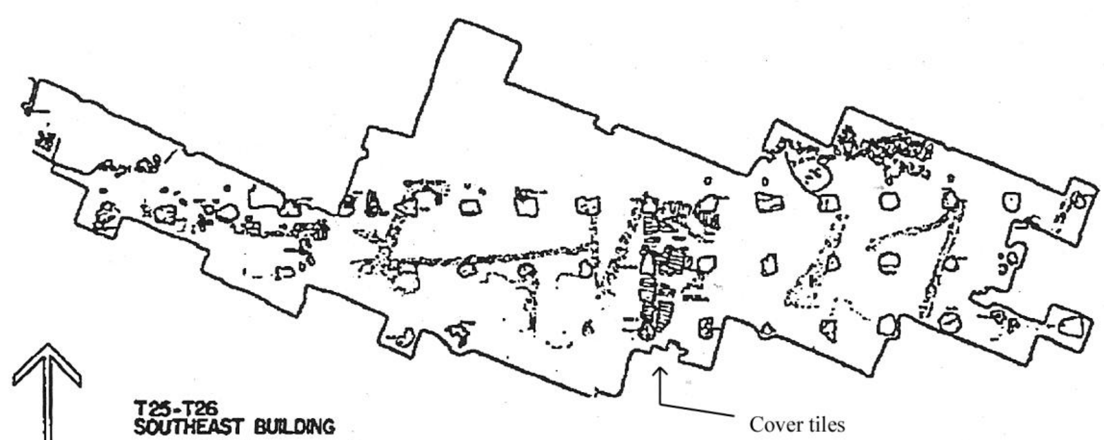


Figure 13: Poggio Civitate - 7th c. BC Southeast Building (Adapted from Nielsen 1987, Fig. 4)

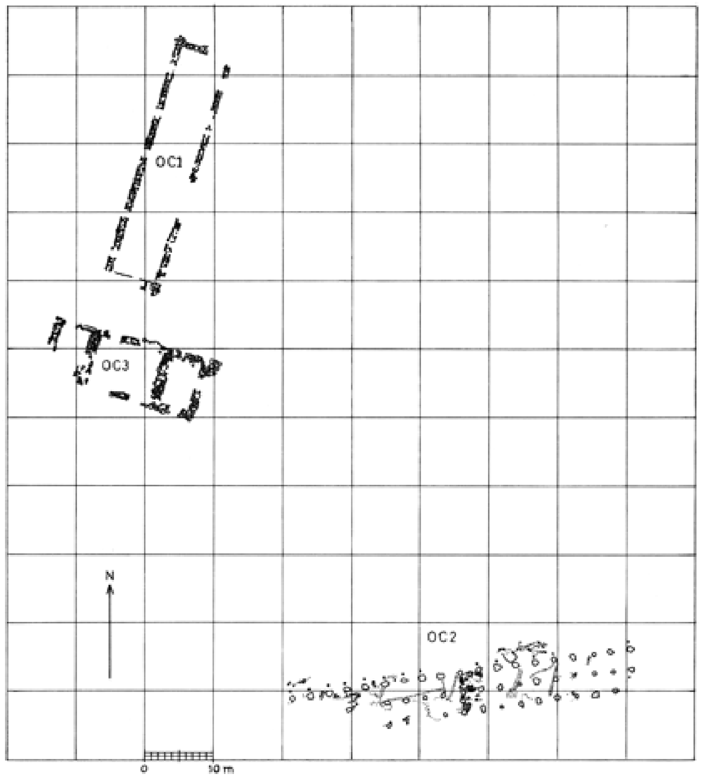


Figure 14: Poggio Civitate - Orientalizing complex (Winter 2009, Plan 8)

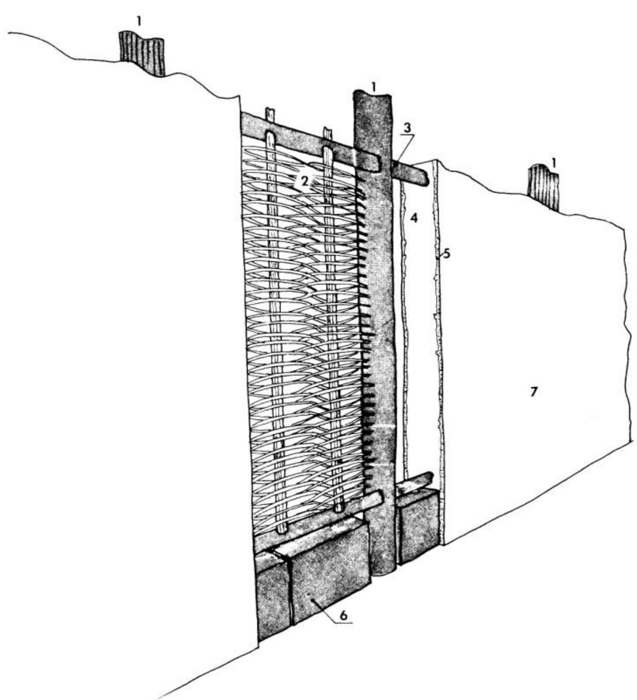


Figure 15: Acquarossa - Reconstruction of a wattle-and-daub wall (Ostenberg 1975, 133)

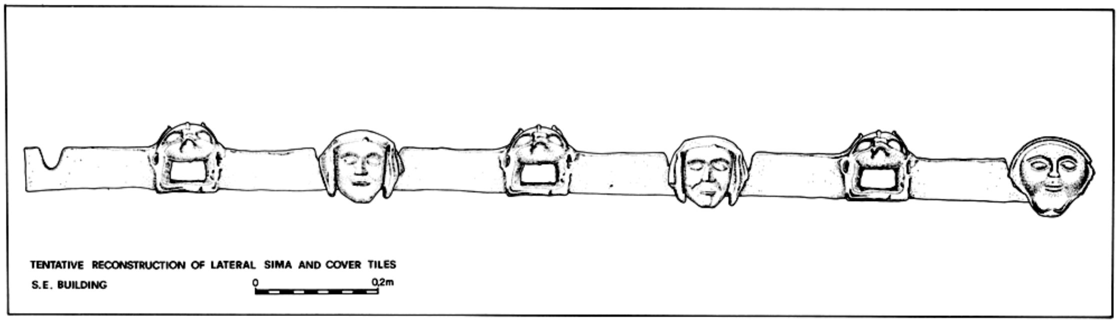


Figure 16: Poggio Civitate - Lateral sima of OC2 (Nielsen 1991, 250)

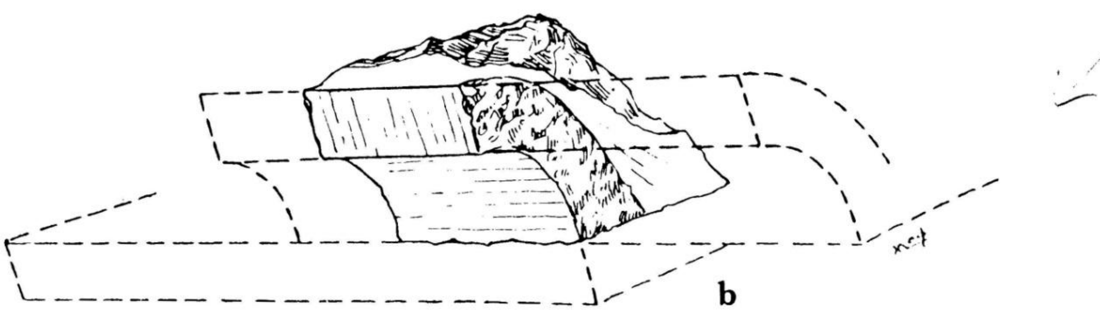


Figure 17: Corfu - Cavetto raking sima (Mertens-Horn 1990, 247)

Figure 18: Corfu - Antefixes and lion-head spout (Dontas 1976, 124)

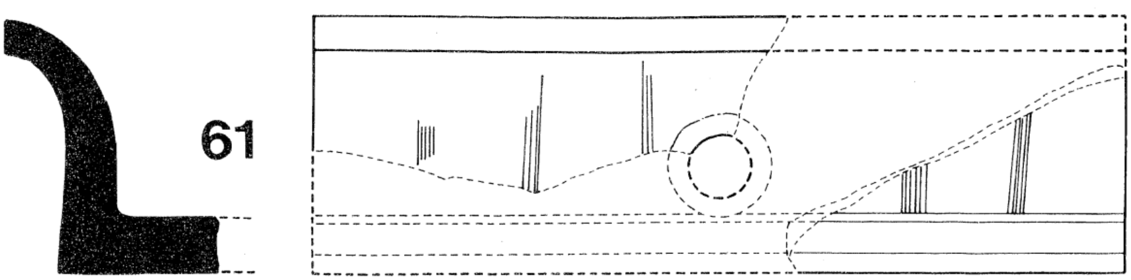


Figure 19: Syracuse - Lateral sima (Ch. Wikander 1986, Fig. 13)

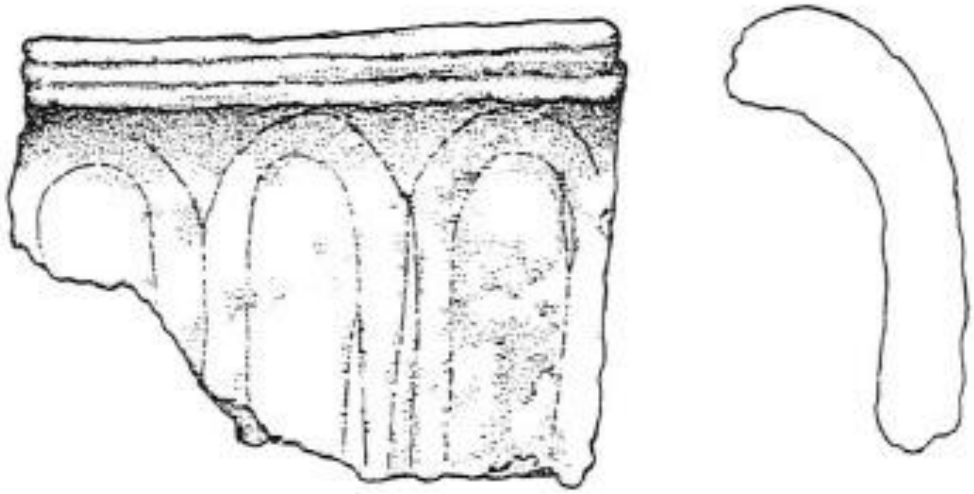


Figure 20: Poggio Civitate - Cavetto raking sima (Winter 2000, 253)

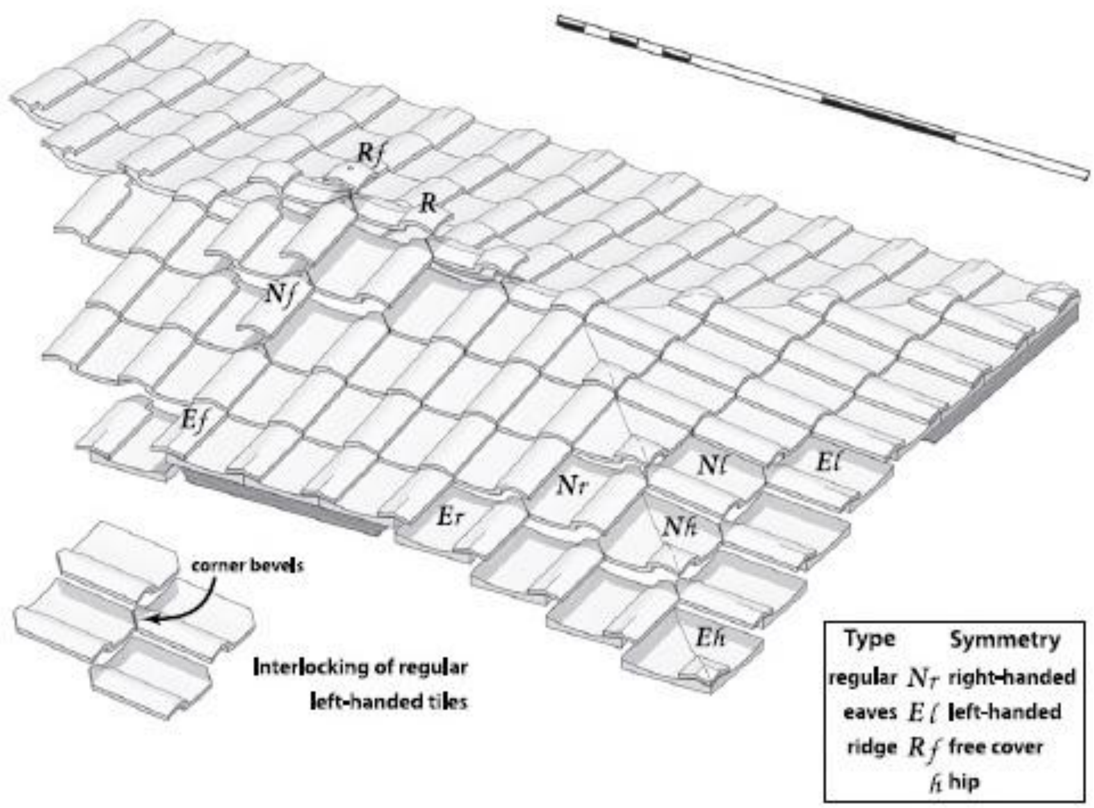


Figure 21: Corinth - Roof of Old Temple (Sapirstein 2009, 200)

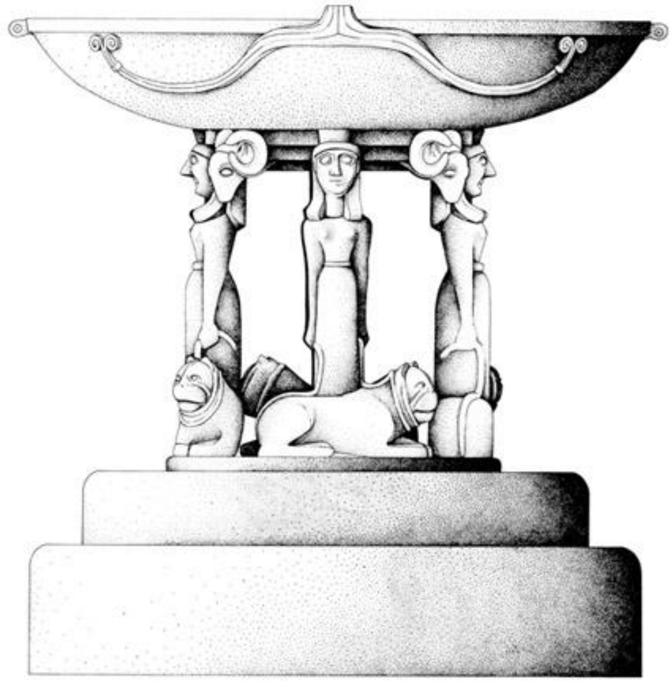


Figure 22: Isthmia - Perirrhanterion (Sturgeon 1987, Fig. 1)

Figure 23: Kore with painted tongue pattern on perirrhanterion (Sturgeon 1987, Fig. 7)

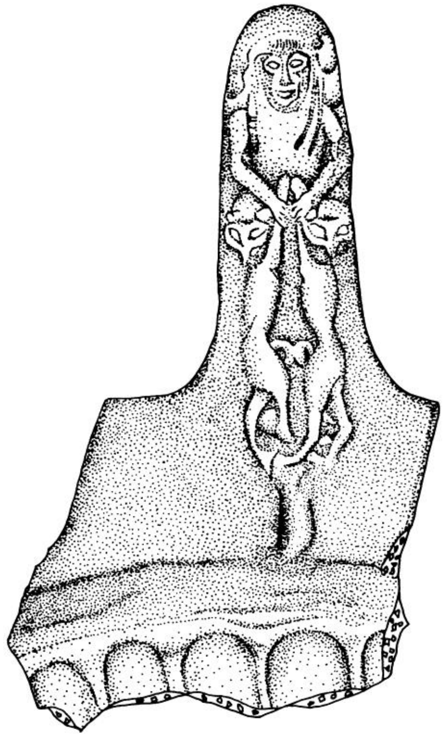


Figure 24: Poggio Civitate - Kyathos handle (Berkin 2006, Fig. 13)

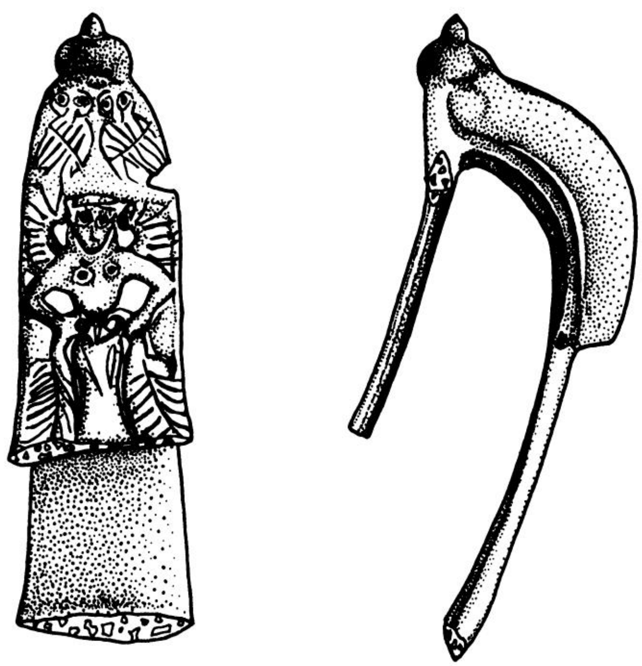


Figure 25: Poggio Civitate - Kyathos handle (Berkin 2006, Fig. 15)

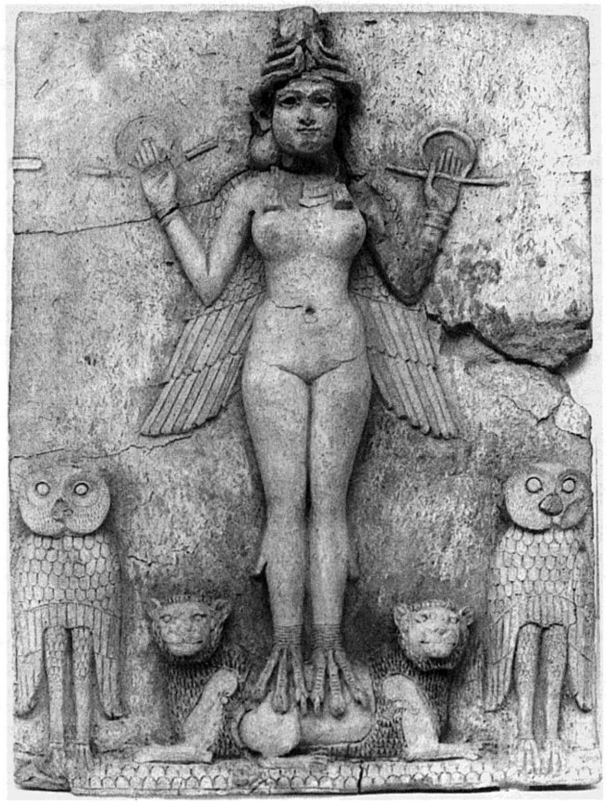


Figure 26: The Burney Relief (Albenda 2005, 172)

Figure 27: Poggio Civitate - Lamashtu amulet (Martelli and Gilotta 2000, 456)

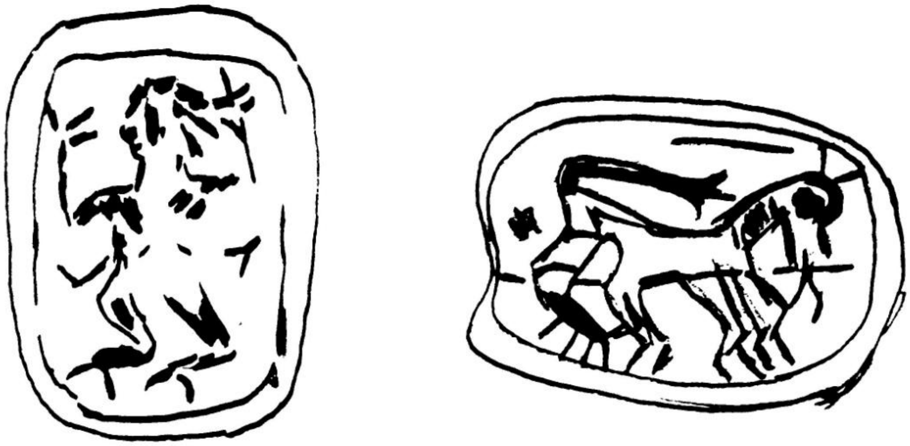


Figure 28: Poggio Civitate - Lamashtu amulet (Patzek 1988,230)

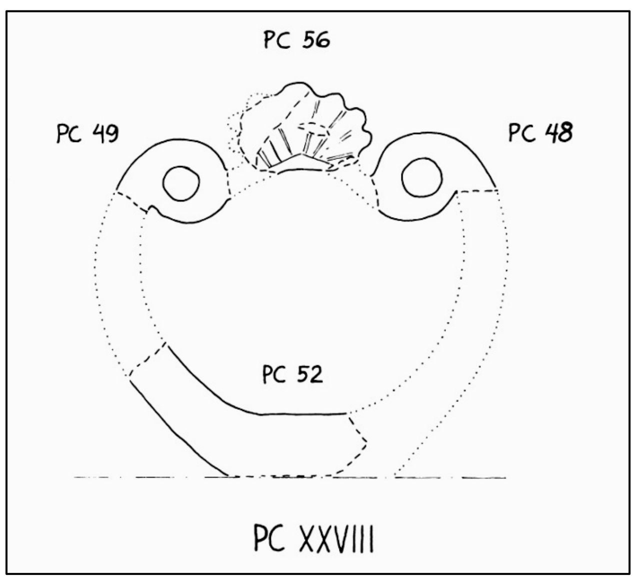


Figure 29: Poggio Civitate - Lotus-and-palmette acroterion (Rystedt 1983, 74)

Figure 30: Bucchero handle with potnia theron and lotus-and-palmette (Valentini 1969, Tav.107)

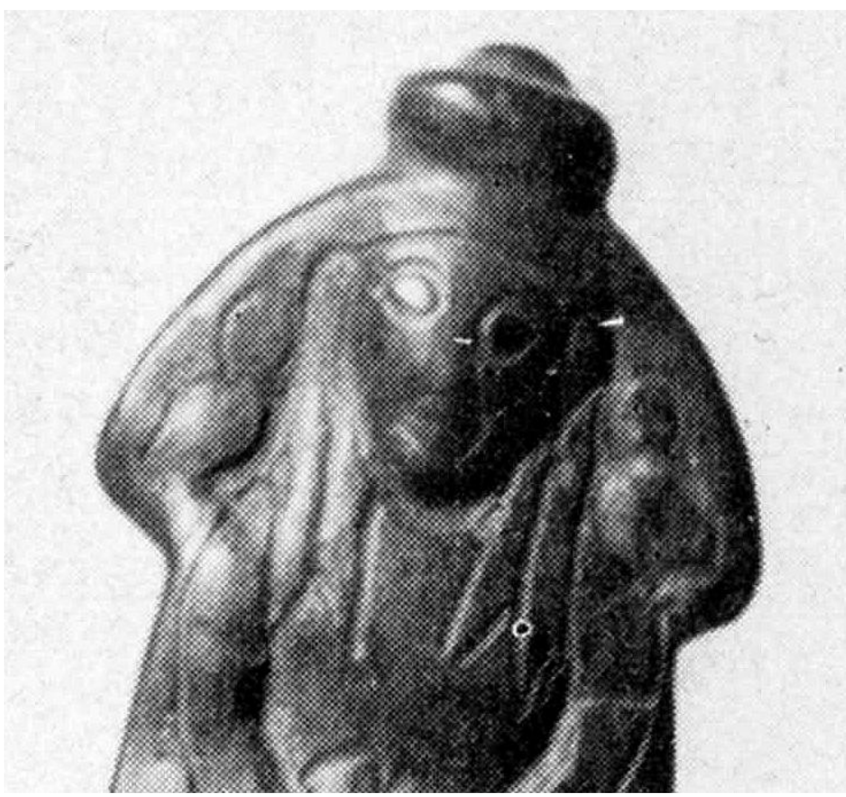


Figure 31: Bucchero handle with potnia theron and lotus-and-palmette (Valentini 1969, Tav.107)

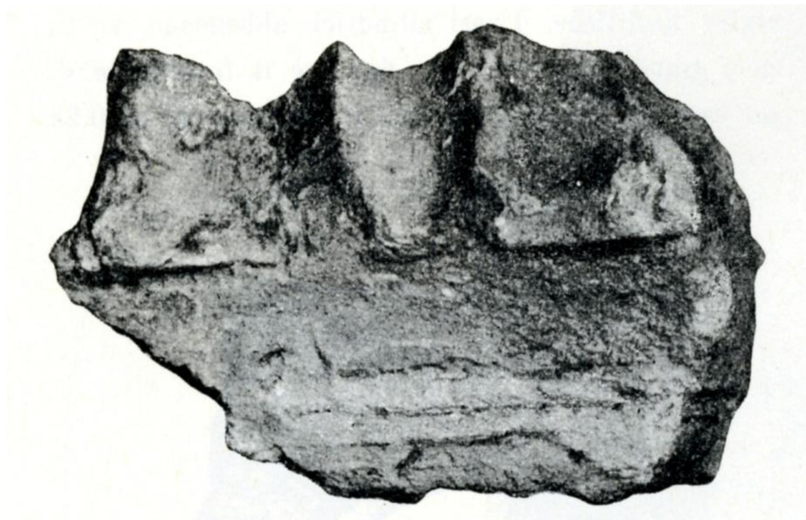


Figure 32: Pulo di Molfetta - Wattles above flat timber impression (Mosso 1910, Fig. 1)

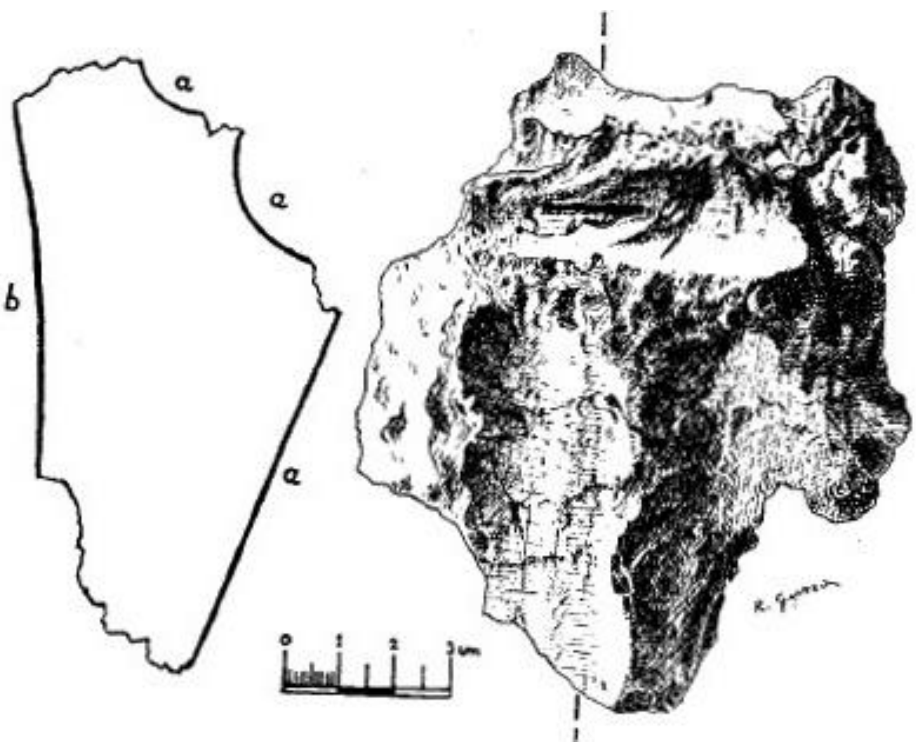


Figure 33: Francavilla Fontana - Daub with intersecting wattles (Acanfora 1952, Fig 4)

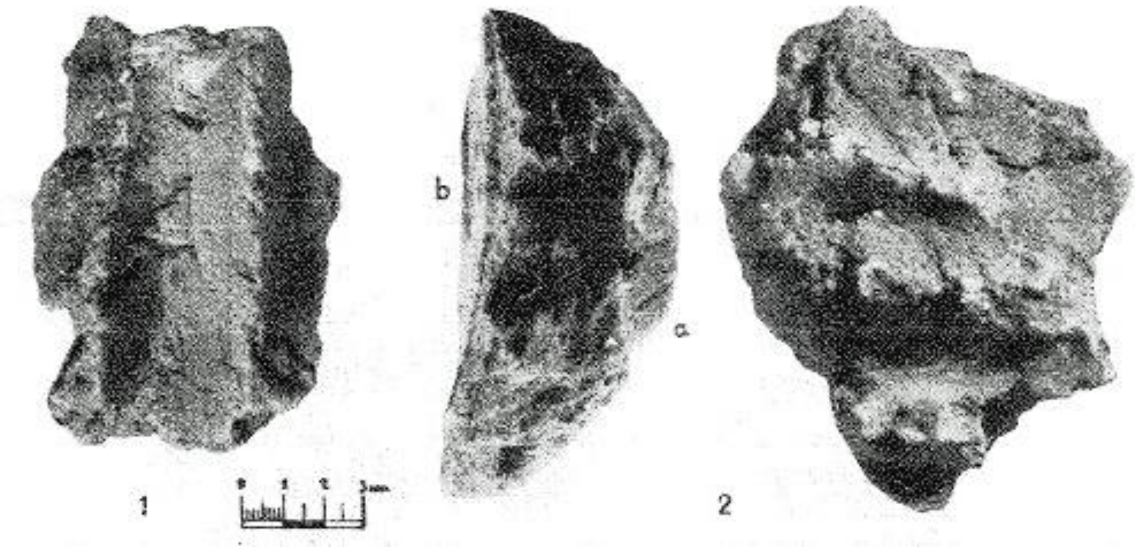


Figure 34: Francavilla Fontana- Daub with wattle impressions (Acanfora 1952, Fig. 3)

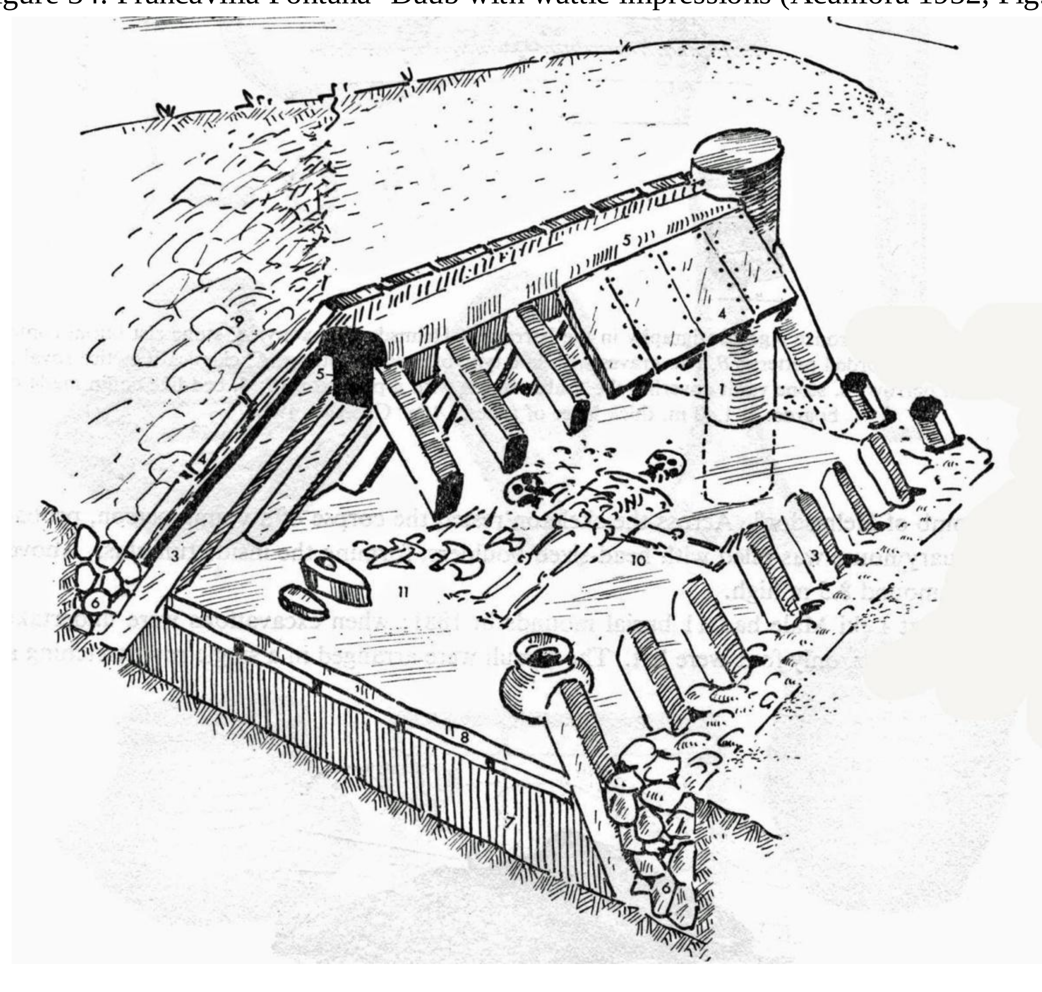


Figure 35: Saxony - Royal tomb at Leubingen(Gimbutas 1965, 264)

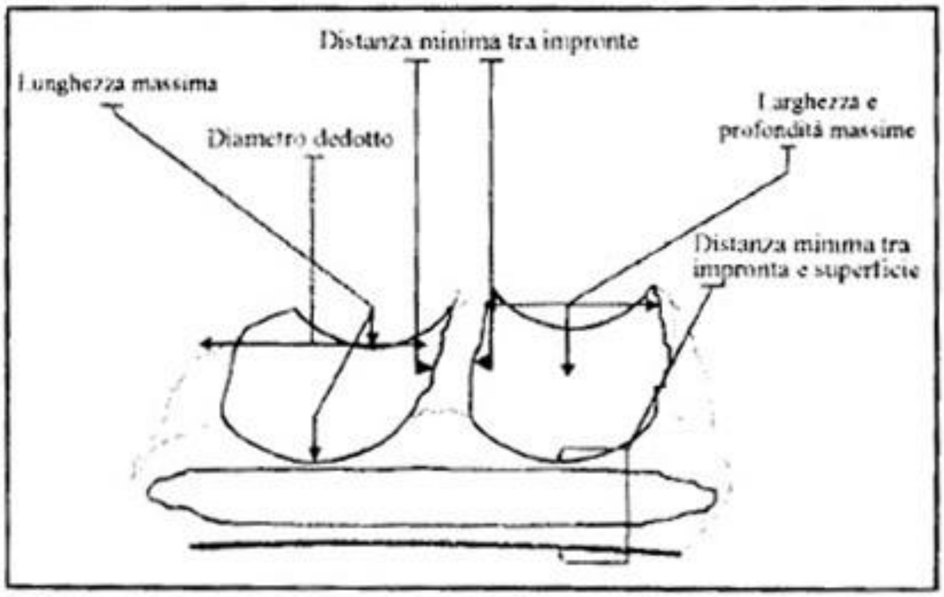


Figure 36: Trasano - Measured dimension of daub (Tasca 1998b, Fig.1)

Figure 37: Trasano - Daub with vertical binding impression (Tasca 1998b, Fig. 6)

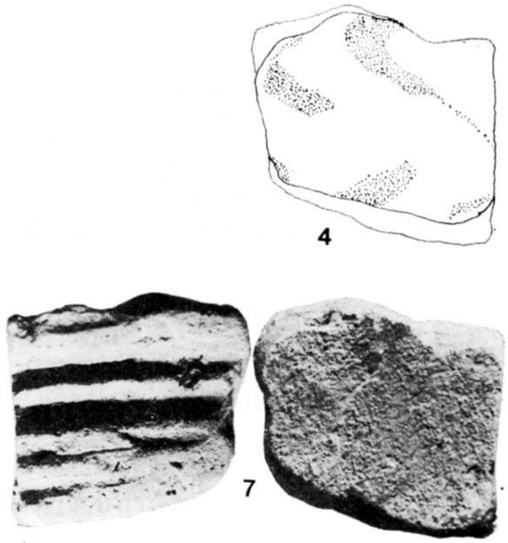


Figure 38: Tirlecchia - Daub with surface decoration (Bernabo Brea 1984, 35)

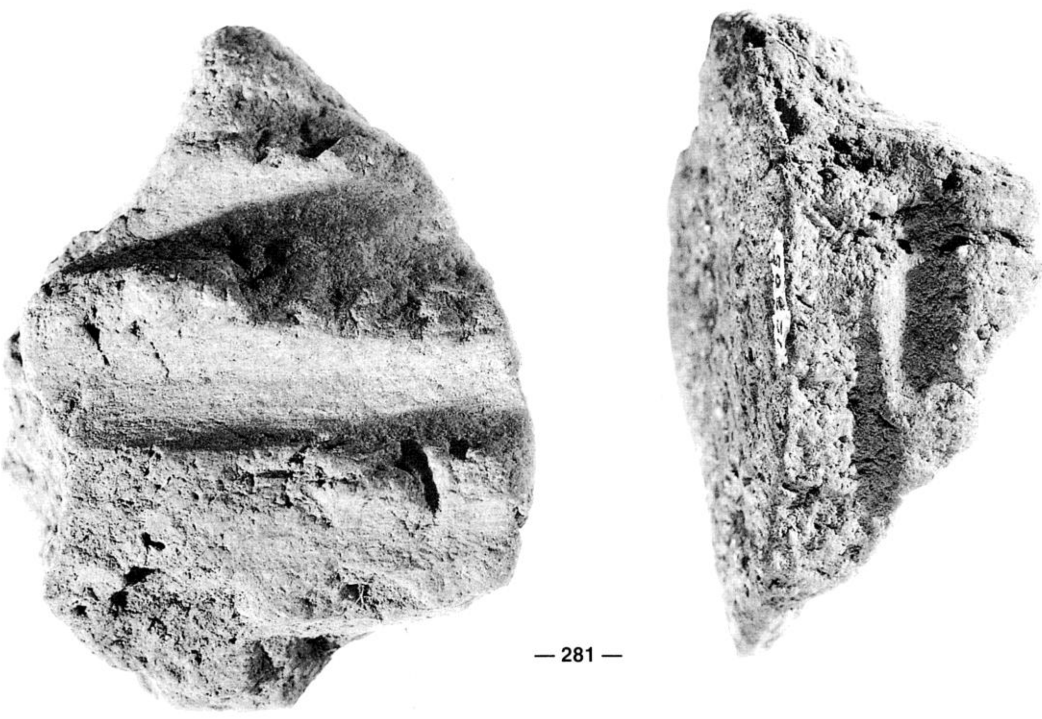


Figure 39: Murgia Timone - Daub with impressions (Lo Porto 1998, Pl. 34)

355

Figure 40: Murgia Timone - Daub with flat impression (Lo Porto 1998, Pl. 39)

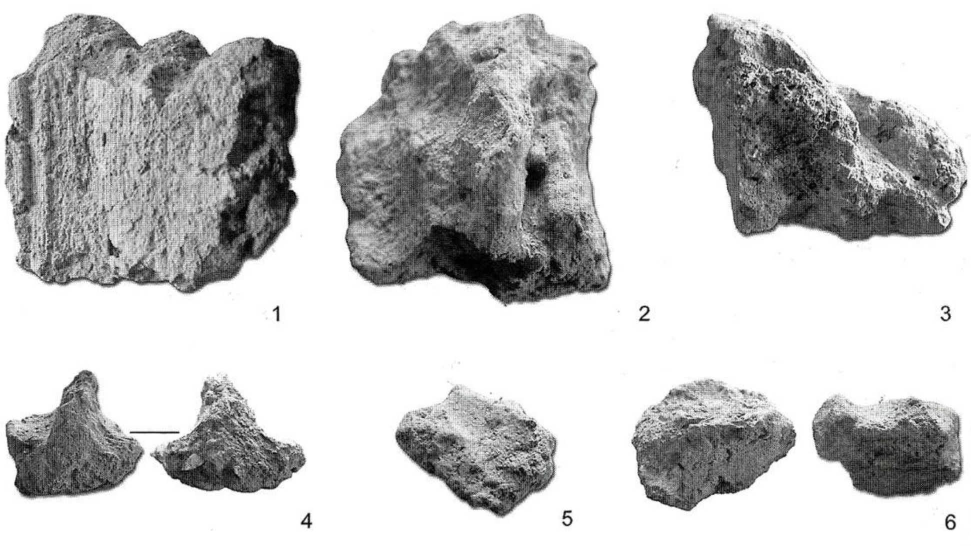


Figure 41: Le Grotteline - Daub with impressions (Lorenzi and Serradimigni. 2009, 56)

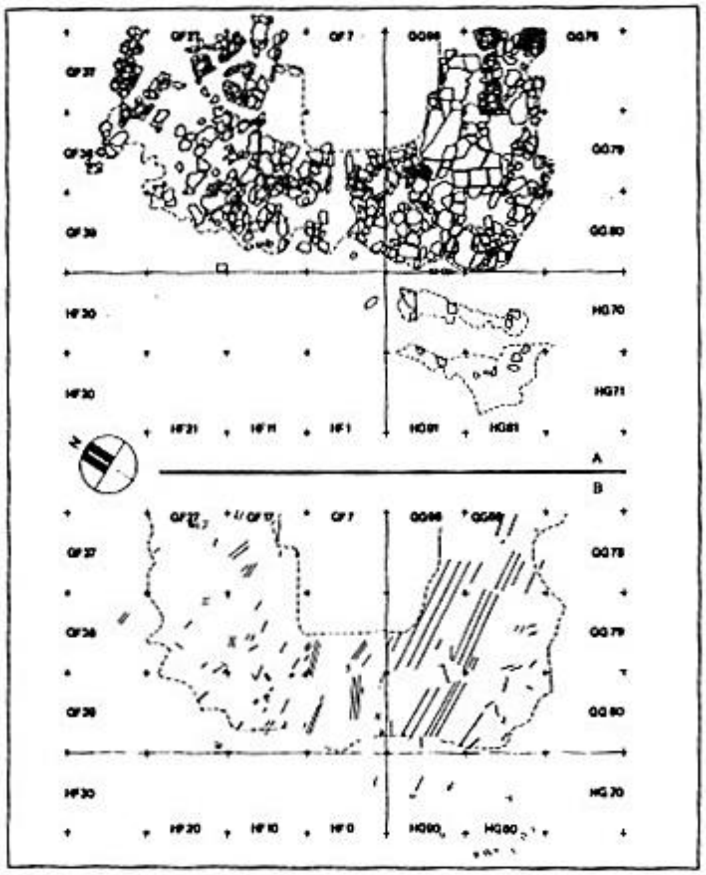


Figure 42: Ripa Tetta - Plan of daub collapse with key below showing the orientation of wattle impressions (Tasca 1998b, Fig. 8)

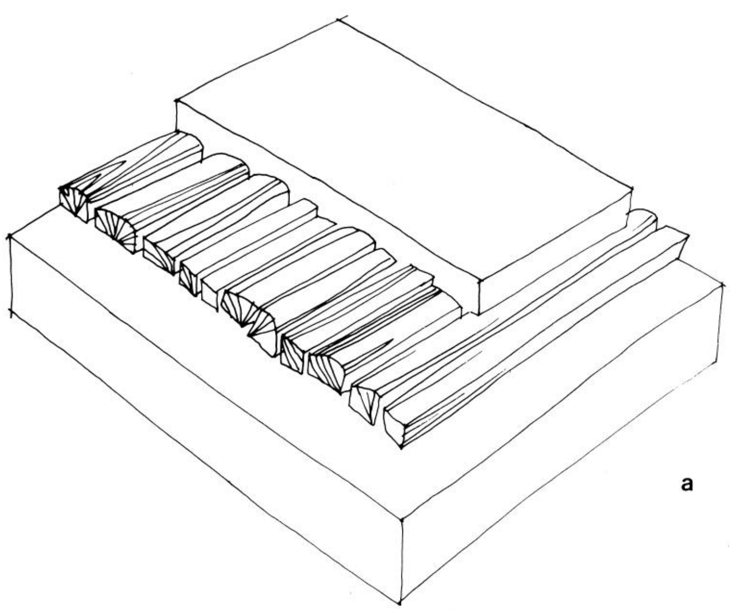


Figure 43: Divostin (Serbia) - Daub floor (McPherron and Srejovic 1988, Fig 5.25)

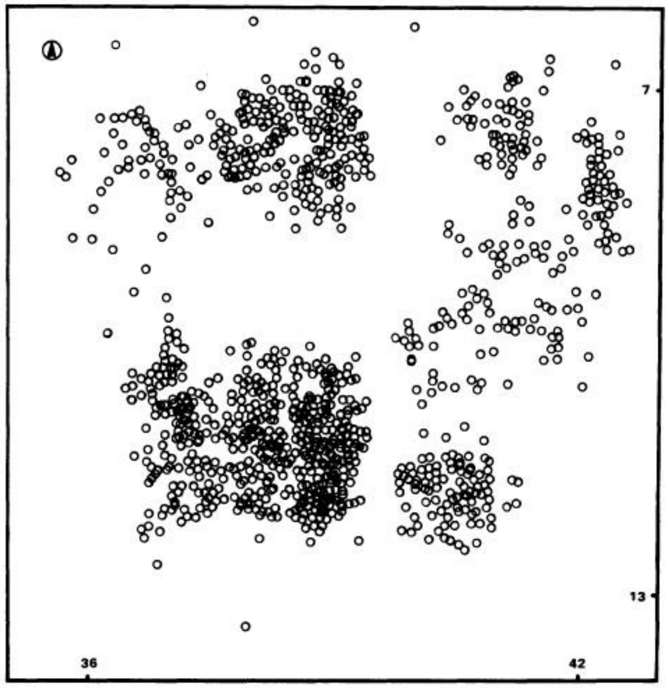


Figure 44: Piana di Curinga – Distribution of daub in Area H (Ammermann et al. 1988, Fig. 4)

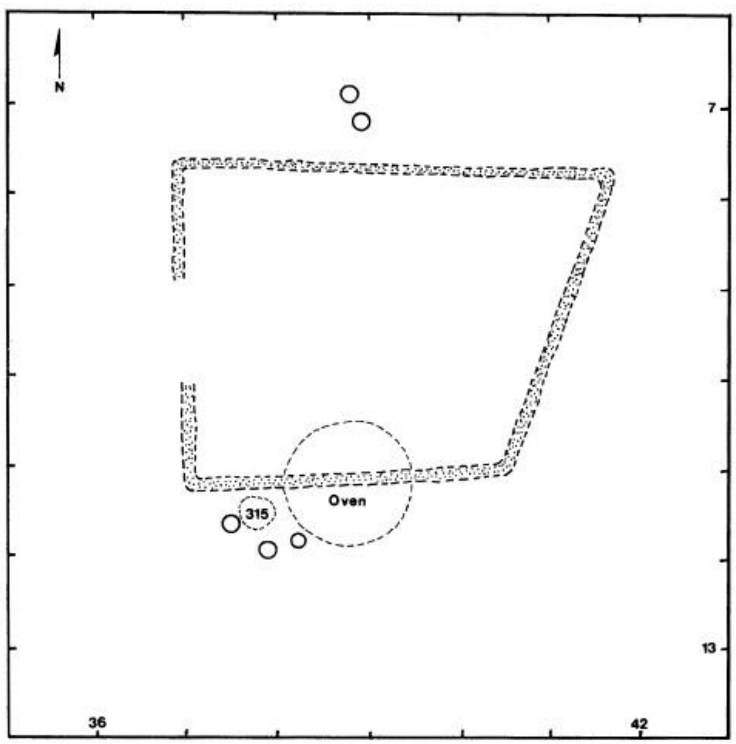


Figure 45: Piana di Curinga - Plotted wall for hut in Area H (Ammermann et al. 1988, Fig. 6)

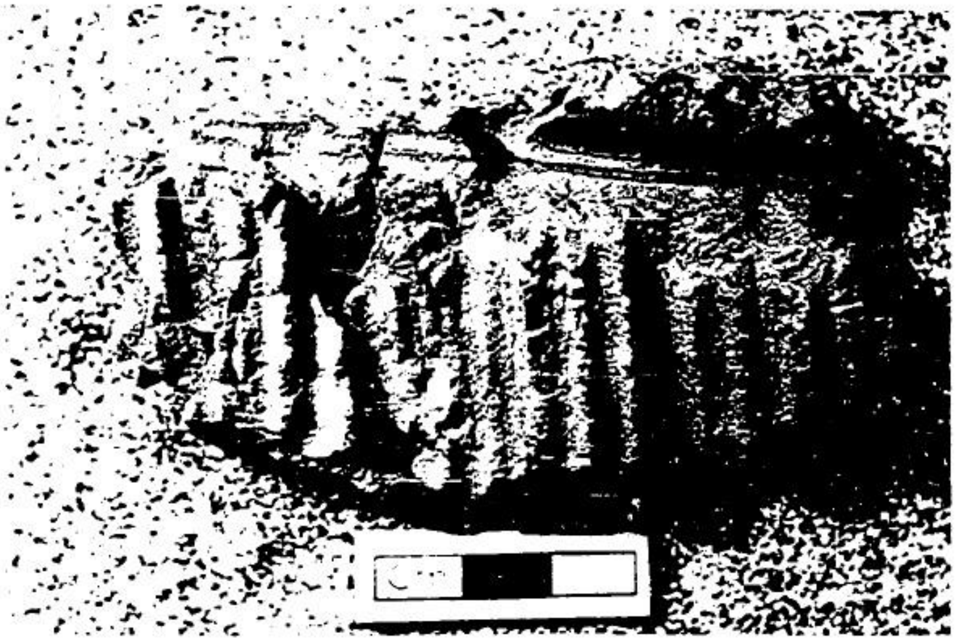


Figure 46: Piana di Curinga - Reed impressions in possible roofing/outer wall fragments (Shaffer 1983, Fig. 122)

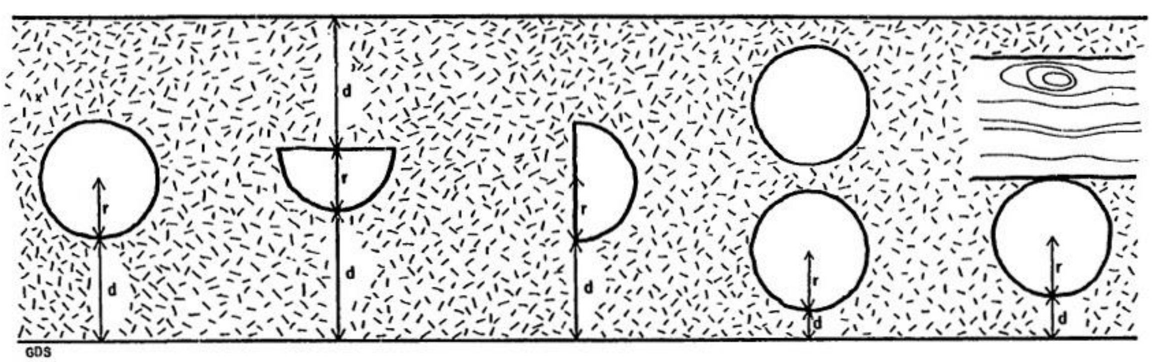


Figure 47: Piana di Curinga- Estimation of wall thickness (Shaffer 1983, Fig. 37)

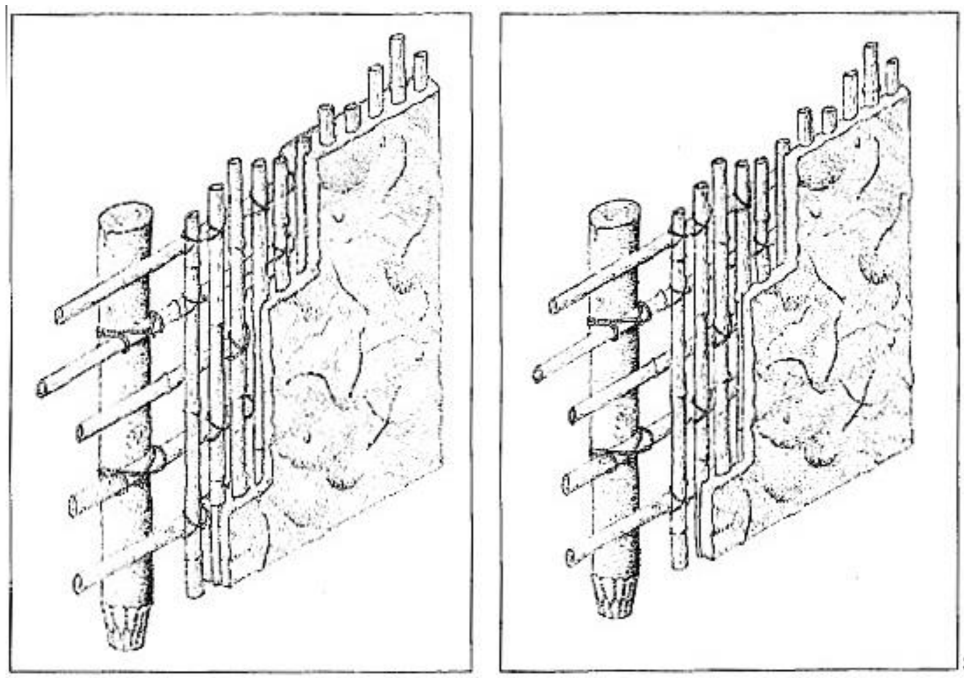


Figure 48: Balsignano - Possible wall reconstructions with daub on both sides of the wall face (left) or on one side of a wall face (right) (Fiorentino and Muntoni 2002, Fig. 5)

Figure 49: Favella - Daub with impressions (Tine 2009, Fig.70)

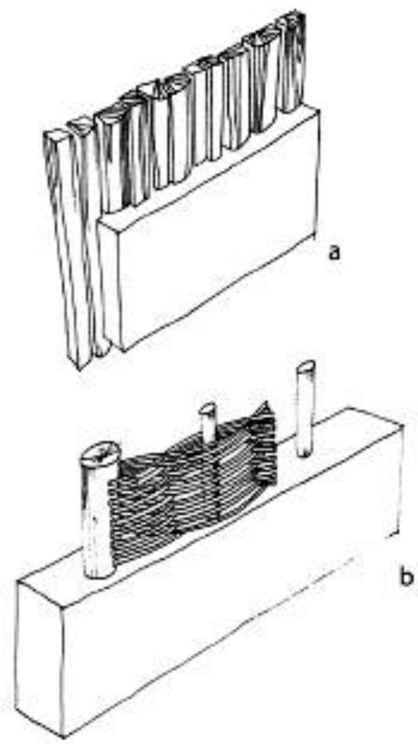


Figure 50: Favella -Hypothetical wall (a) versus wattle-and-daub wall (b) (Tine 2009, Fig. 68)

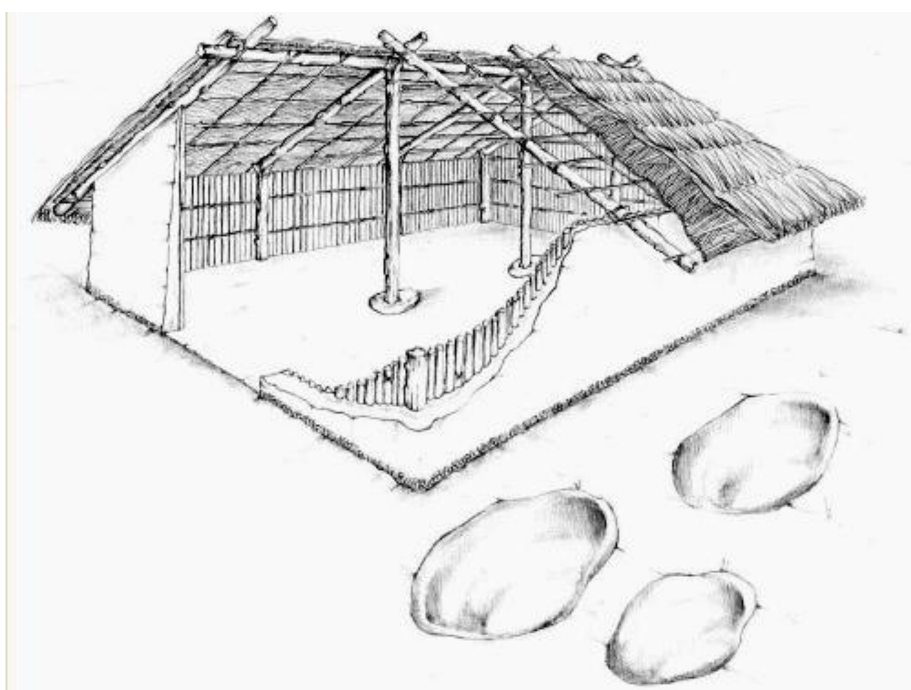


Figure 51: Favella - House reconstruction (Tine 2009, Fig.72)

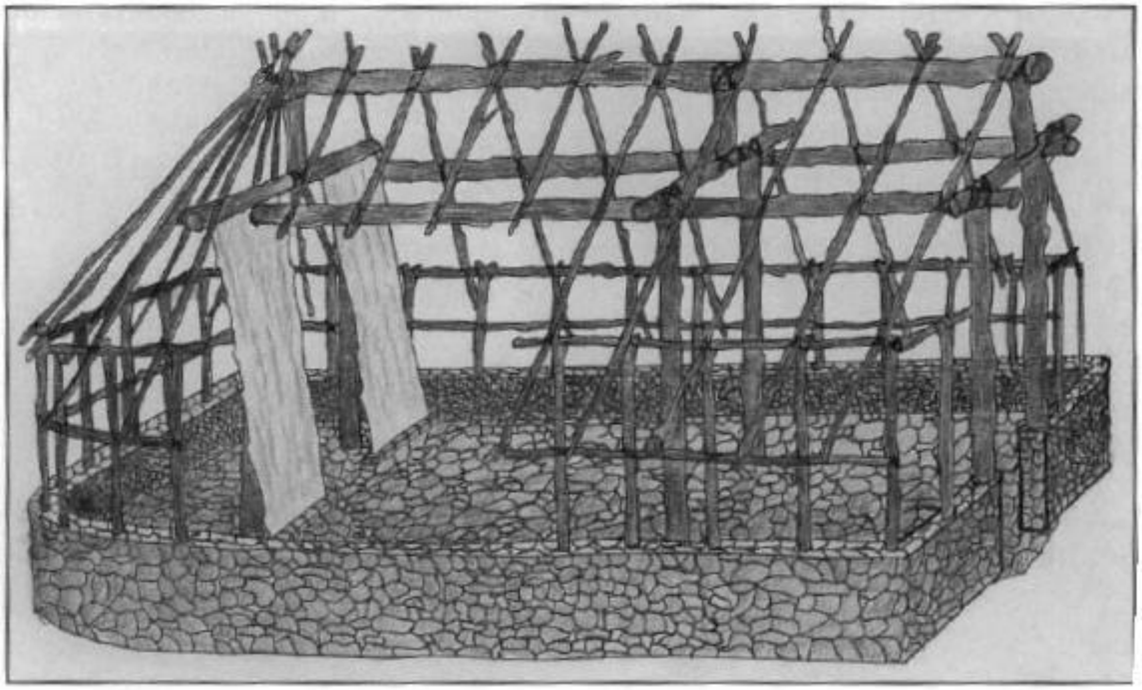
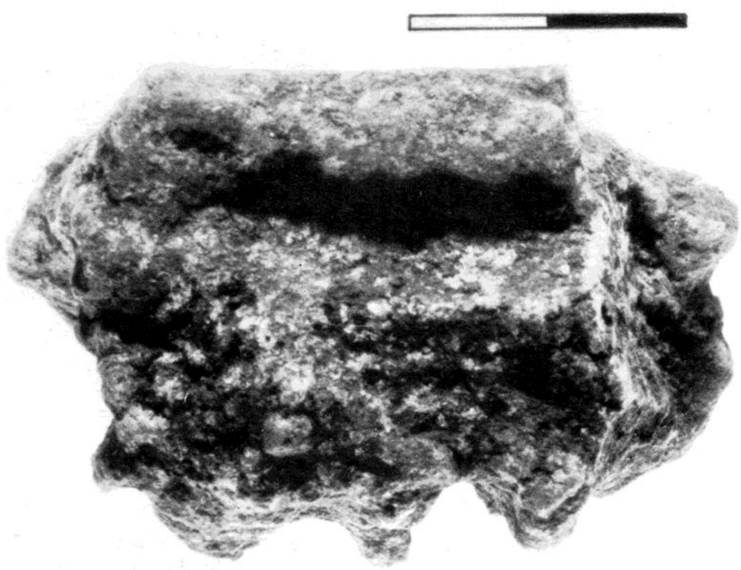


Figure 52: Passo di Corvo - Reconstruction of hut (Tine 1983, Tav.59)



5

Figure 53: Tor Vergata - Daub with impressions (Cazzella and Moscolini 1984, Tav.6, 5)

Figure 54: Pienza - Daub with impressions (Calvi Rezia 1972, 296)

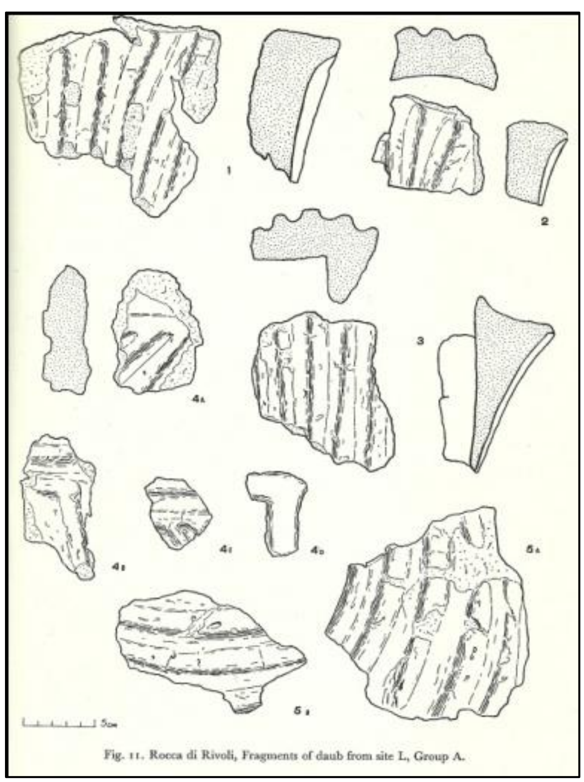


Figure 55: Rocca di Rivoli - Decorative daub (Barfield 1966, Fig. 11)

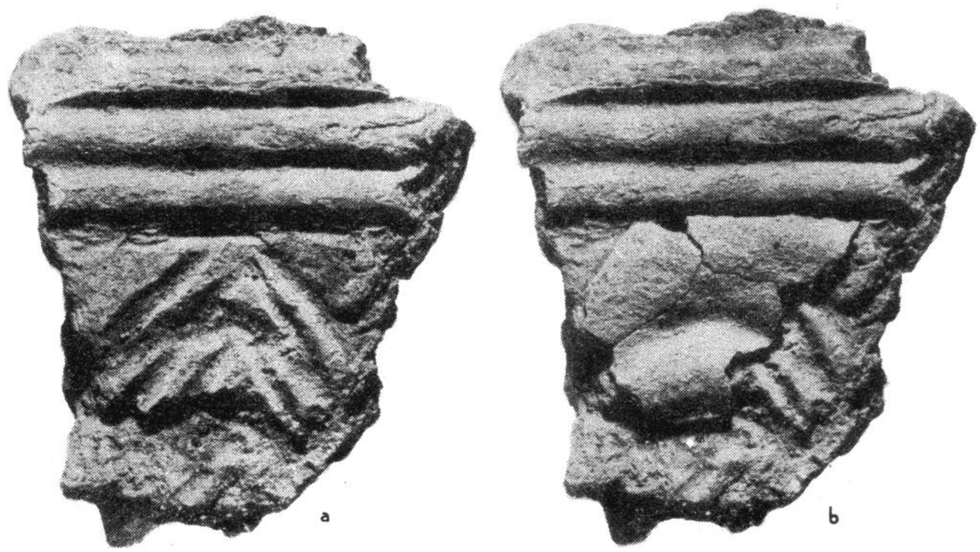


Figure 56: Daub used as crenellation above doorway/roof from Trebatice, Slovakia (Paulik 1962, 38)

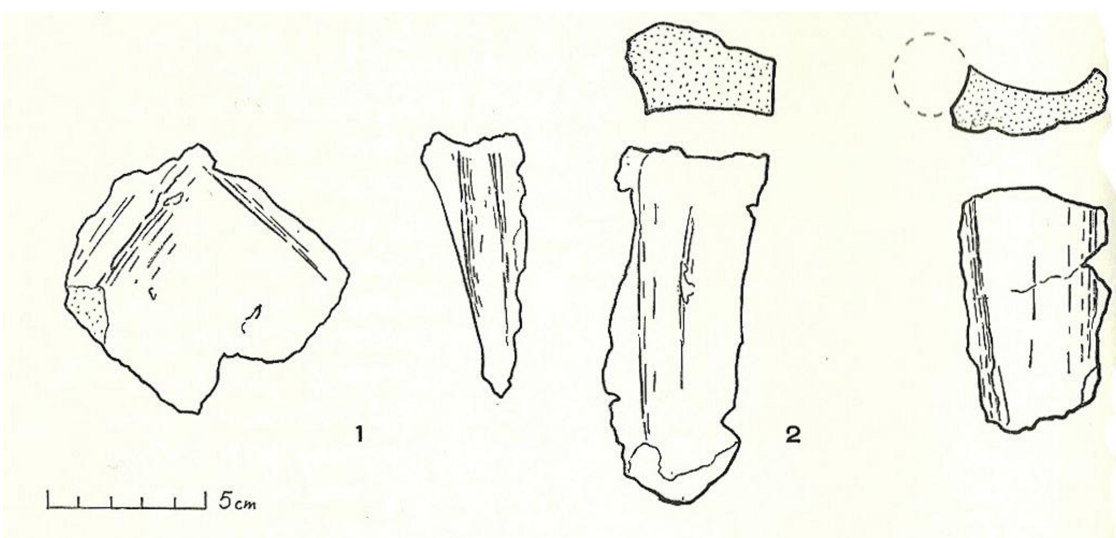


Figure 57: Rocca di Rivoli - Undecorated daub (Barfield 1966, Fig. 13)

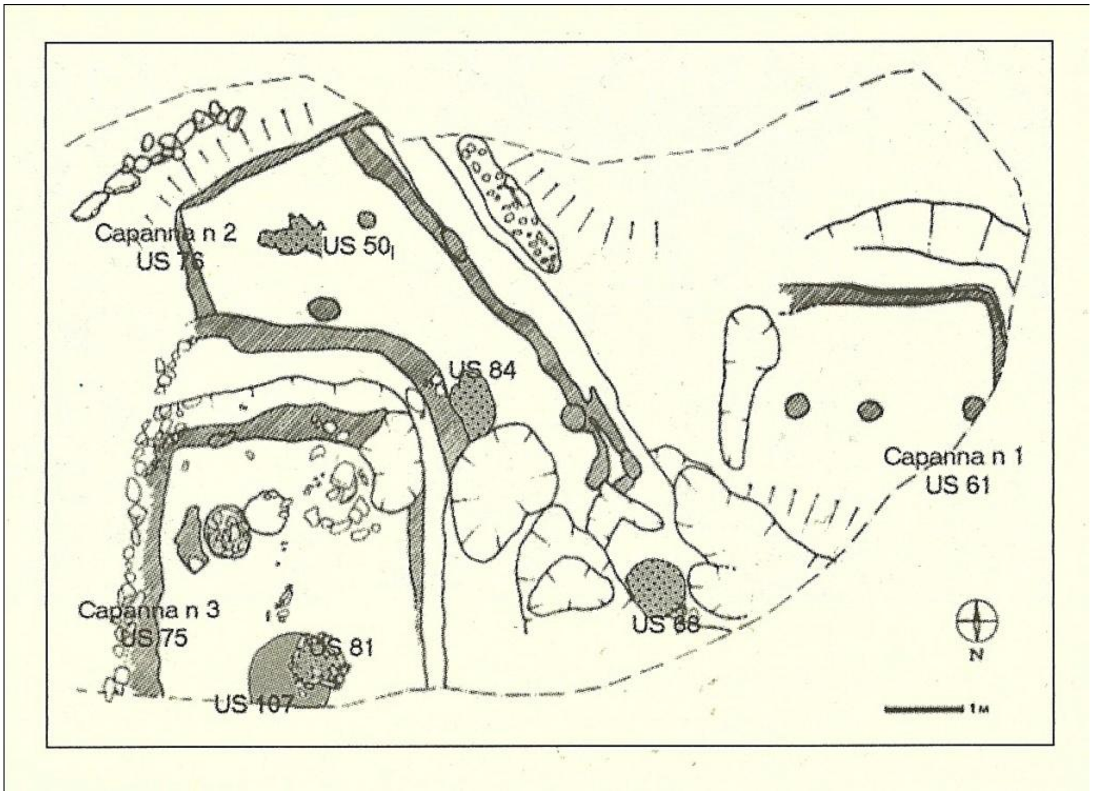


Figure 58: Isera-La Torretta - Plan of huts (Pedrotti 2000, Fig. 36)

Figure 59: Isera-La Torretta - Decorated daub (Pedrotti 2000, Fig.41)

Figure 60: House model from Kodzadermen (Fol and Lichardus 1988, Fig. 6)

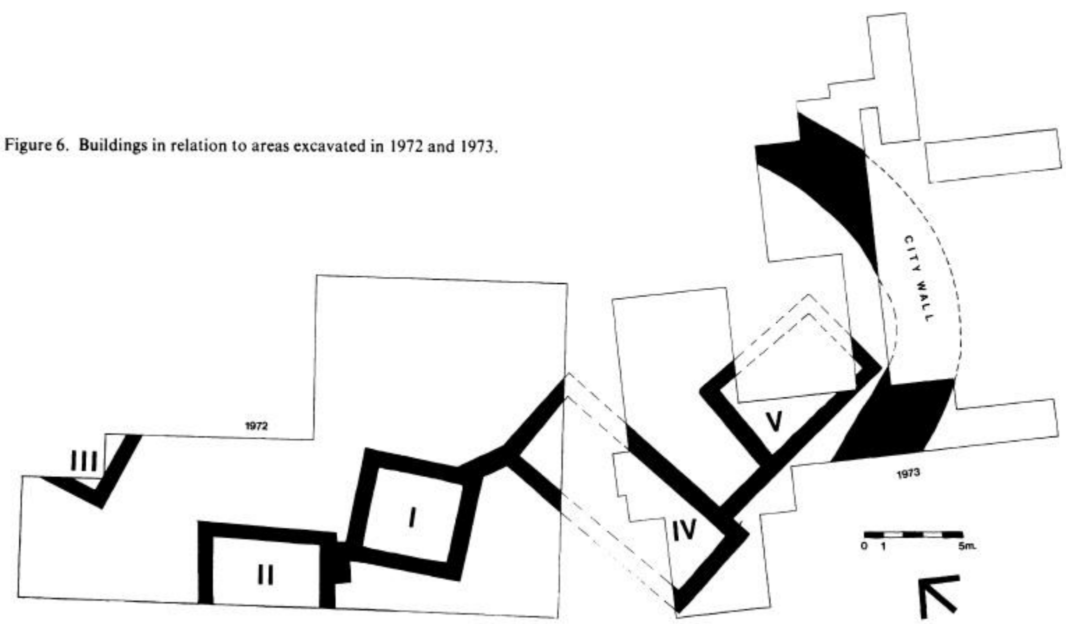


Figure 61: Tufariello - Plan of early Bronze Age structures (Holloway et al. 1975, Fig. 6)

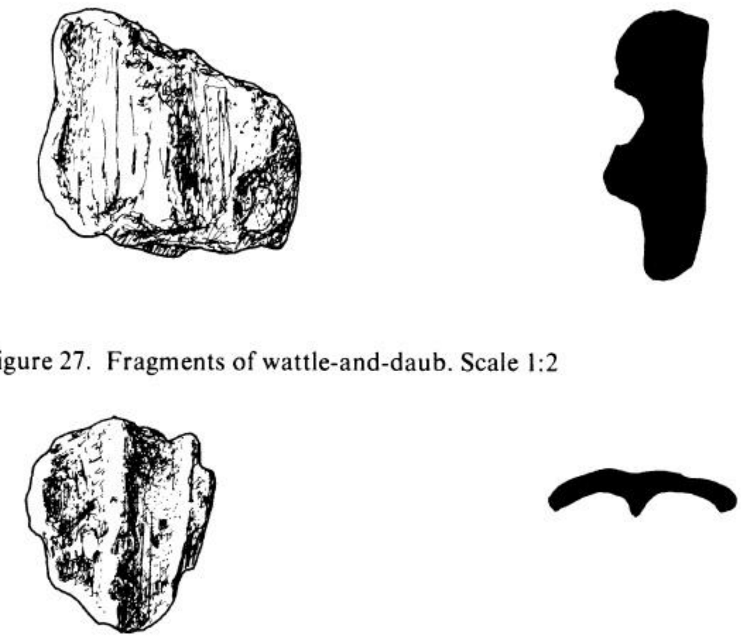


Figure 62: Tufariello - Daub fragments (Holloway et al. 1975, Fig 27)

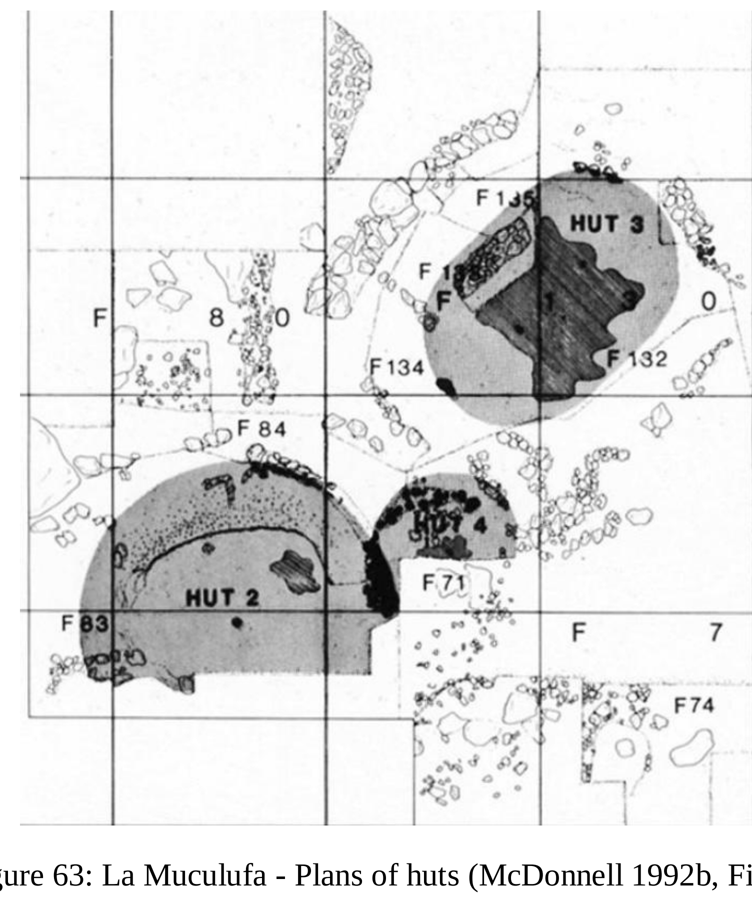


Figure 63: La Muculufa - Plans of huts (McDonnell 1992b, Fig. 3)

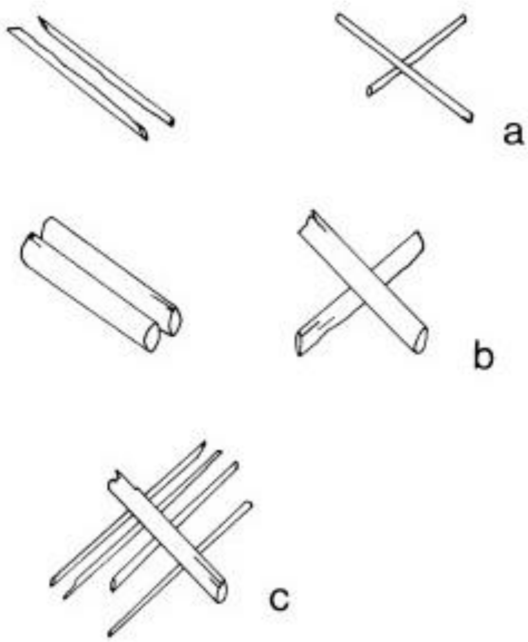


Figure 64: La Muculufa - Daub impressions (McDonnell 1992b, Fig. 10)

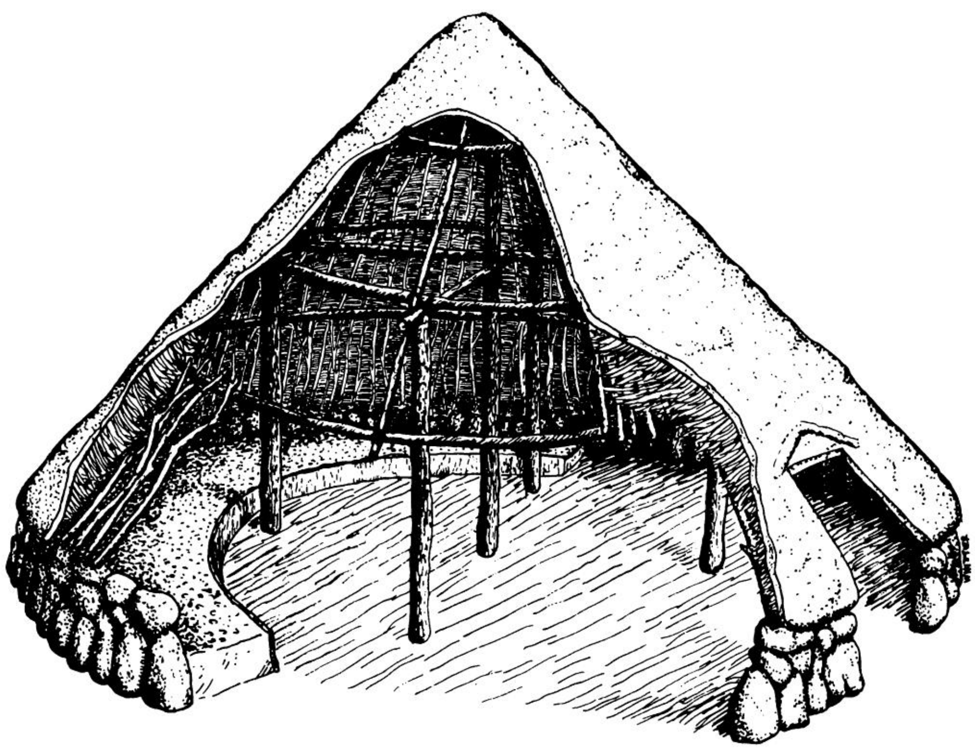


Figure 65: La Muculufa - Hut 2 reconstruction (McDonnell 1992b, Fig. 12)

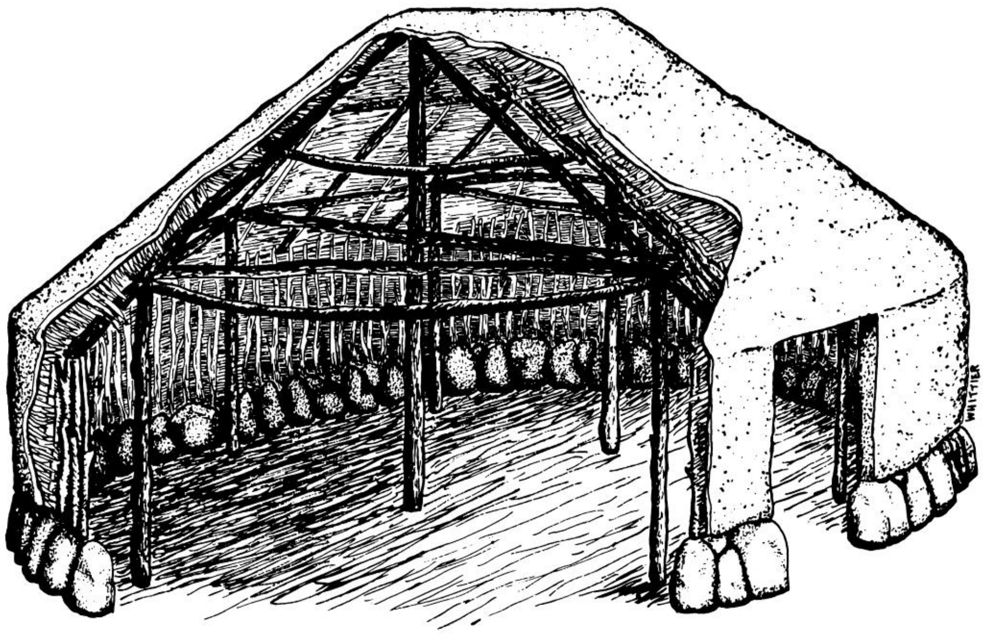


Figure 66: La Muculufa - Hut 3 reconstruction (McDonnell 1992b, Fig. 13)

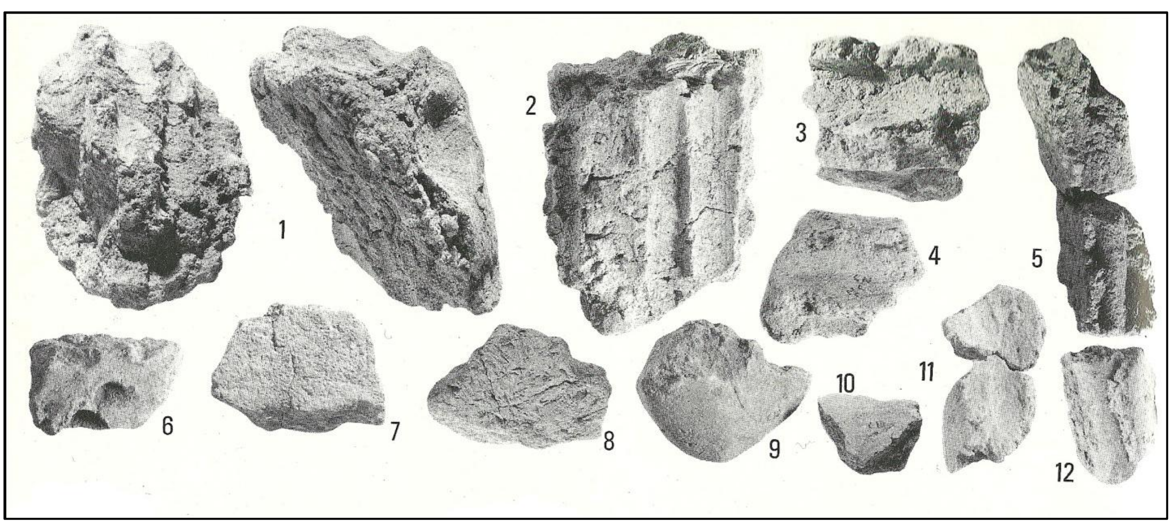


Figure 67: Coppa Nevigata - Daub (Cazzella and Moscoloni 1988, Fig. 96)

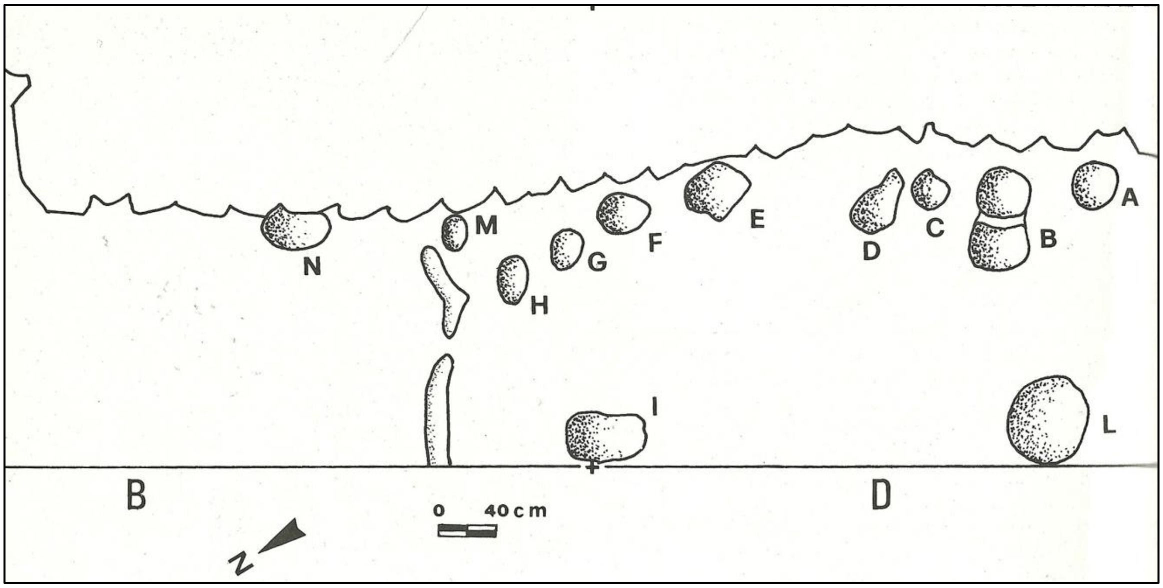


Figure 68: Coppa Nevigata - Partial plan of structure (Cazzella and Moscoloni 1988, Fig. 57)

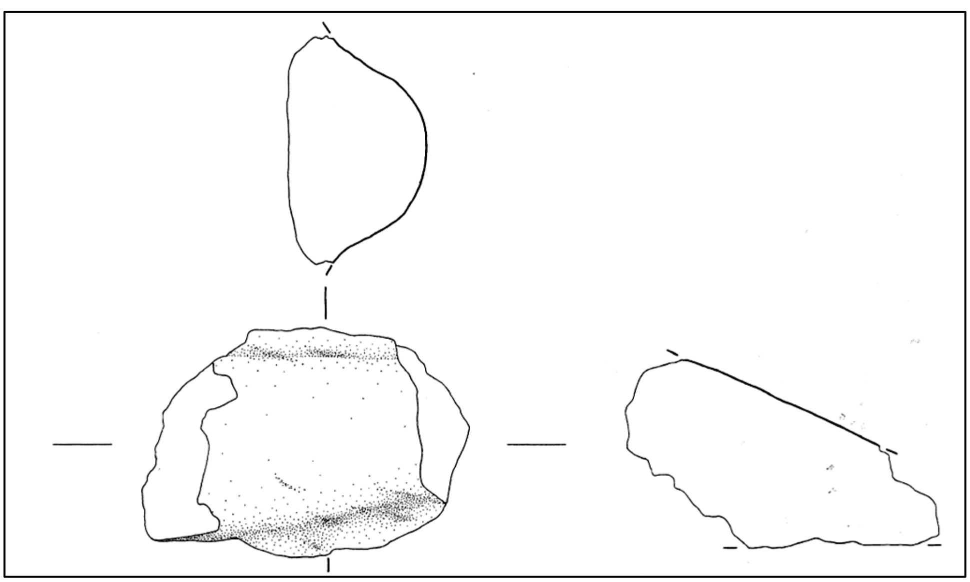


Figure 69: Broglio di Trebisacce - Daub with curved sections (Moffa 2002, Fig. 18)

Figure 70: Broglio di Trebisacce - Daub with impressions (Moffa 2002, Fig. 19)

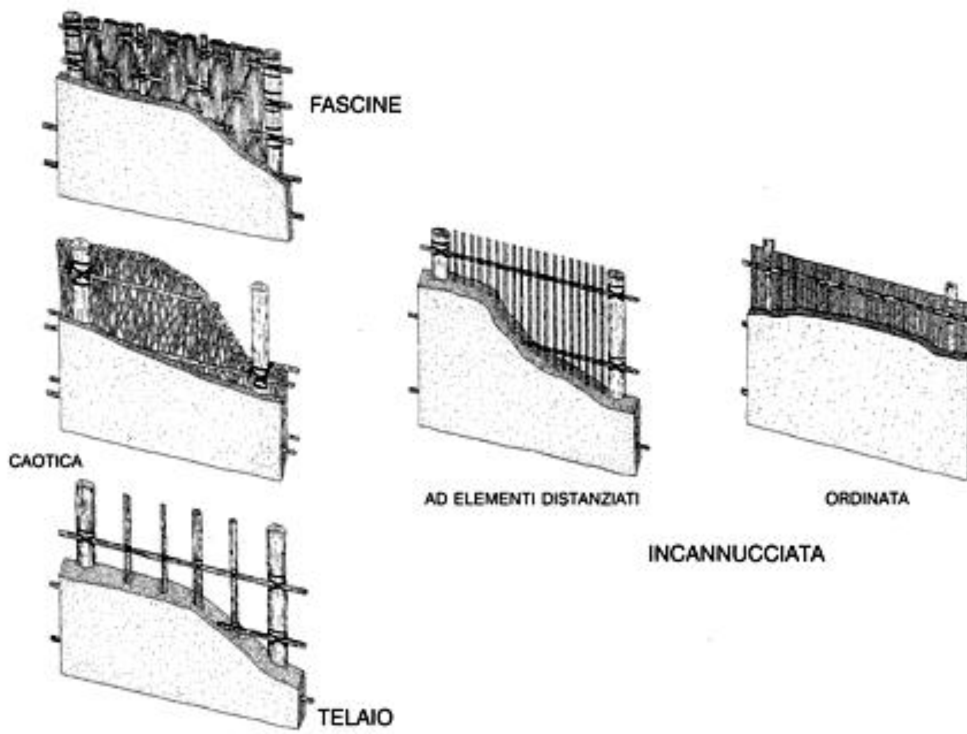


Figure 71: Broglio di Trebisacce - Reconstruction of possible earthen walls (Moffa 2002, Fig. 22)

Figure 72: Populonia - Wattle-and-daub wall at experimental archaeological park

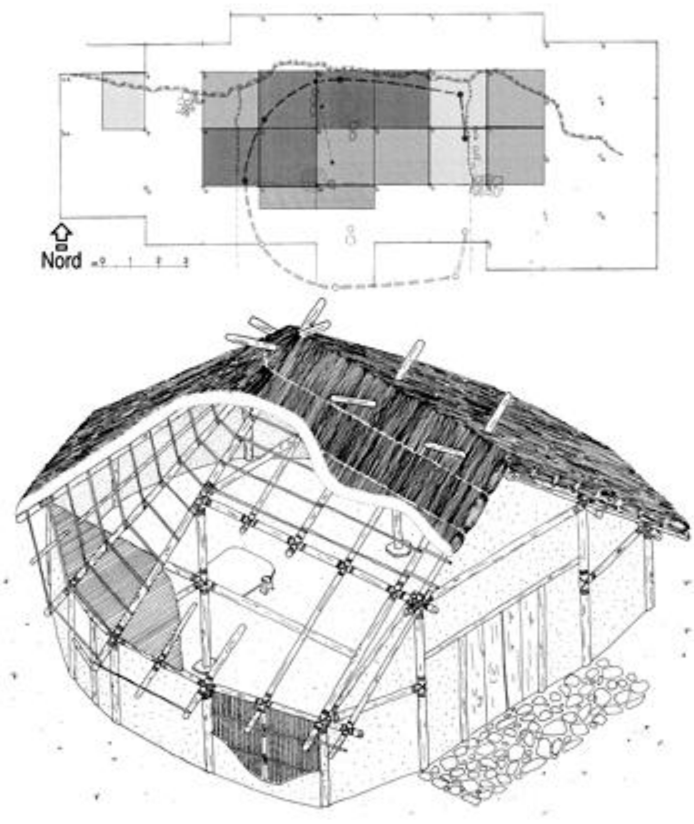


Figure 73: Broglio di Trebisacce - Reconstruction of casa centrale with plan of daub distribution above (Moffa 2002, Fig. 27)

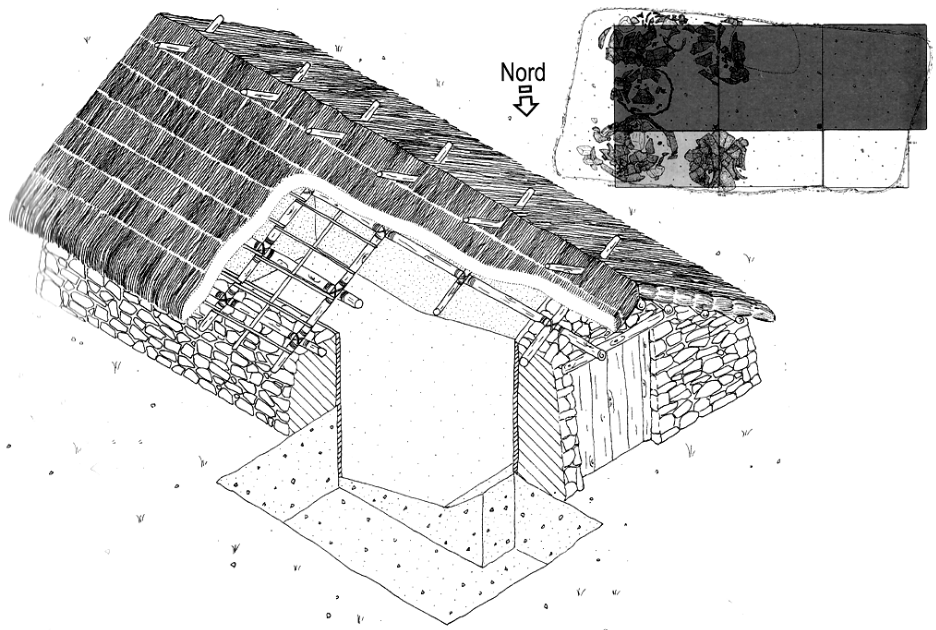


Figure 74: Broglio di Trebisacce - Reconstruction of dolia building with plan of daub distribution above (Moffa 2002, Fig. 28)

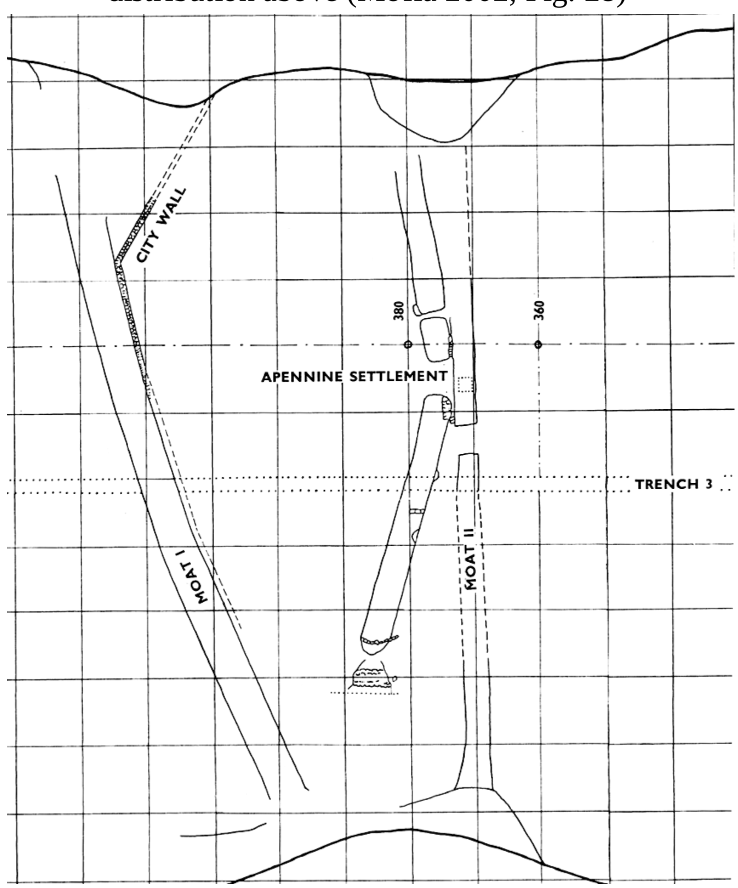


Figure 75: Luni sul Mignone - Plan of Bronze Age settlement (Ostenberg 1967, Fig. 2)

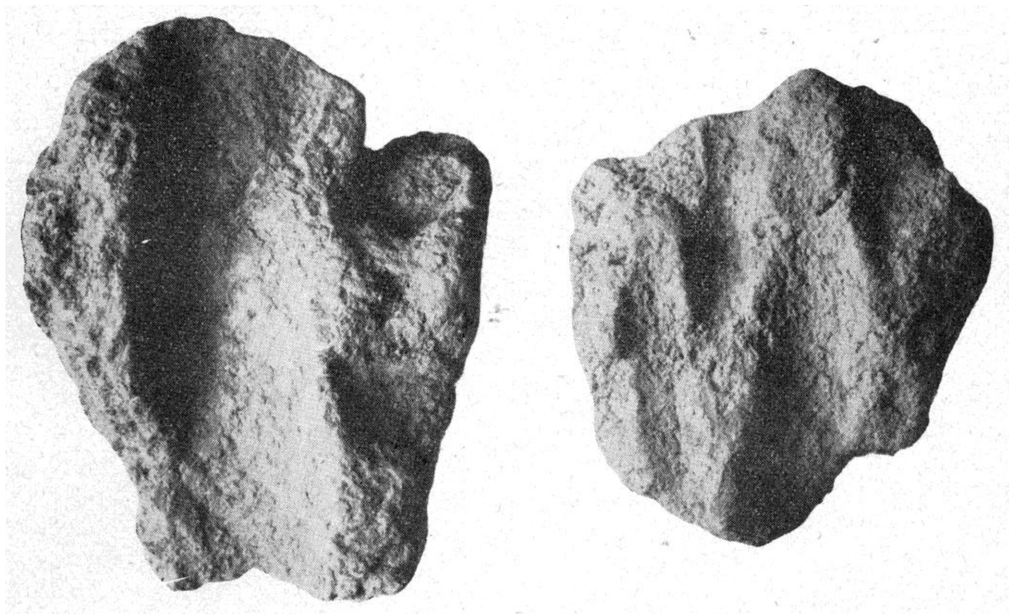


Figure 76: Belverde - Daub with impressions (Calzoni 1954, 39)

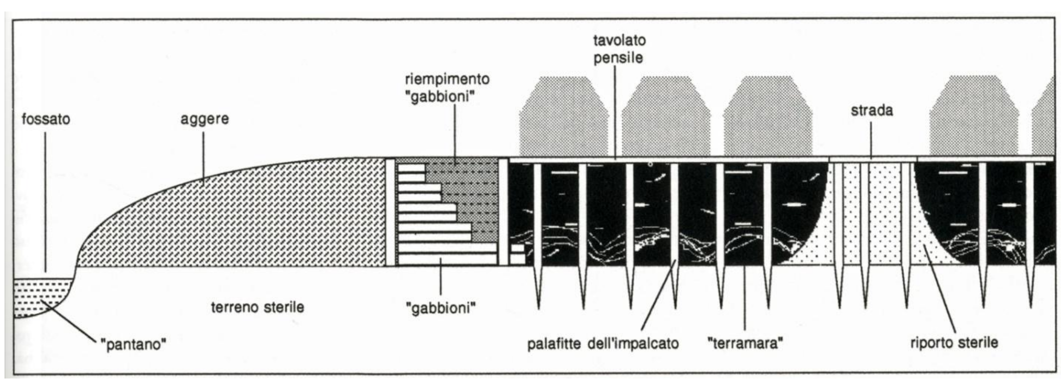


Figure 77: Elevation of a typical terramare settlement with houses supported on wooden piles and set behind an earthen agger (Leonardi 1997, 77)

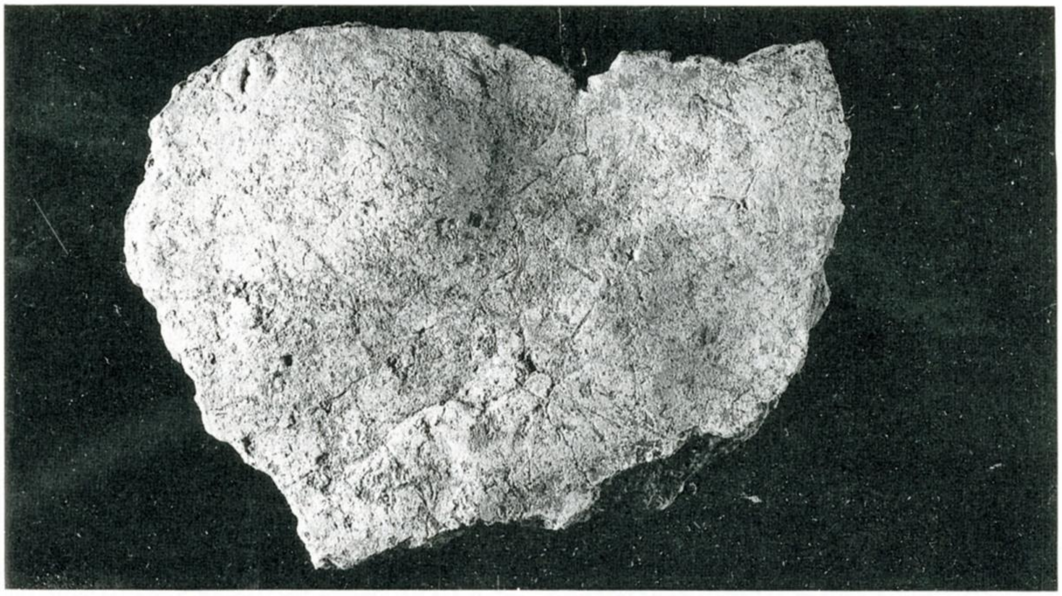


Figure 78: Pilastri - Daub with white patina (Celli 1995, 63)

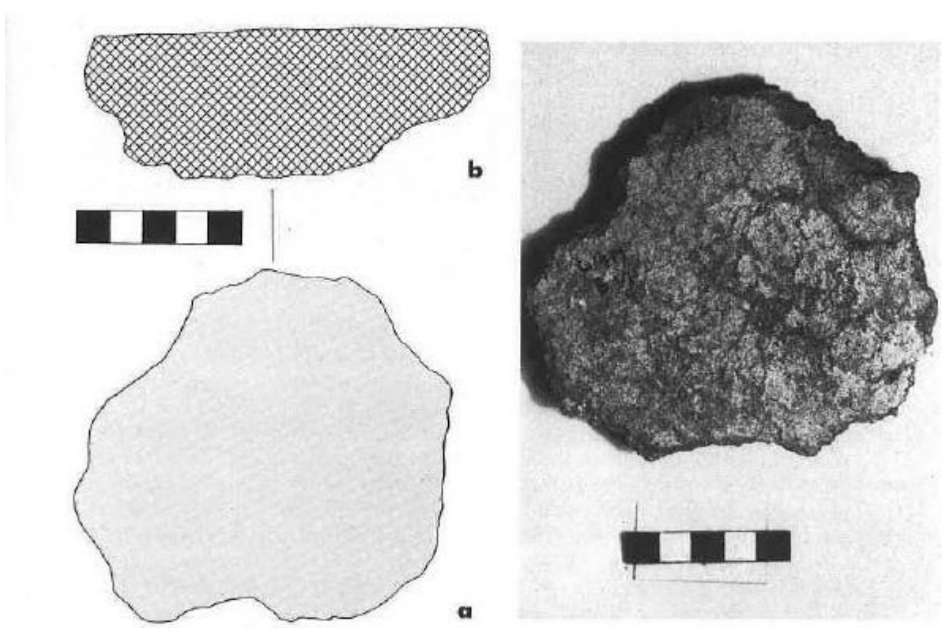


Figure 79: Camogli - Concotto (Milanese 1983, 221)

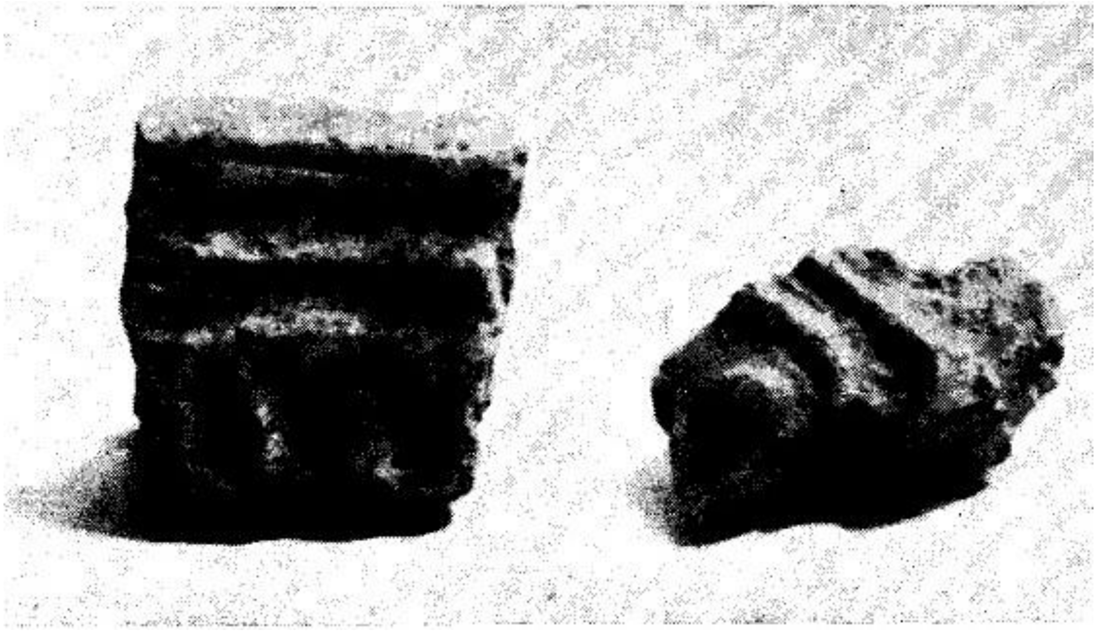


Figure 80: Vidolasco - Possible daub fragments with impressions (Fusco 1970, 6)

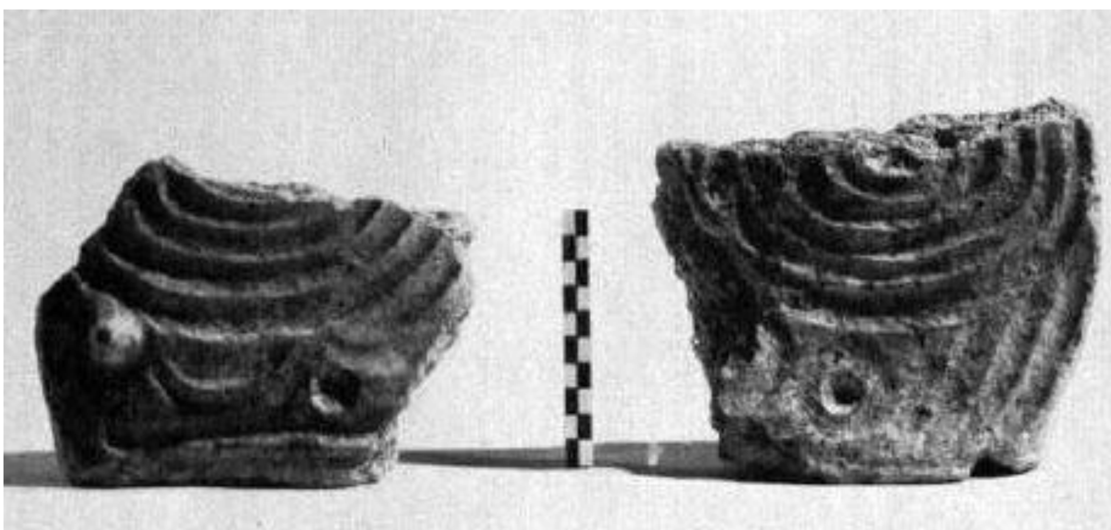


Figure 81: Vidolasco - Decorated terracotta with grooves and nodules (Mirabella Roberti 1962, 17)

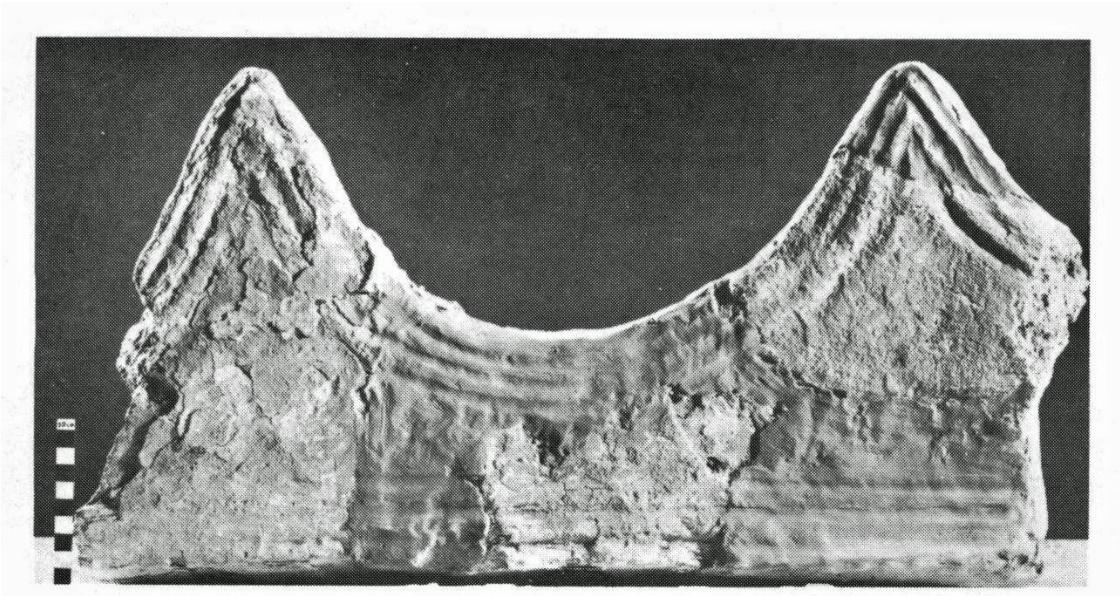


Figure 82: Daub used as crenellation above doorway/roof from Slovakia (Paulik 1962, 36)

Figure 83: Populonia - Reconstruction of 'King's house' (Bartoloni 2010, 10)

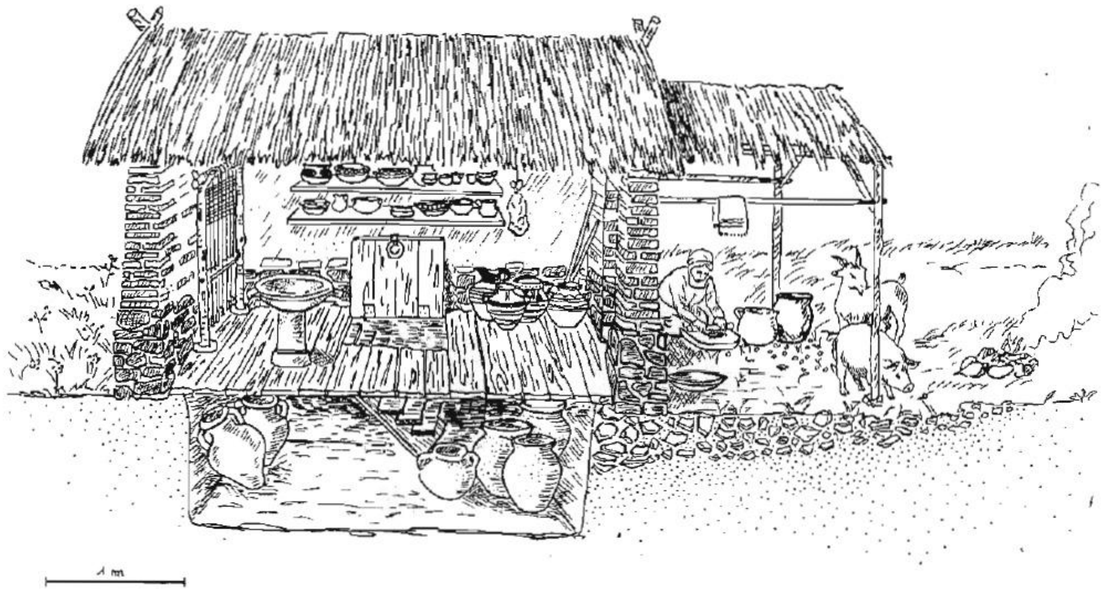


Figure 84: Incoronata -Reconstruction of hut (Lambrugo 2003, 50)

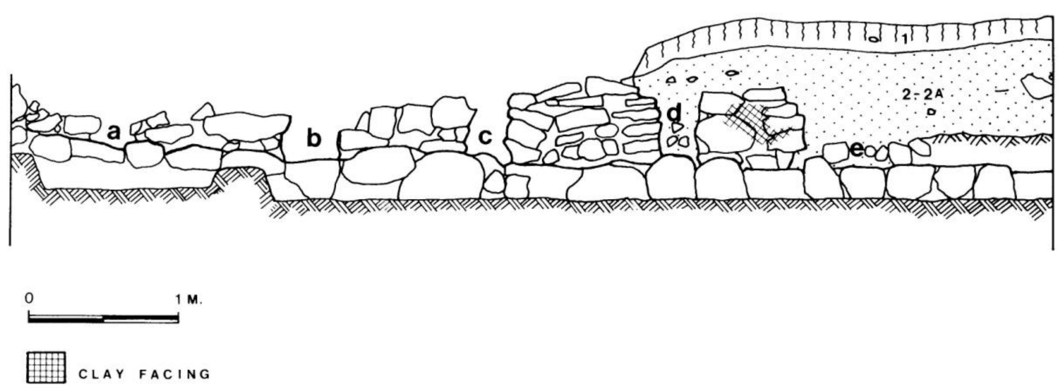


Figure 85: Cittadella – Wall elevations showing posthole locations (a-e) (Leighton 1993, 25)

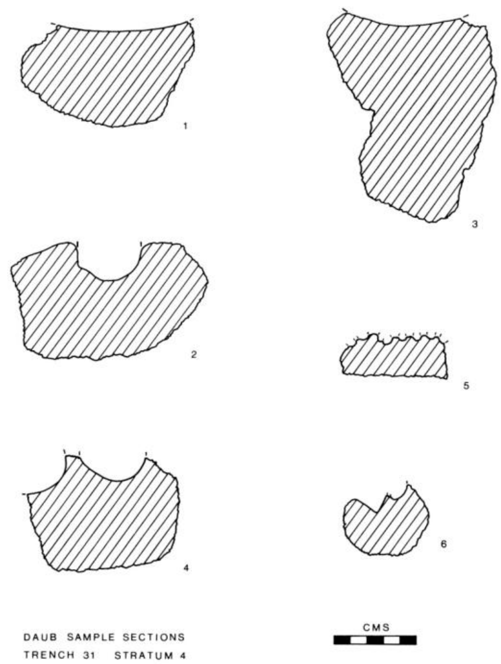


Figure 86: Cittadella - Daub with impressions (Leighton 1993, 90)

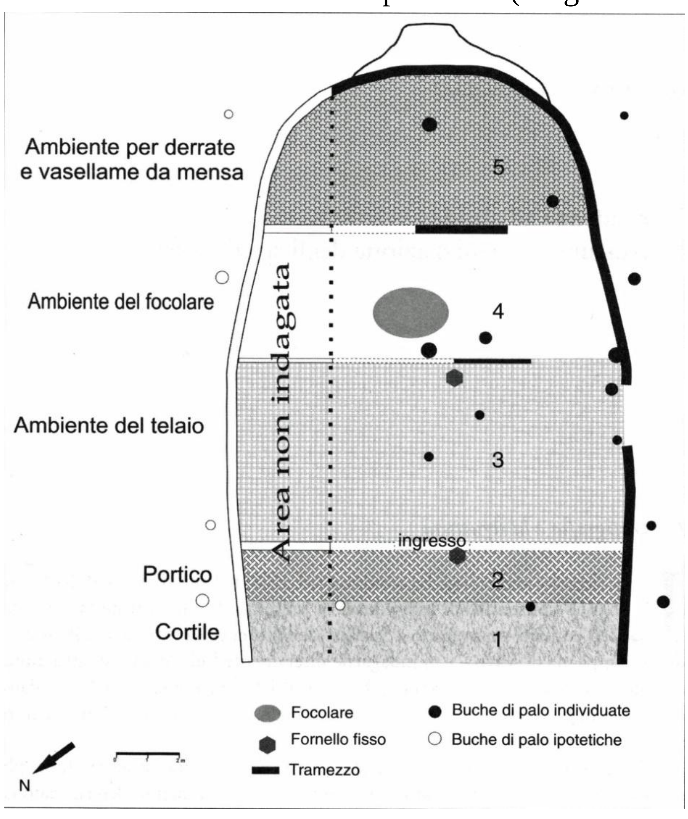


Figure 87: Torre di Satriano - Plan of apsidal building (Giammatteo 2009, Fig. 1)

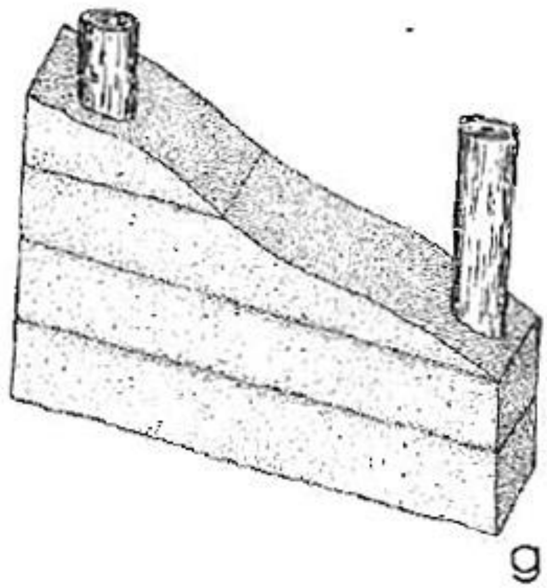


Figure 88: Drawing of a 'reinforced' pisé wall (Moffa 2005, Fig.1)

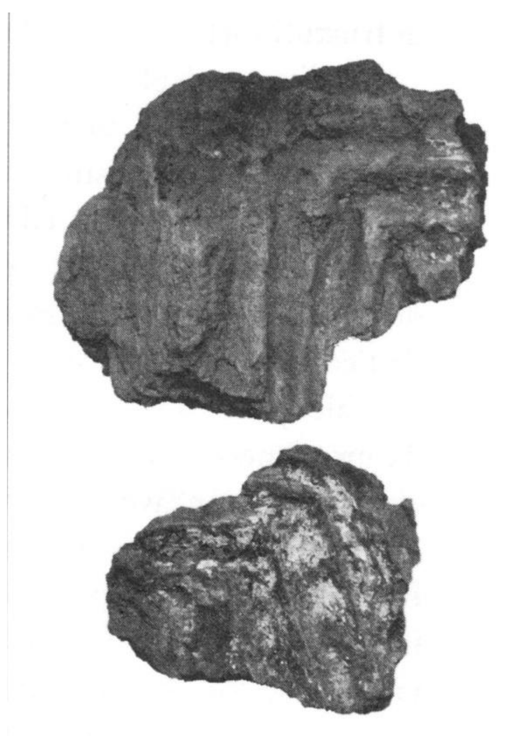


Figure 89: Torre di Satriano – Incised Daub (Carollo 2009, 21)

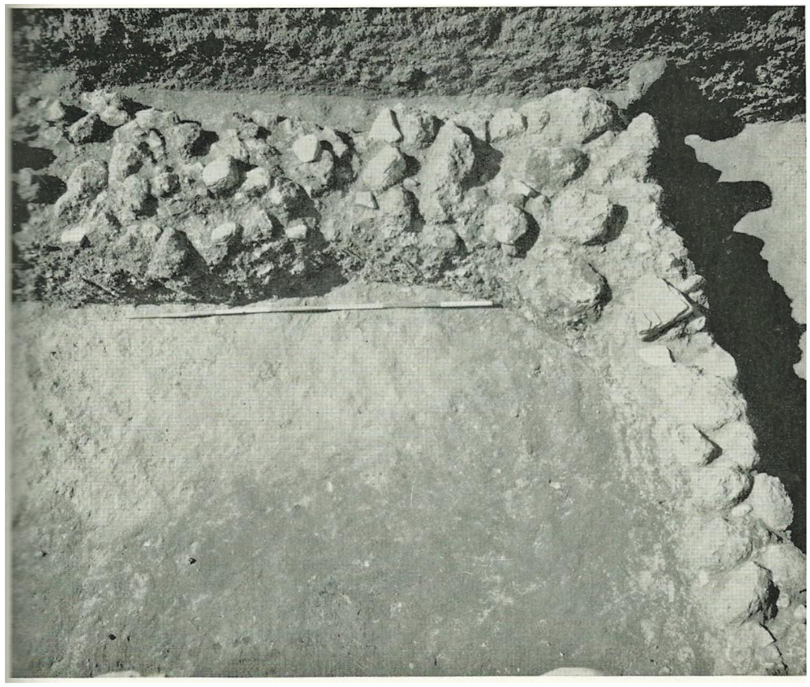


Figure 90: Luni sul Mignone-Stone embankment around hut at Tre Erici (Ostenberg 1967, Fig. 4)

Figure 91: Luni sul Mignone - Decorated daub from hut at Tre Erici (Ostenberg 1967, Fig. 5)

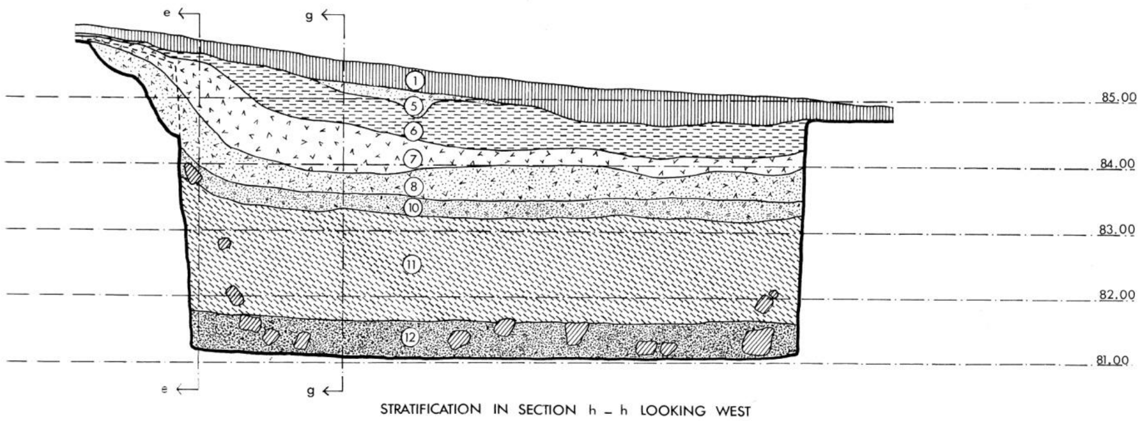


Figure 92: Luni sul Mignone - Section of dugout of Iron Age house (Hellström 1975, Pl. 58)

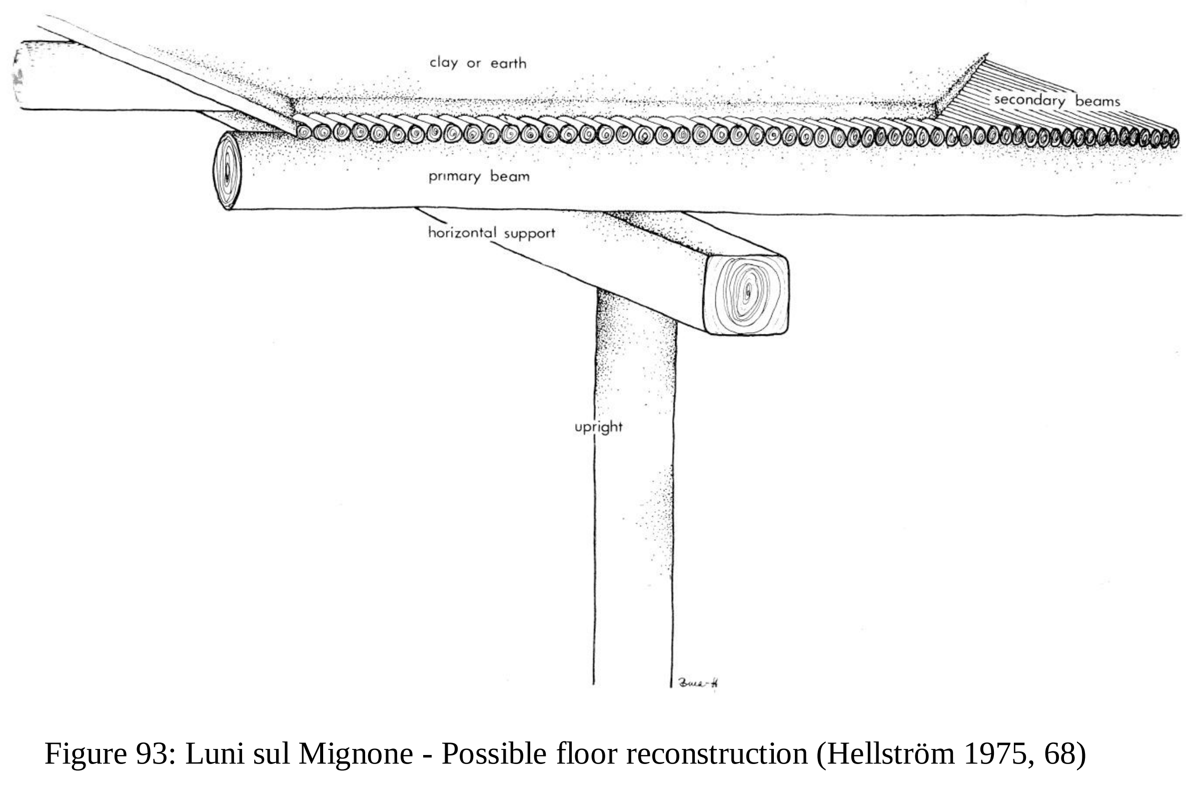


Figure 93: Luni sul Mignone - Possible floor reconstruction (Hellström 1975, 68)

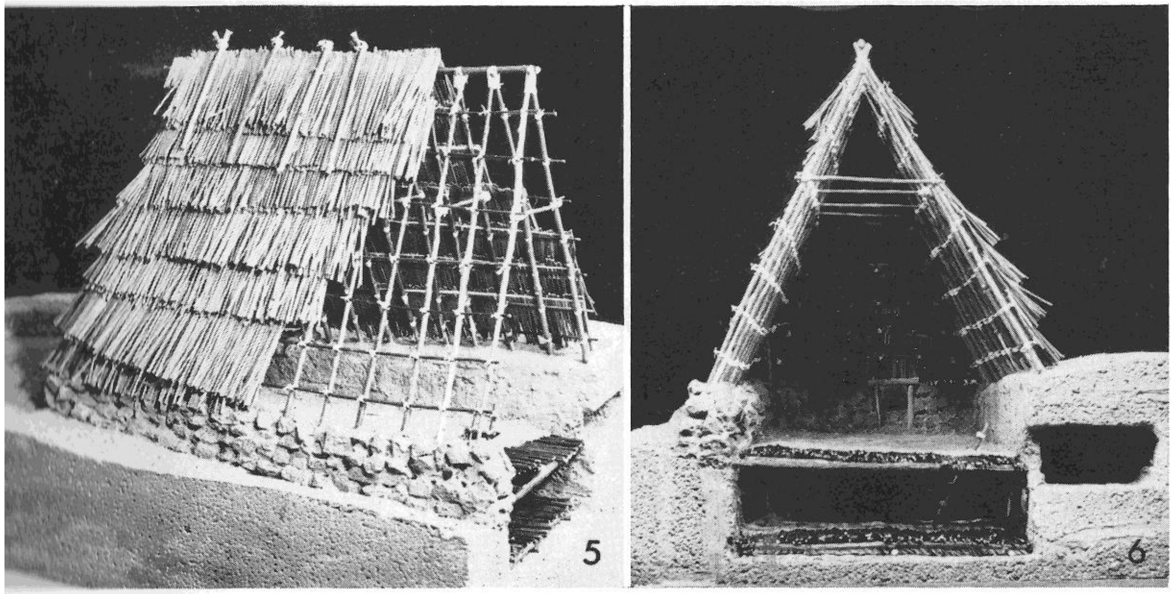


Figure 94: Luni sul Mignone - Hut reconstruction (Hellström 1975, Pl. 14)

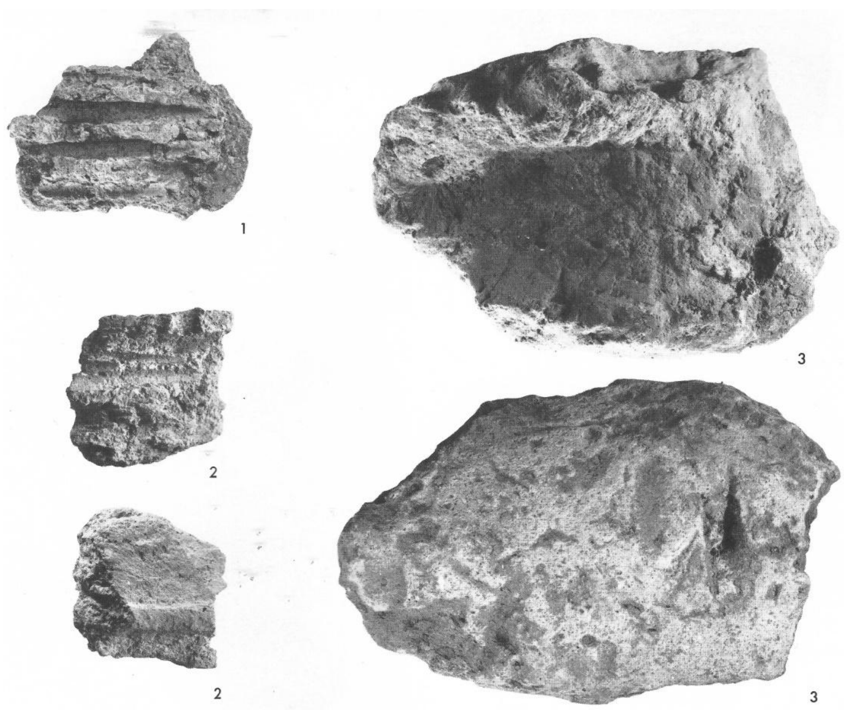


Figure 95: Luni sul Mignone - Daub from statum 12 of dugout (Hellström 1975, Pl. 53)

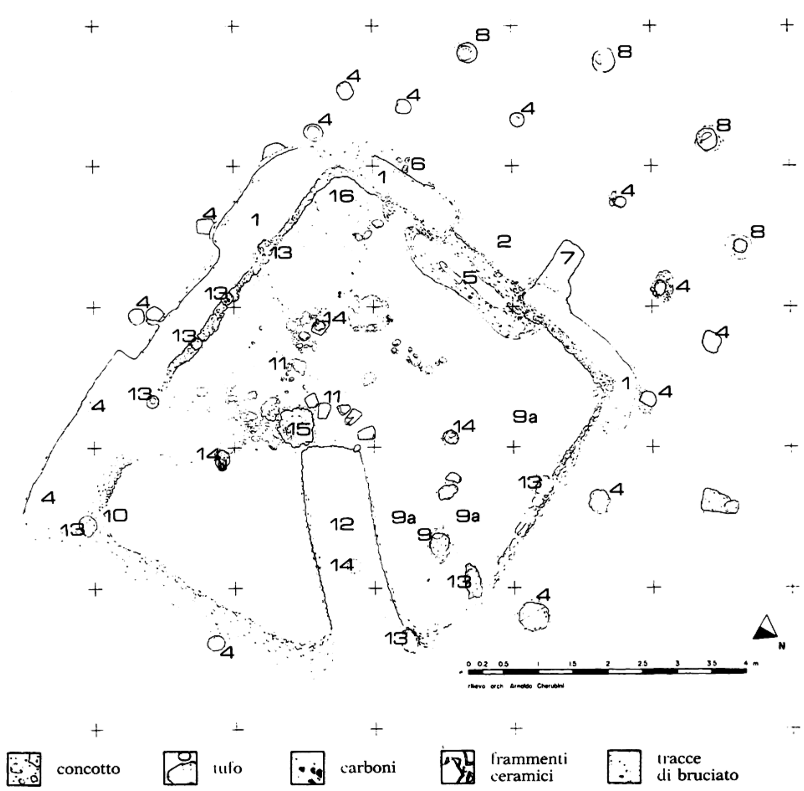


Figure 96: Fidenae - Plan of structure with pisé walls outlined by external (#4) and internal (#13) postholes (Bietti Sestieri and De Santis 2001, 213)

Figure 97: Construction of pisé wall (Genovesi 2000, 314)

Figure 98: Fidenae - Remains of pisé wall (De Santis et al. 1998, 8)

Figure 99: Fidenae - Exterior view of reconstructed hut (Bietti Sestieri and De Santis 2001, 219)

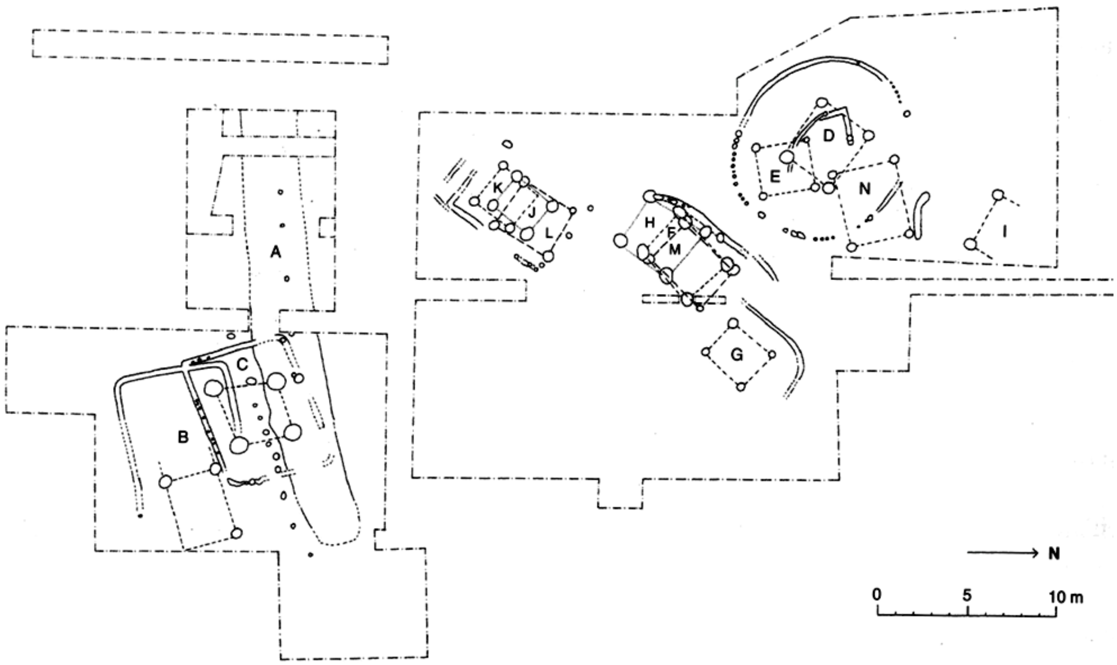


Figure 100: Ficana - Plan of huts from area 3b-c (Brandt 1996, 22)

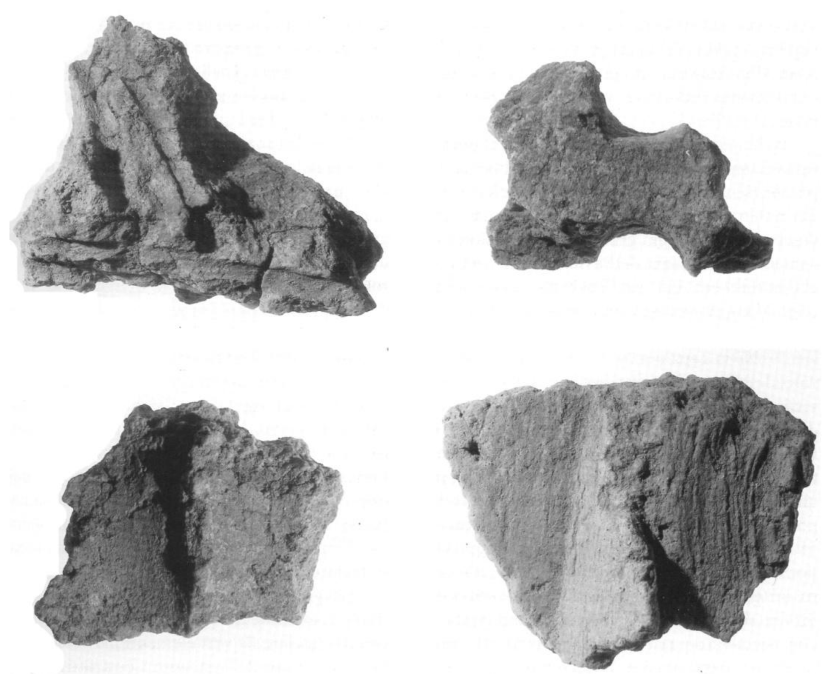


Figure 101: Ficana - Daub types (Brandt 1996, Fig. 7)

Figure 102: Roselle - 7th c. BC earthen architecture (in black) (Adapted from Colonna 1986, Tav. 10)

Figure 103: Roselle - Cross section of brick wall (Laviosa 1961, Tav.Vb)

Figure 104: Acquarossa - Aerial view of Zone F (Persson 1986, 42)

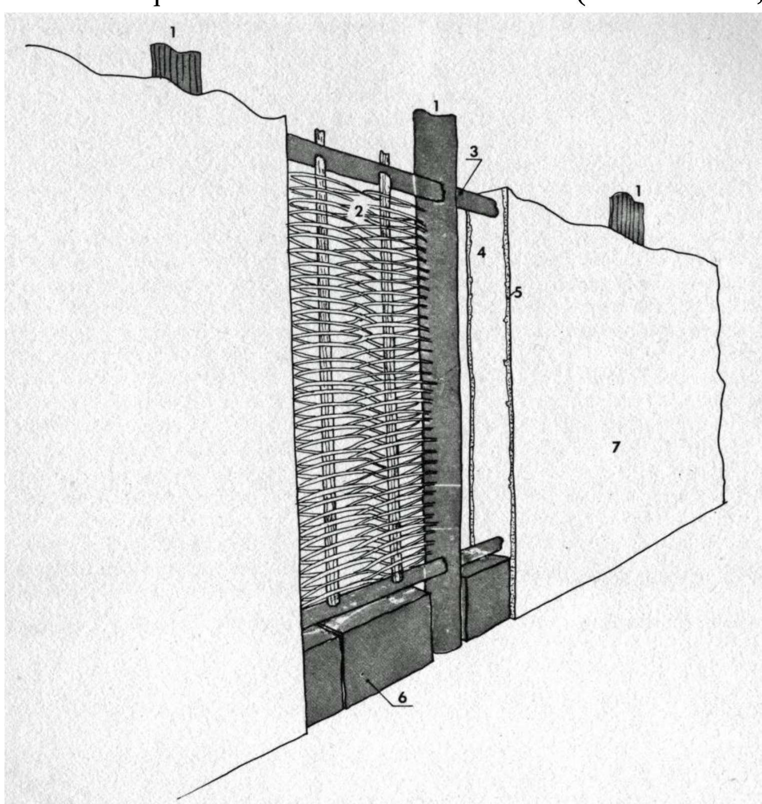


Figure 105: Acquarossa - Proposed scheme for a wattle-and-daub wall (Wendt 1986, 59)

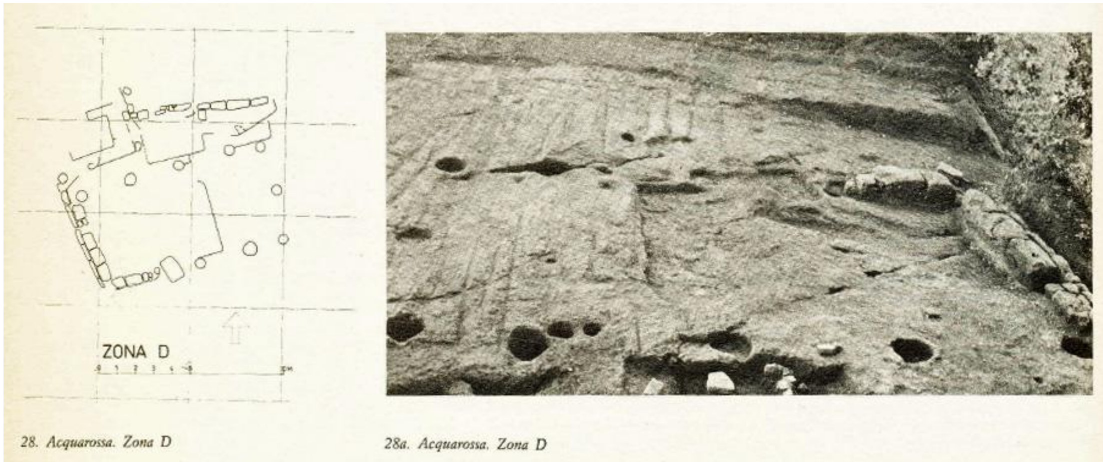


Figure 106: Acquarossa - Plan and image of Casa A, Zone D (Viden 1986, 54)

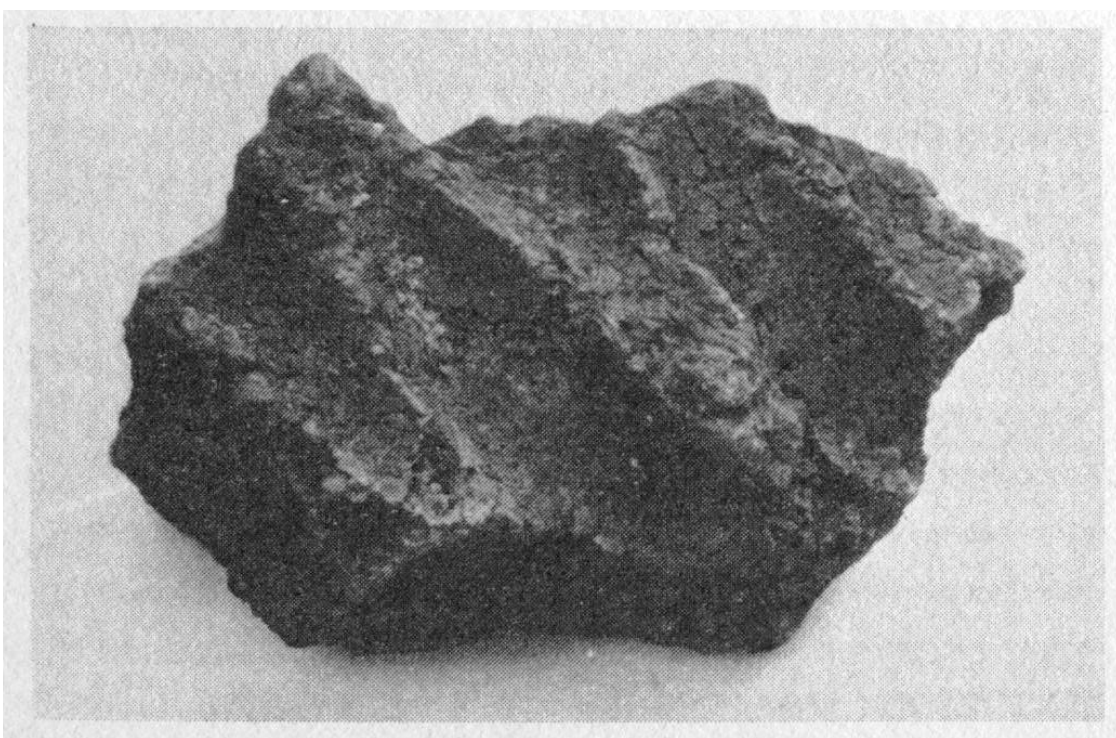


Figure 107: Acquarossa - Daub with impressions (Wendt 1986, 60)

Figure 108: San Giovenale – Stone walls of 7^{th}-6^{th} c. BC houses on Borgo (Colonna 1986, Fig. 269)

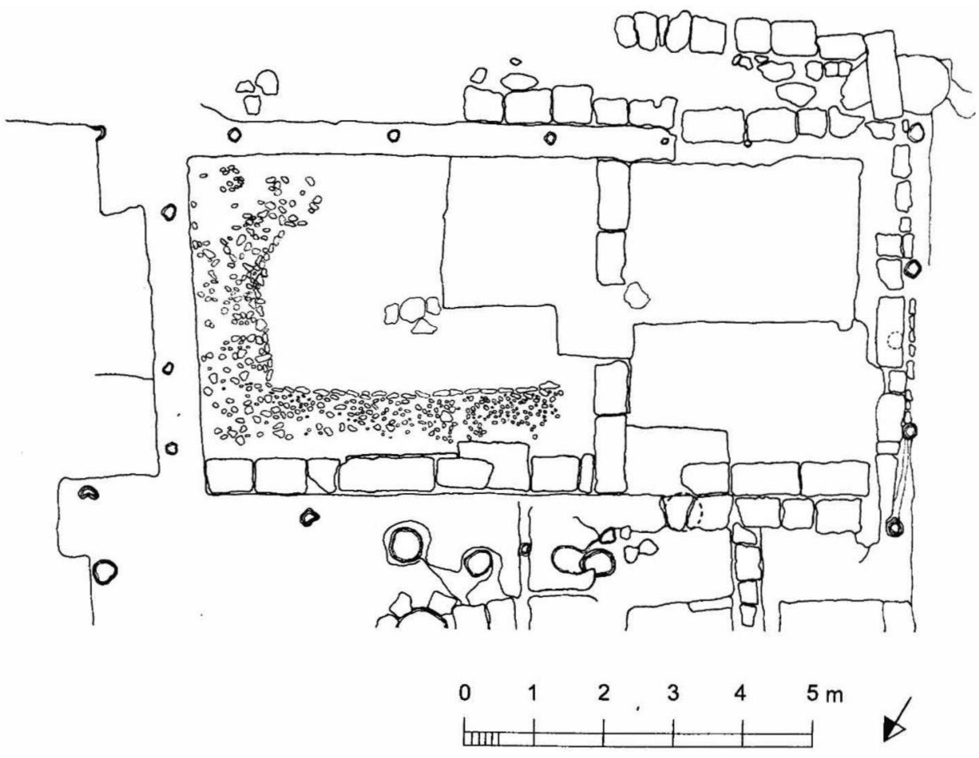


Figure 109: San Giovenale - Plan of House I, Area F (Karlsson 2006, 142)

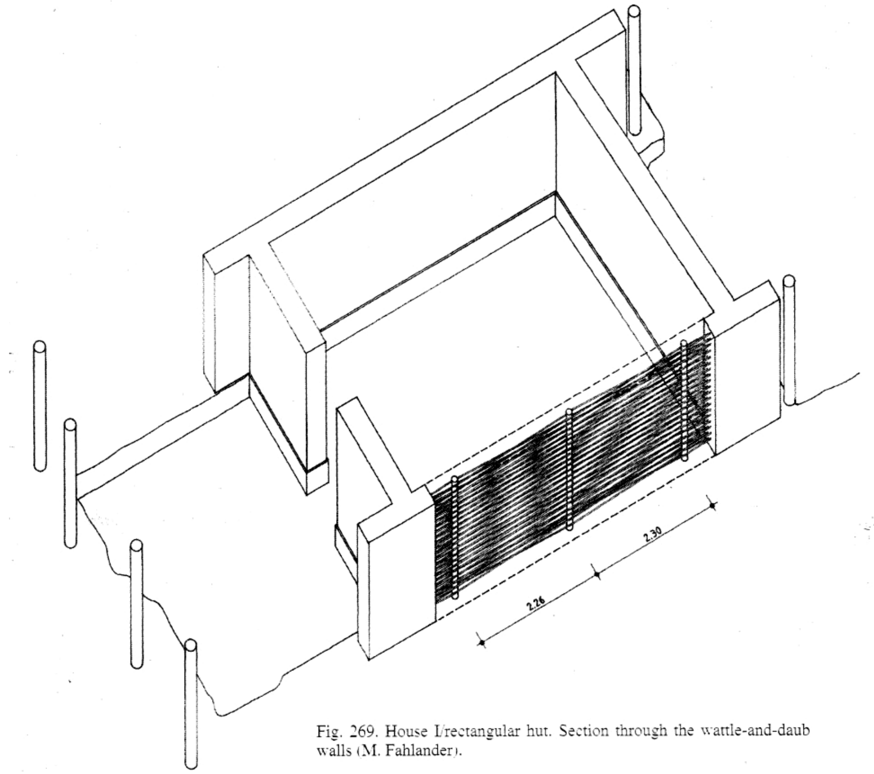


Fig. 269. House I/rectangular hut. Section through the wattle-and-daub walls (M. Fahlander).

Figure 110: San Giovenale - Reconstruction of House I, Area F (Karlsson 2006, 145)


Fig. 272. House I. Fragments of daub found during excavation of Room B.

Figure 111: San Giovenale - Daub fragments (Karlsson 2006, 147)

Figure 112: San Giovenale - Plan of House III, Area F (Karlsson 2006, 41)

Figure 113: San Giovenale - Decorative daub associated with Iron Age huts (Karlsson 2006, 105)

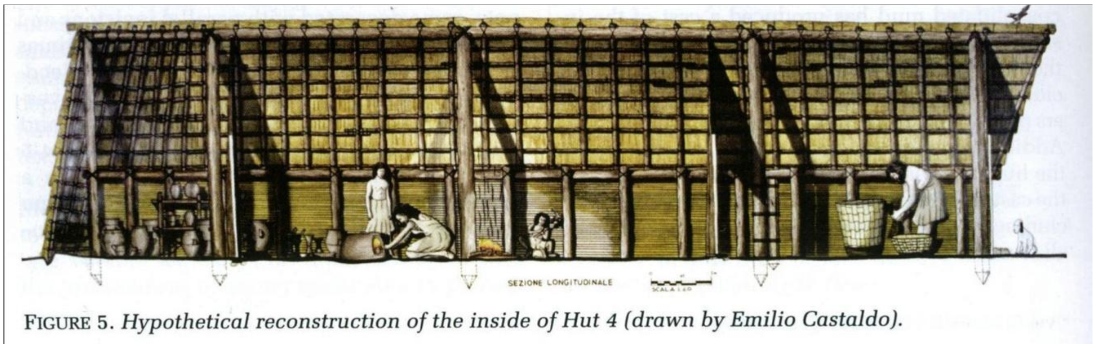


Figure 114: Nola-Croce della Papa - Reconstruction of house (Albore Livadie 2002, 942)

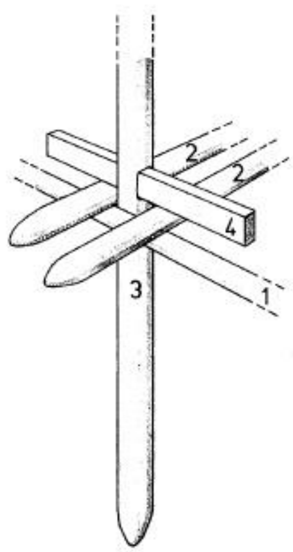


Figure 115: Fiave - Drawing of wooden pile connection (Marzatico 1997, 268)

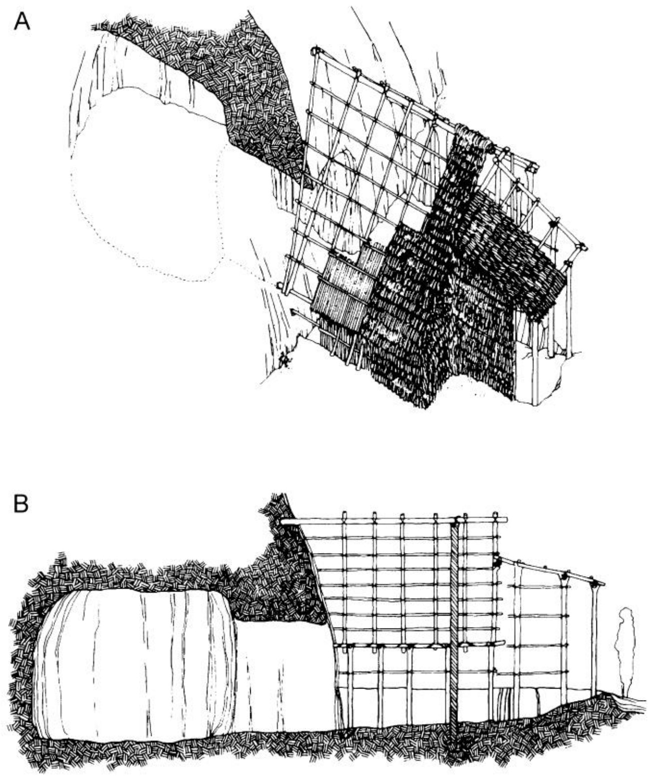


Figure 116: Sorgenti della Nova - Rock shelter building (Negroni Catacchio and Domanico 2001, 338)

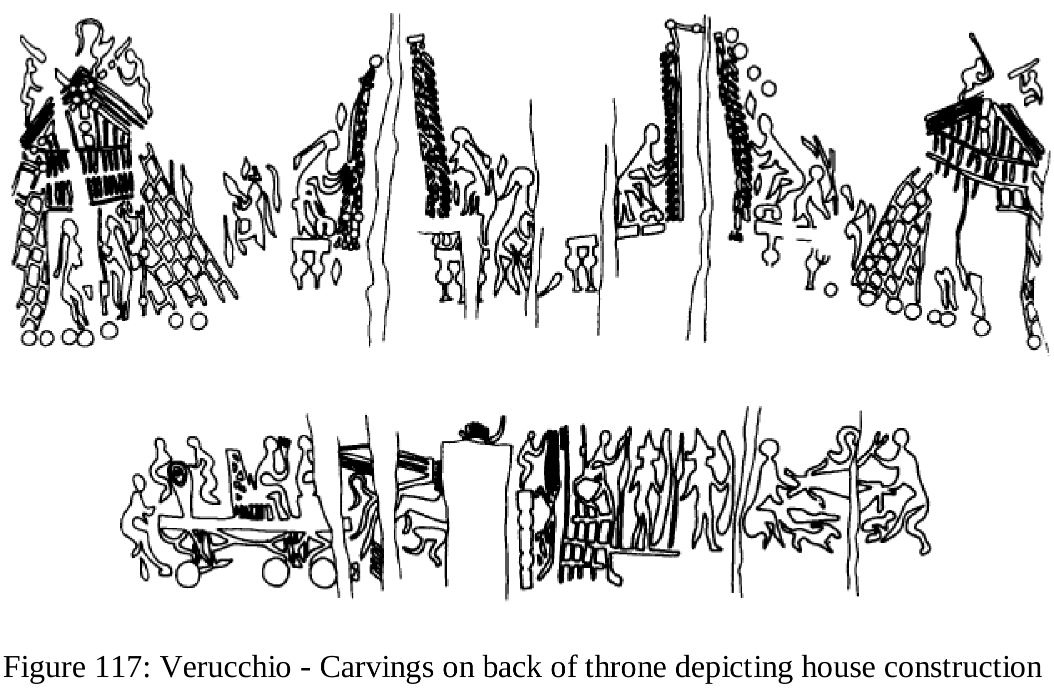


Figure 117: Verucchio - Carvings on back of throne depicting house construction (Haynes 2000, 40)

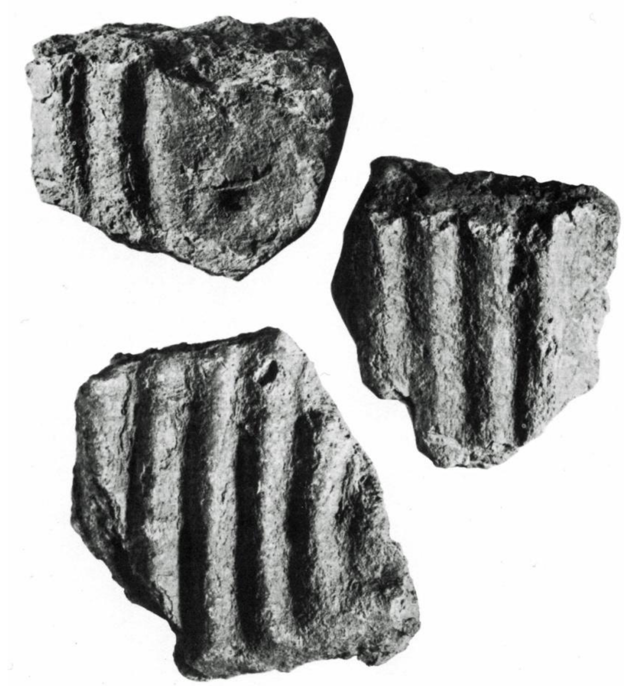


Figure 118: Decorative daub from Cerro de la Encina (Arribas Palau 1974, Pl. 20)

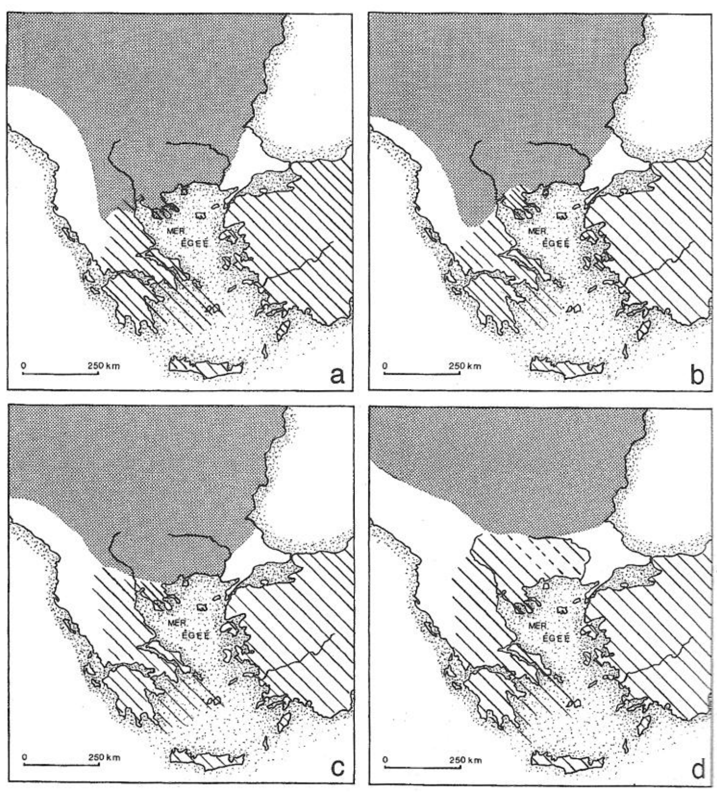


Figure 119: Progression of mudbrick (hatched areas) into areas where the construction technique of wattle-and-daub (shaded areas) was prevalent during the Bronze Age, according to R.Treuil (Chazelles-Gazzal 1997: 48)

Figure 120: Vinarragell - Mudbrick wall set above earthen floor (Mesado Oliver 1974, Pl. 37)

Figure 121: Incoronata - Mudbrick fragments (Orlandini 1986, Tav. 21)

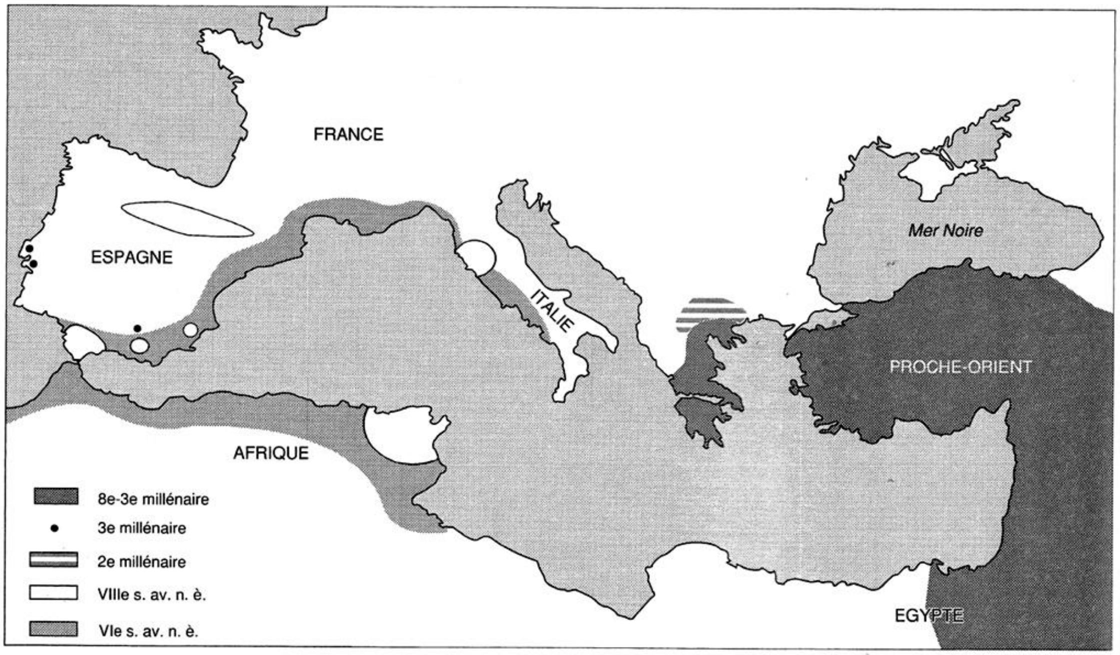


Figure 122: Spread of mudbrick from the Near East into the western Mediterranean during the 8th and 6th centuries BC (Chazelles-Gazzal 1997, 50)

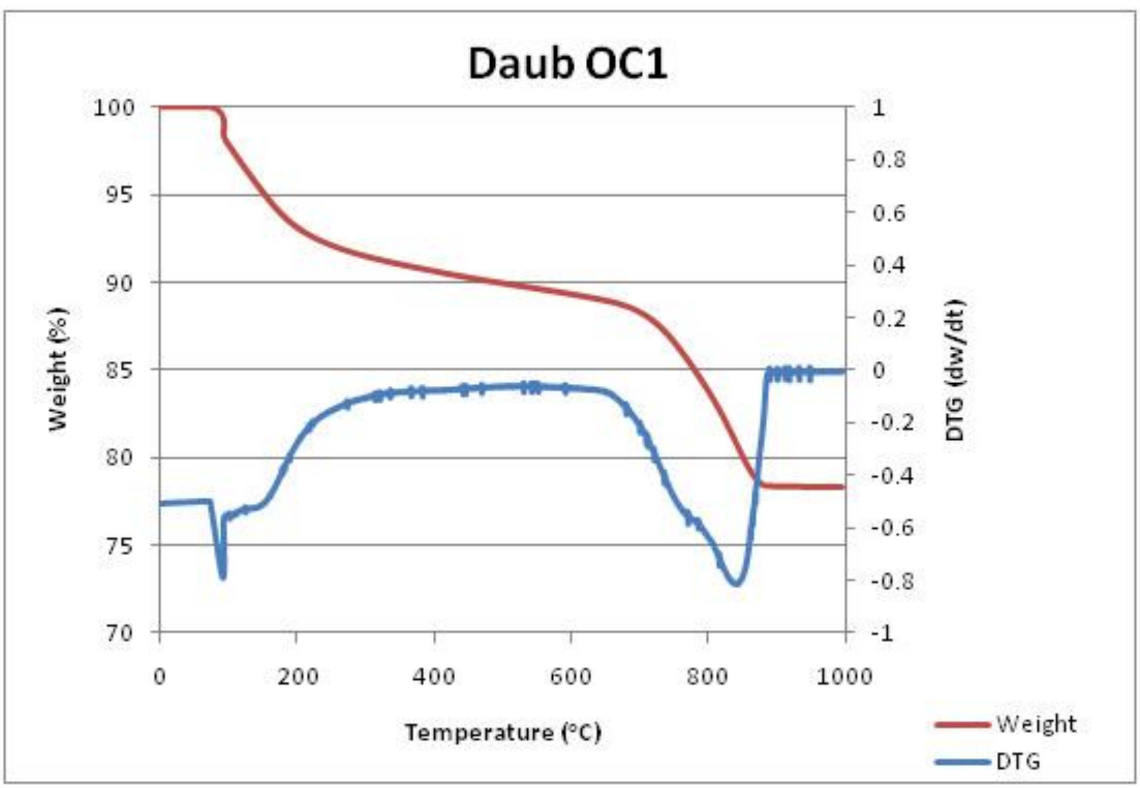


Figure 123: TGA graph for daub from OC1

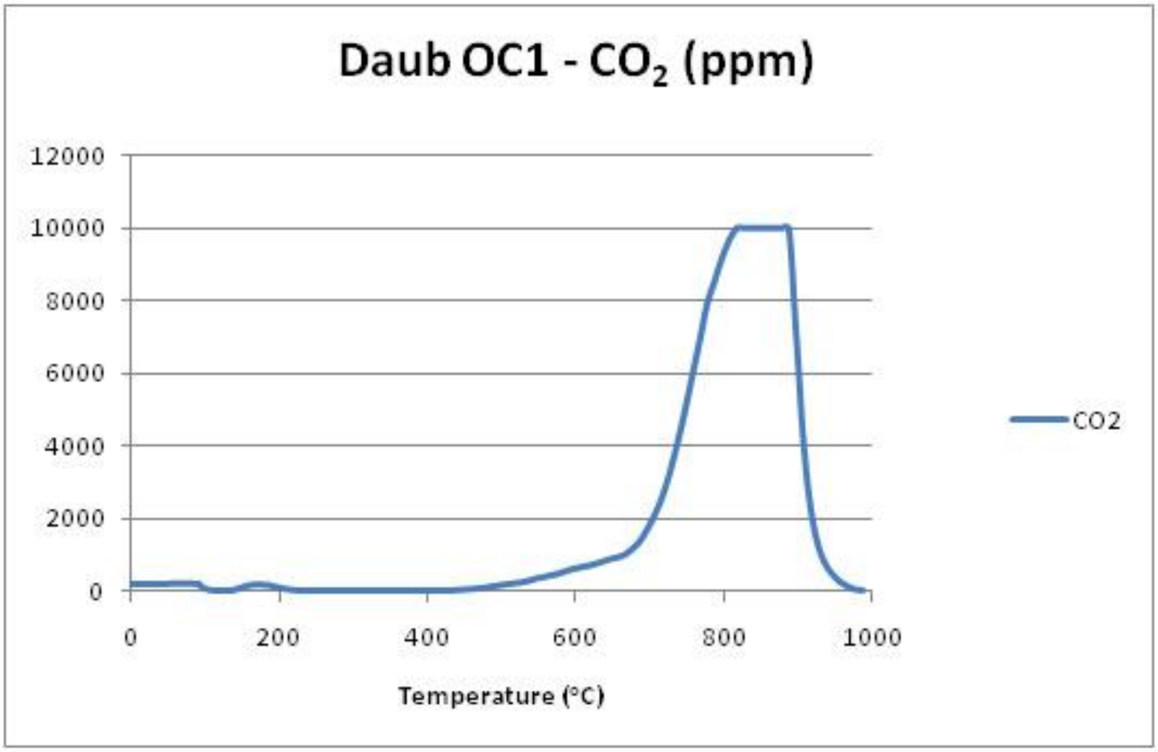


Figure 124: Daub OC1 - CO2 emissions

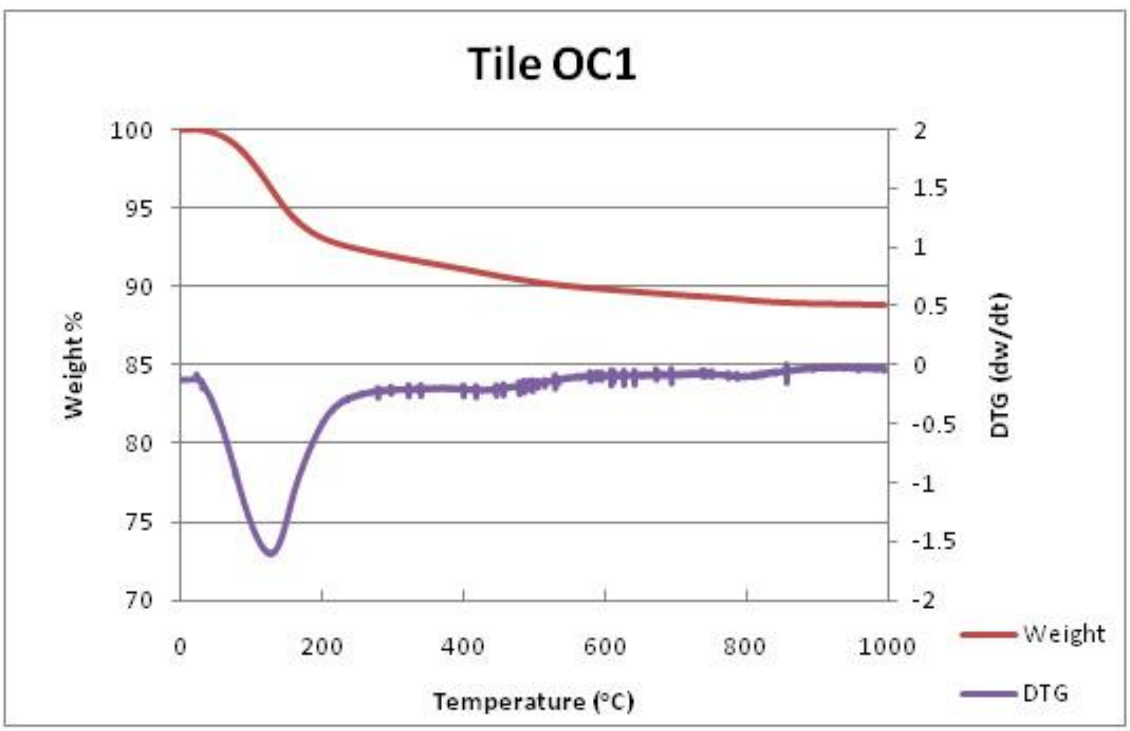


Figure 125: TGA graph for Tile from OC1

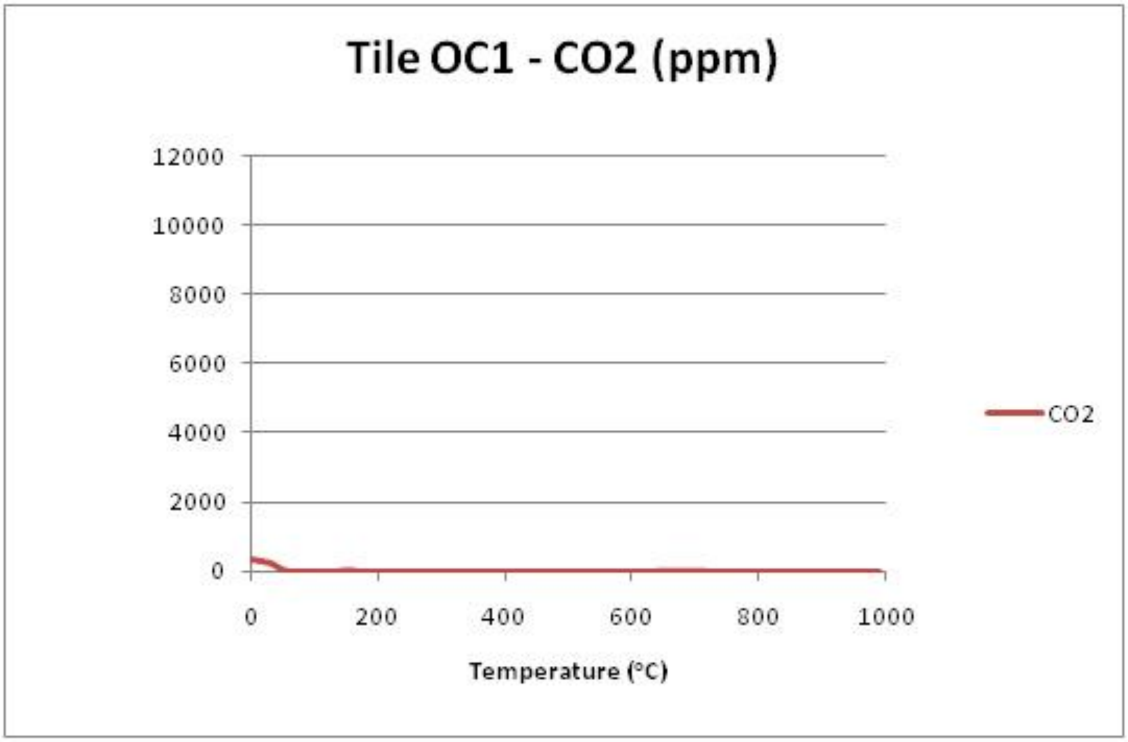


Figure 126: Tile OC1 - CO2 emissions

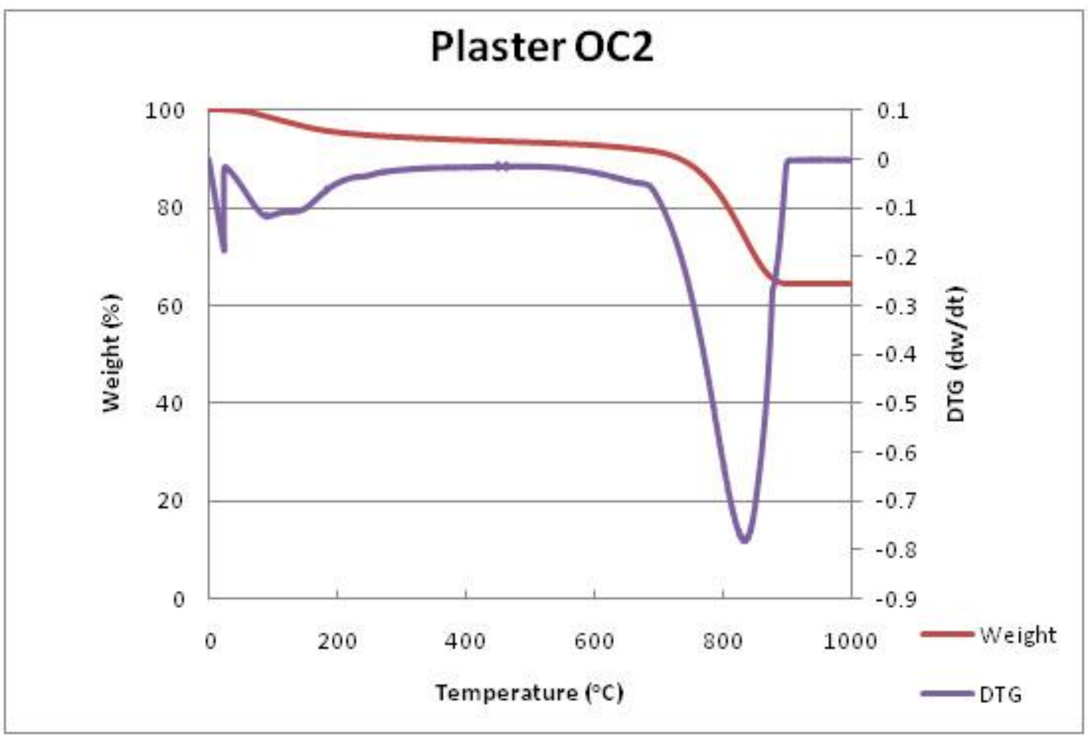


Figure 127: TGA curve for plaster from OC2

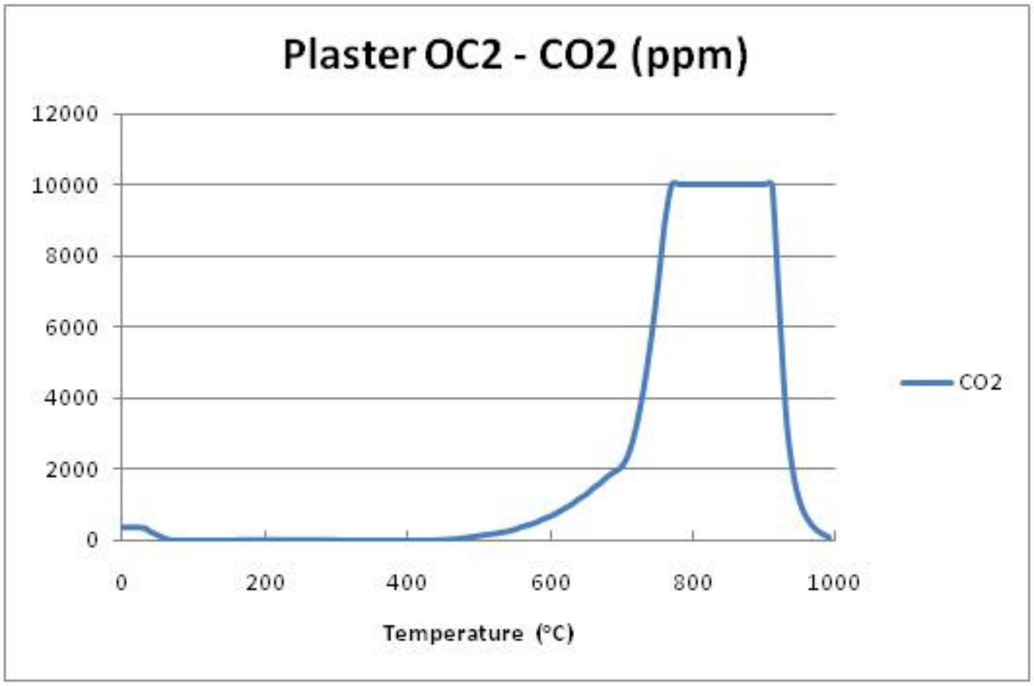


Figure 128: Plaster OC2 - CO2 emissions

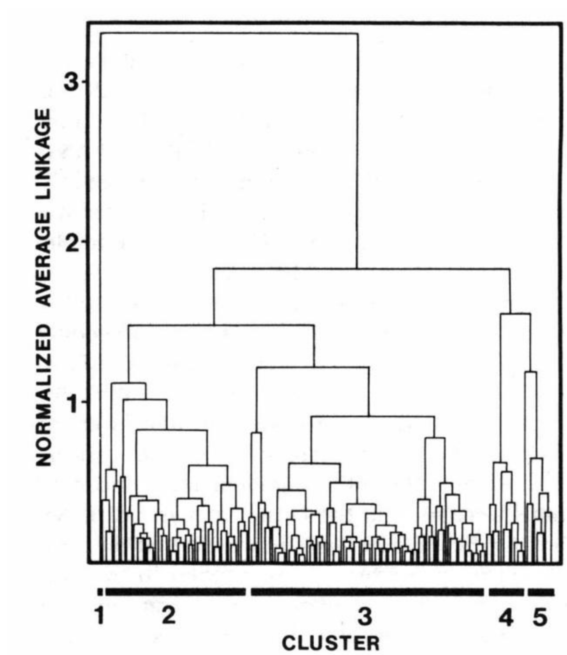


Figure 129: Dendrogram of average-linkage clustering algorithm at Poggio Civitate from 1986 INAA tests (Tobey et al 1986, 118)

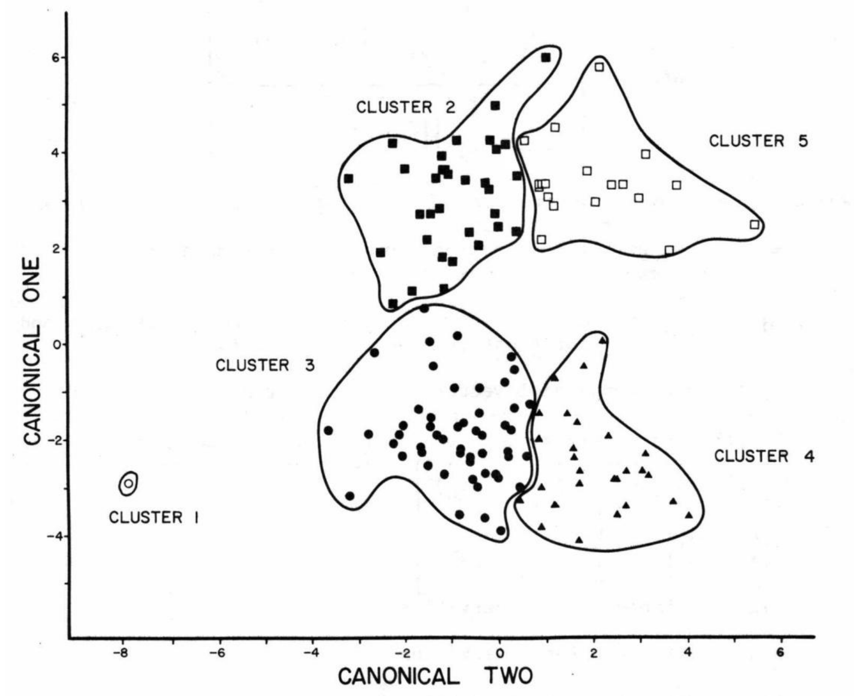


Figure 130: Clusters on bivariate plot according to k-means clustering algorithm from 1986 INAA tests (Tobey et al. 1986, 119)

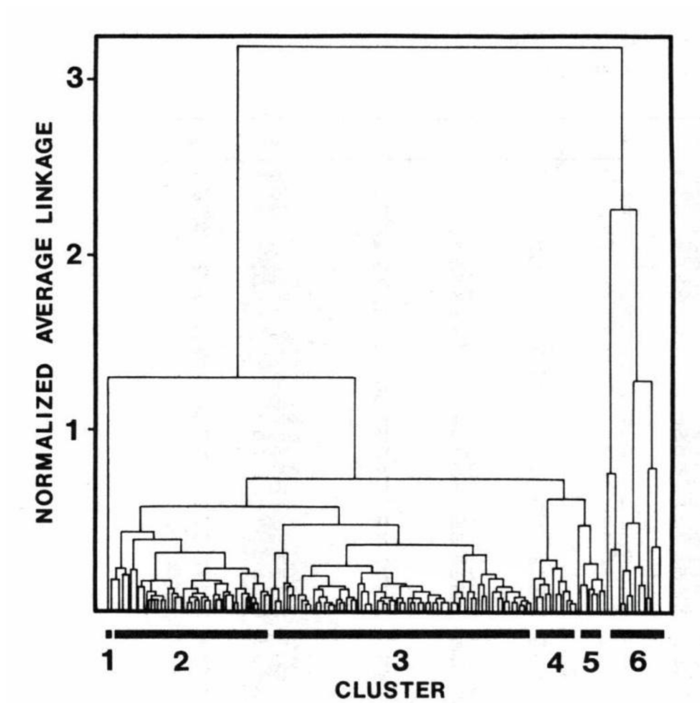


Figure 131: Dendrogram of second average-linkage clustering algorithm at Poggio Civitate from 1986 INAA tests (Tobey et al 1986, 123)

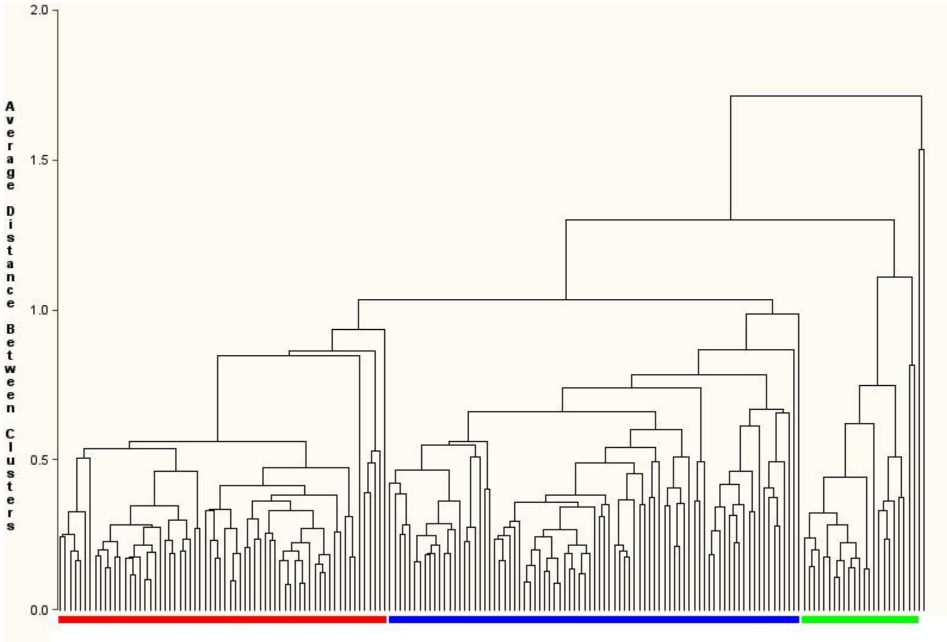


Figure 132: Dendrogram from SAS average-linkage clustering algorithm

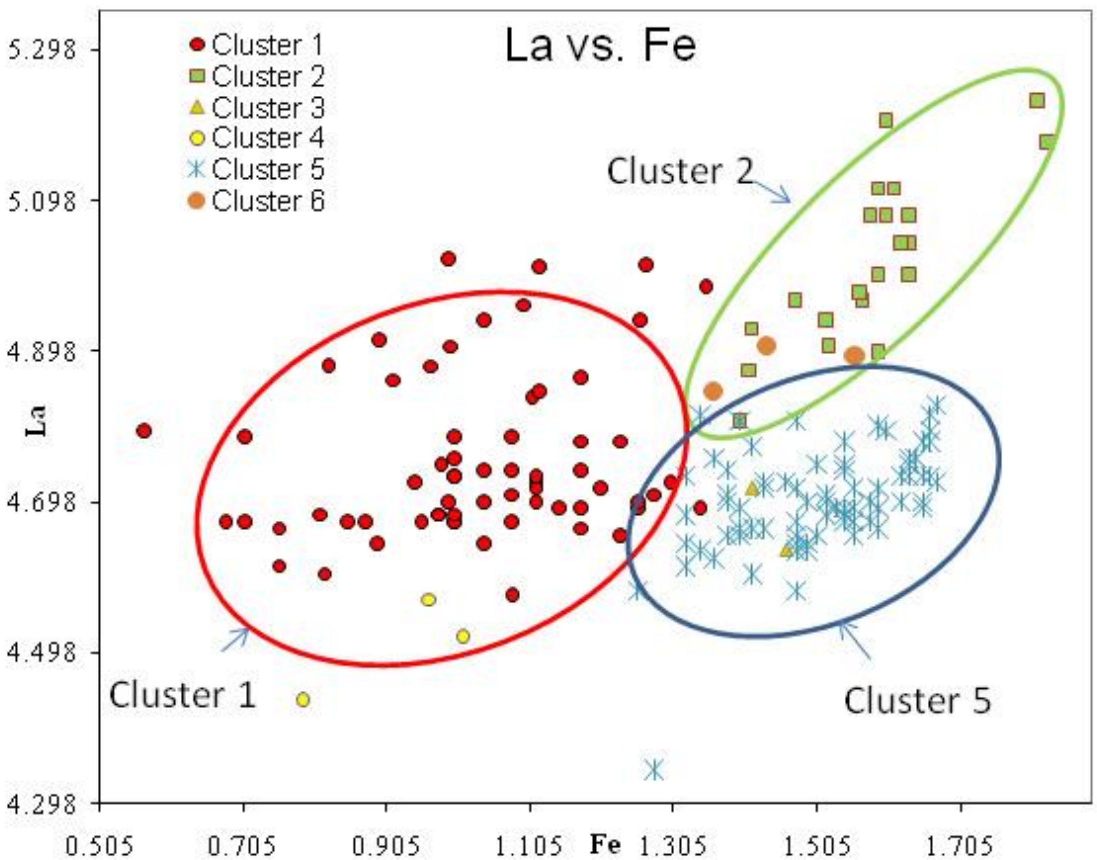


Figure 133: Bivariate plot of three clay groups

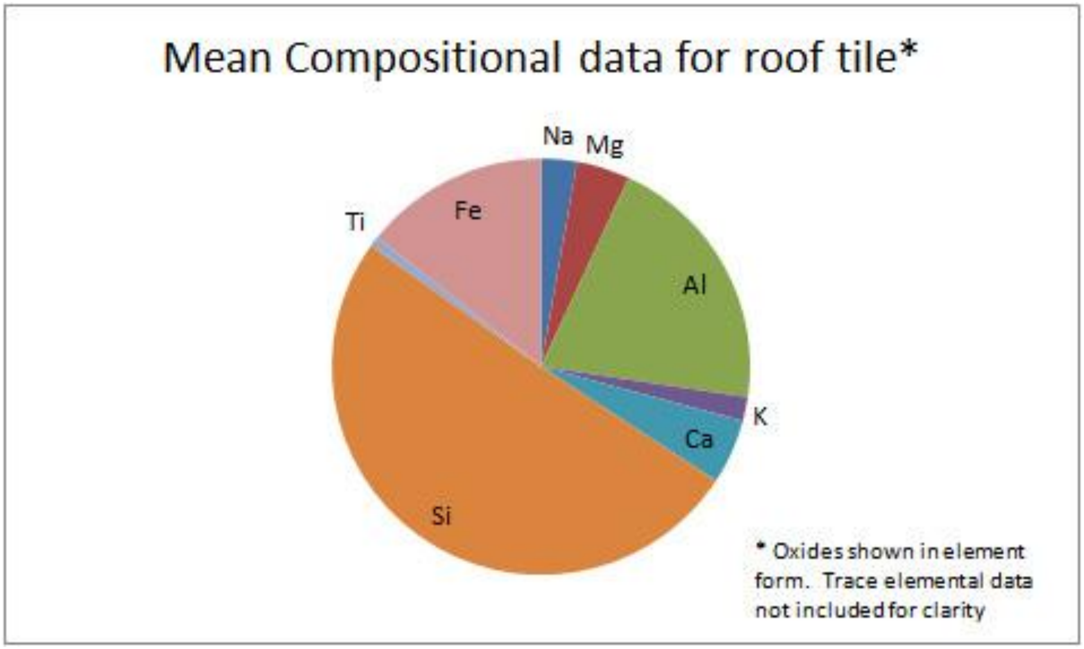


Figure 134: Mean compositional data of roofing tile

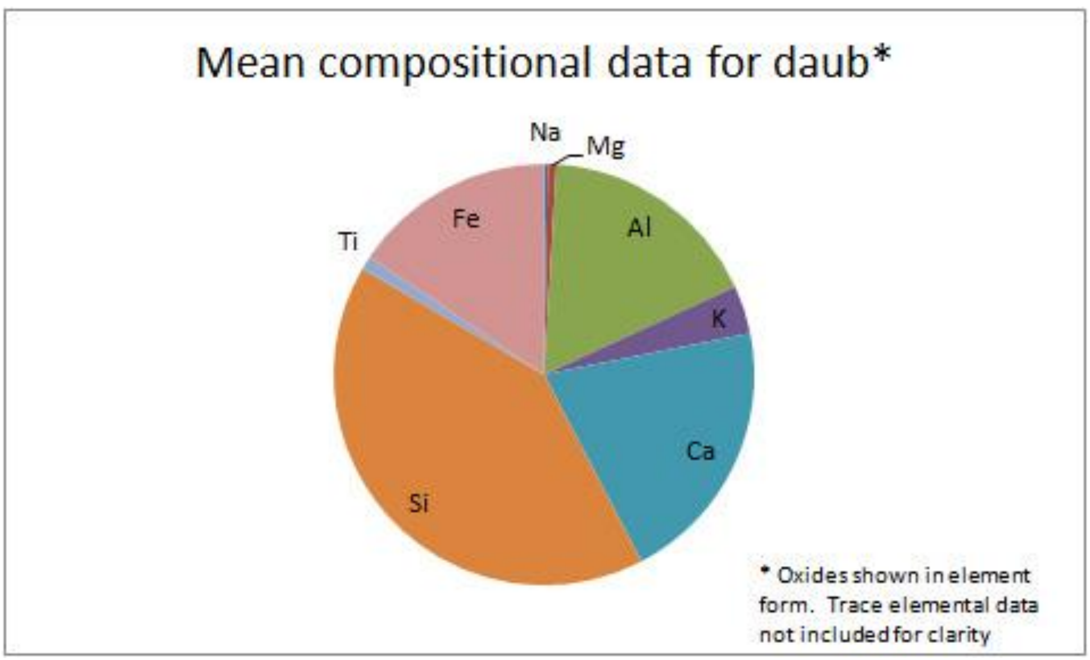


Figure 135: Mean compositional data of daub

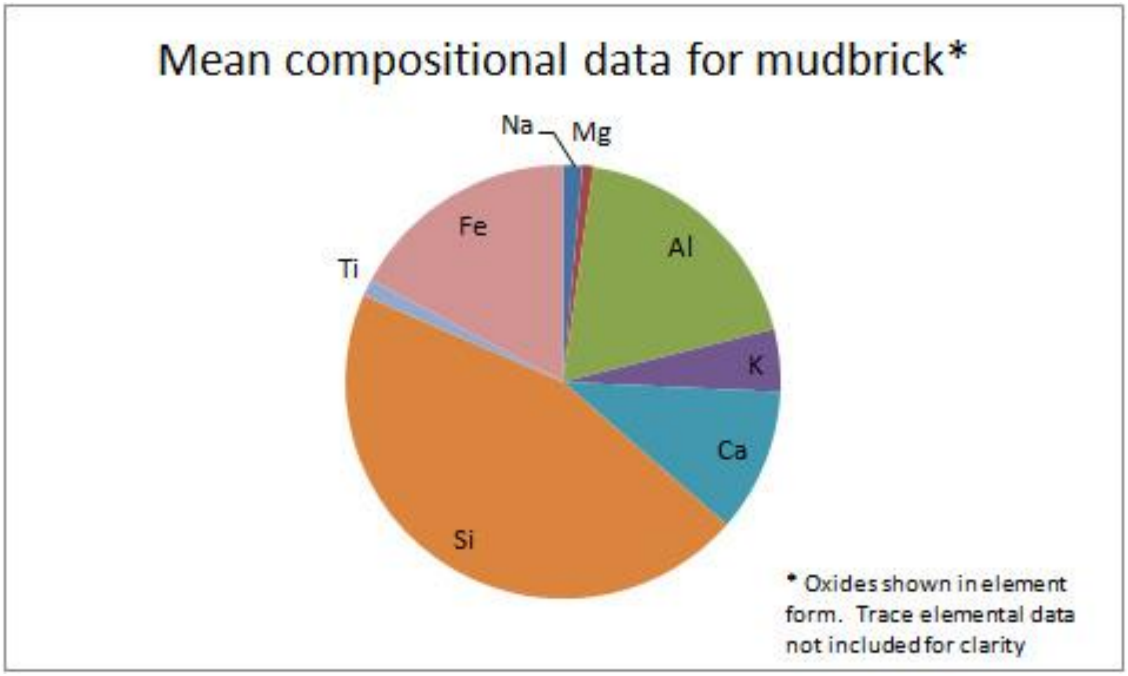


Figure 136: Mean compositional data of mudbrick

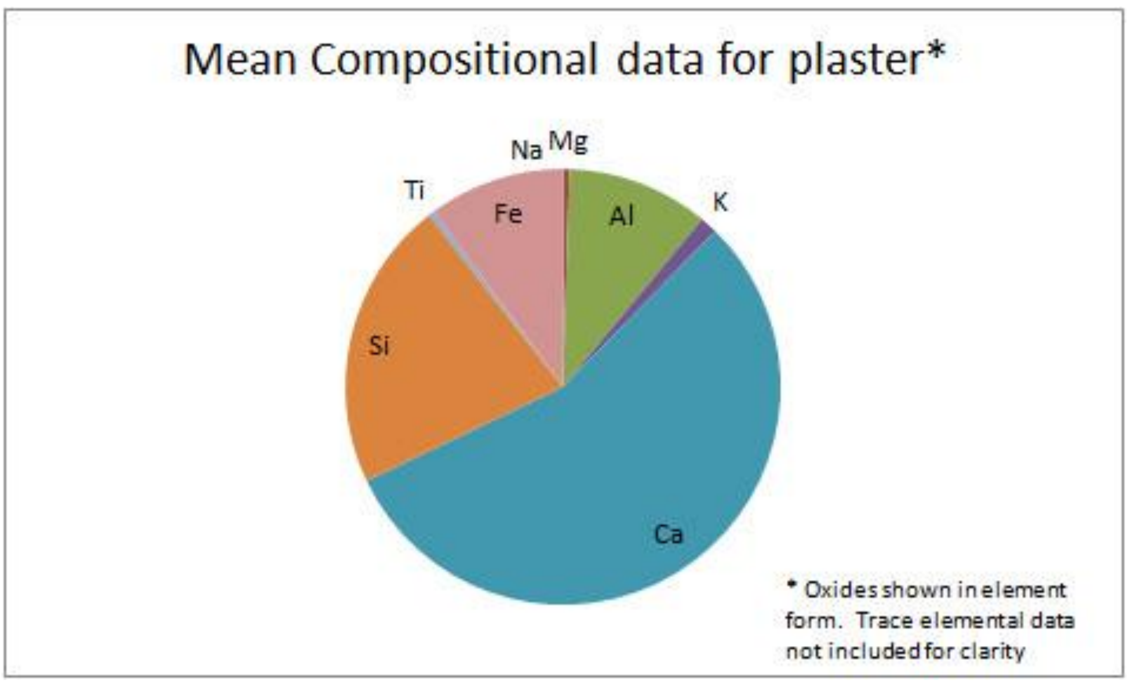


Figure 137: Mean compositional data of plaster

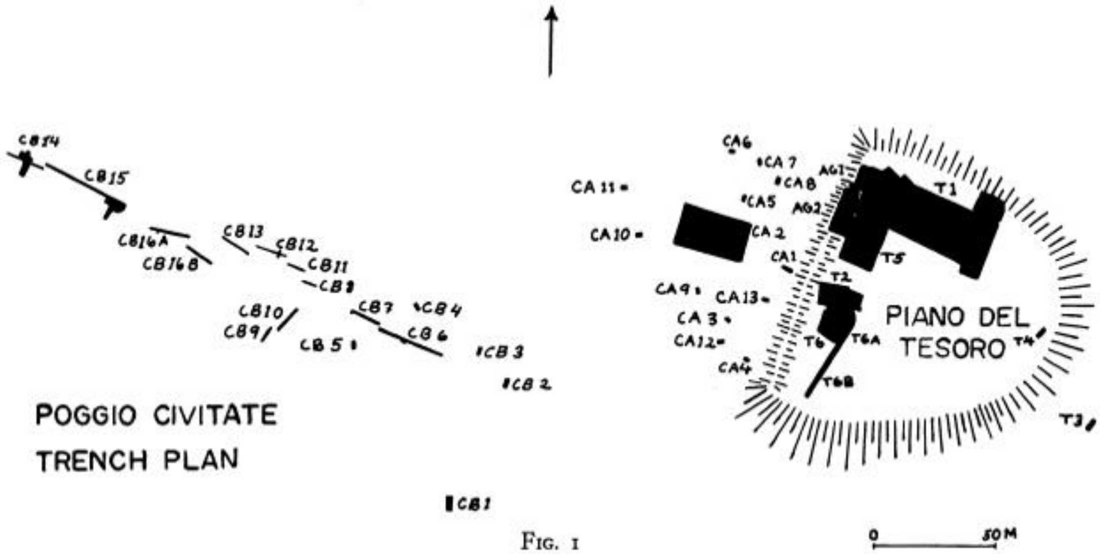


Figure 138: Poggio Civitate: Initial trench plan (Phillips 1969, Pl. 79)

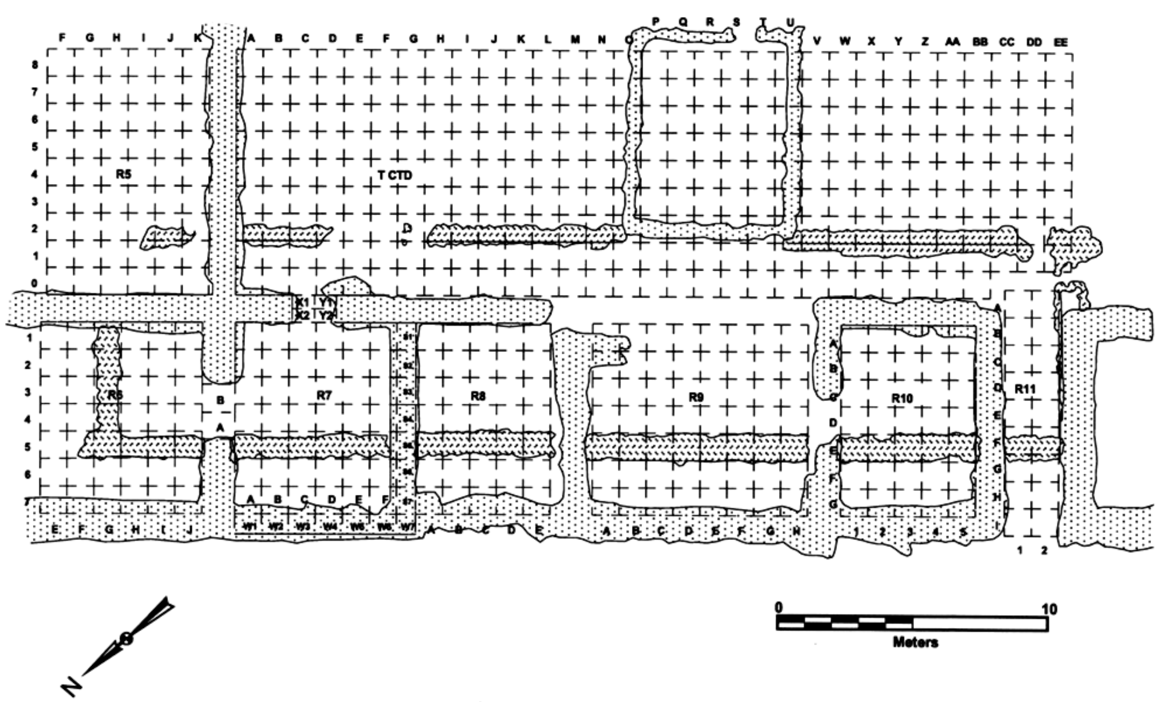


Figure 139: Poggio Civitate - Archaic building superimposed above OC1 (Berkin 2003, 160

)

Figure 140: OC2 - Daub type 1

Figure 141: OC2 - Daub type 2 (Photo by T. Linger)

Figure 142: OC2 - Type 2 daub with impressions intersecting perpendicularly

Figure 143: OC2 - Type 3 daub with timber impression and plaster decoration

Figure 144: OC2- Type 3 daub depicting the impression of a timber stripped of bark

Figure 145: OC2 - Type 4 daub with curvilinear impression on top and two flat impressions on the sides, set between two pan tile fragments for illustrative purposes

Figure 146: OC2 - Type 4 daub with flat impression

Figure 147: OC2 - Type 6 mudbrick fragment (T-26-21-9)

Figure 148: OC2 -Type 6 mudbrick fragment profile (T-26-21-9)

Figure 149: OC2 - Type 3 daub with timber impression running above woven wattles

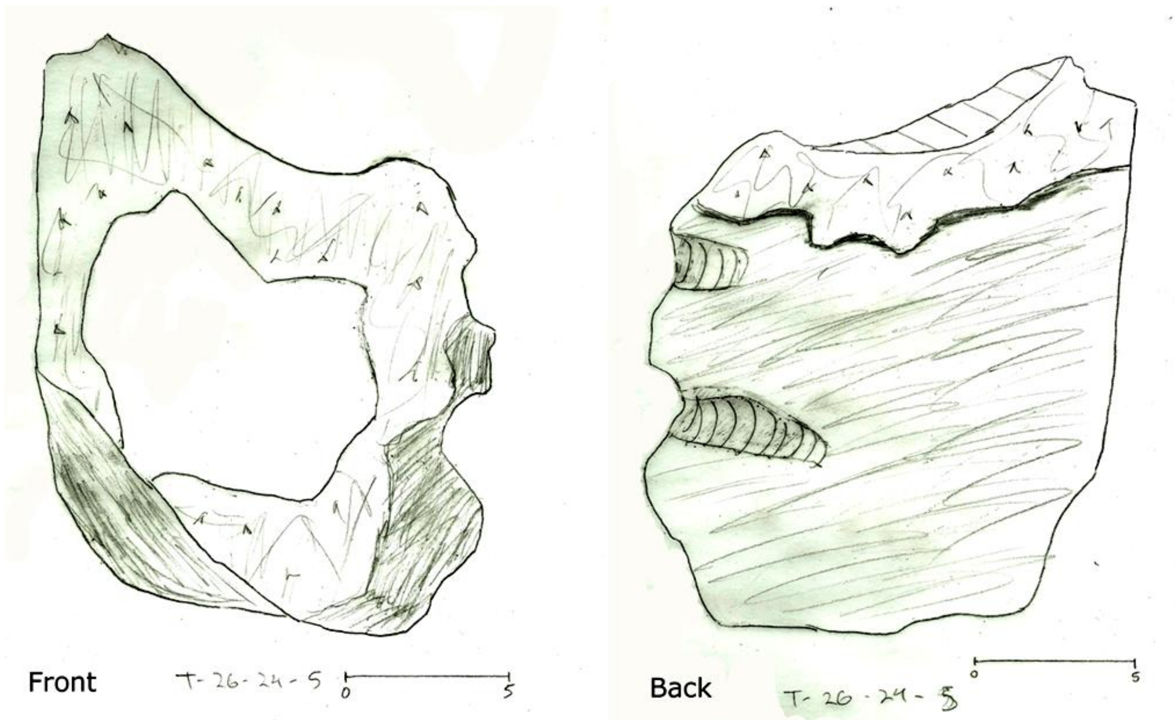


Figure 150: OC2 - Front and back of Type 3 daub with timber impressions and wattles

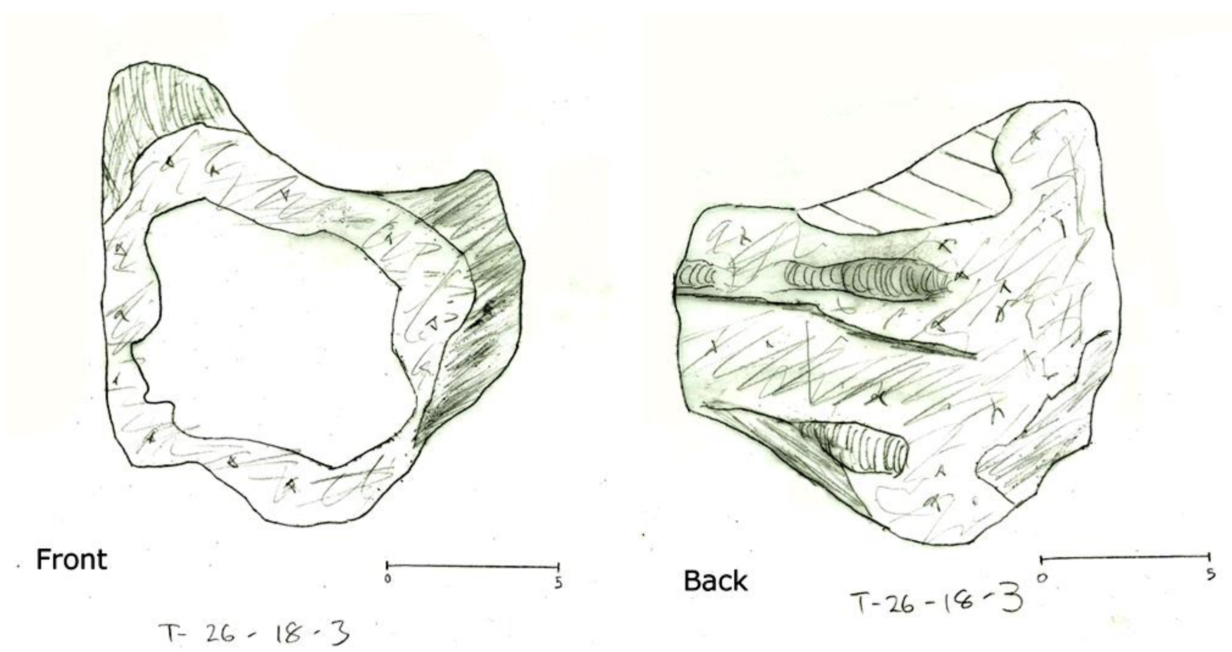


Figure 151: OC2 - Front and back of Type 3 daub with timber impression and wattles

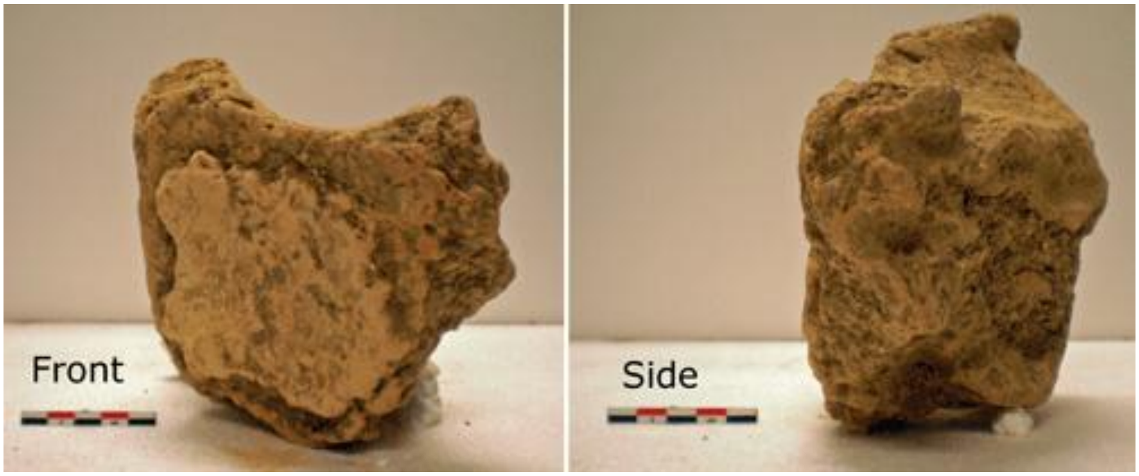


Figure 152: Front and side views of Type 3 daub with timber impression, wattles, and plaster (T-26-18-3)

Figure 153: OC2 - Type 4 daub with two roughly smoothed flat surfaces (T-26-20-2) (Photo by T. Linger)

Figure 154: OC2 - Back side of Fig. 153 with possible wattle impression

Figure 155: OC2 - Type 2 daub with wattles running parallel to flat edge

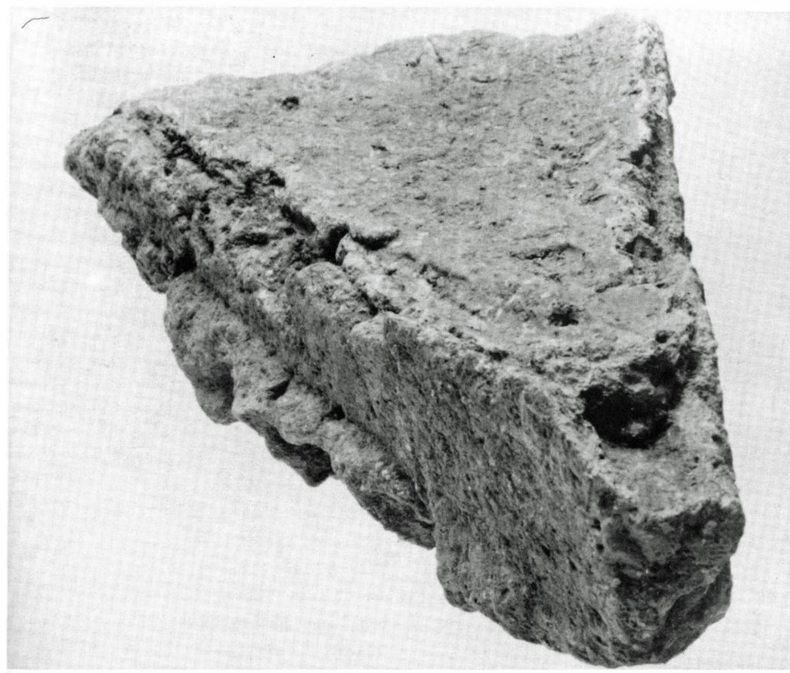


Figure 156: OC2 - Triangular-shaped type 1 daub – PC 82-149 (Nielsen 1991, 253)

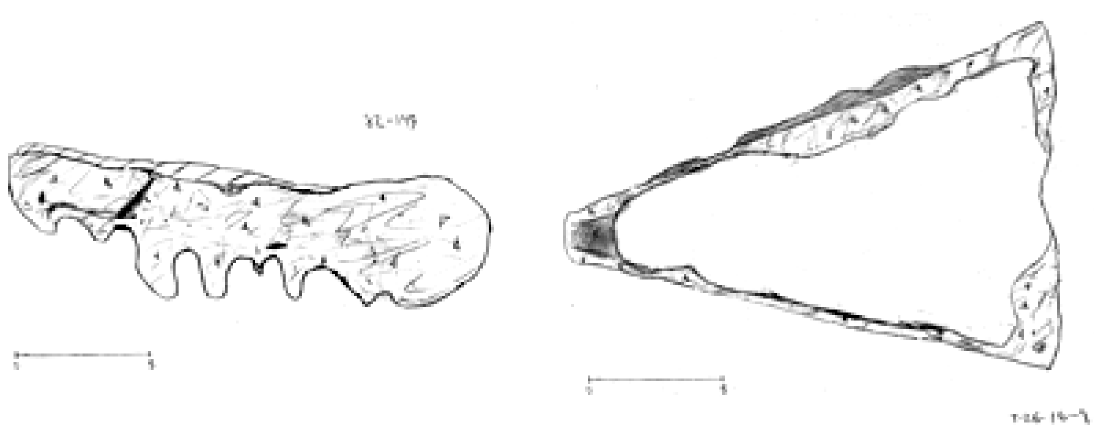


Figure 157: OC2 - Triangular-shaped type 1 daub – PC 82-149 (profile and front with 5 cm scale)

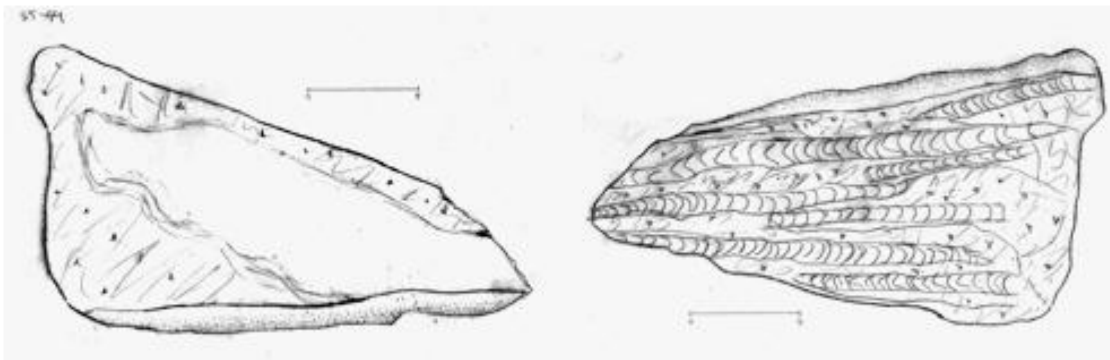


Figure 158: OC2 - Triangular-shaped type 2 daub – PC 85-94 (front and back with 5 cm scale)

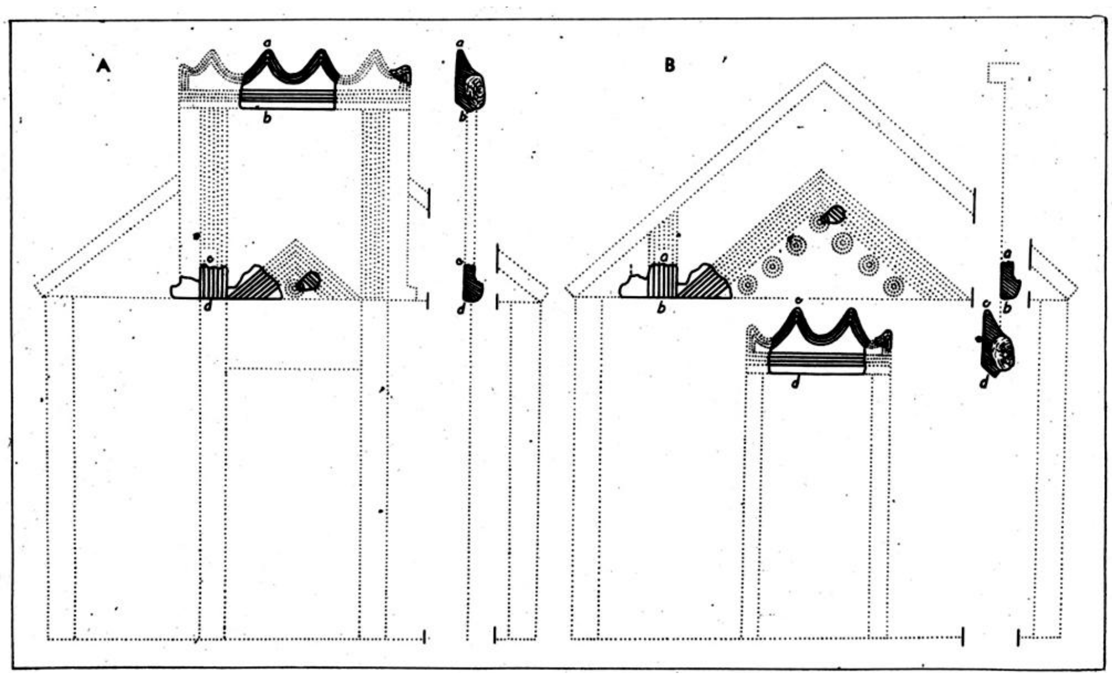


Figure 159: Daub used as crenellation above doorway/roof from Trebatice, Slovakia (Paulik 1962, 38)

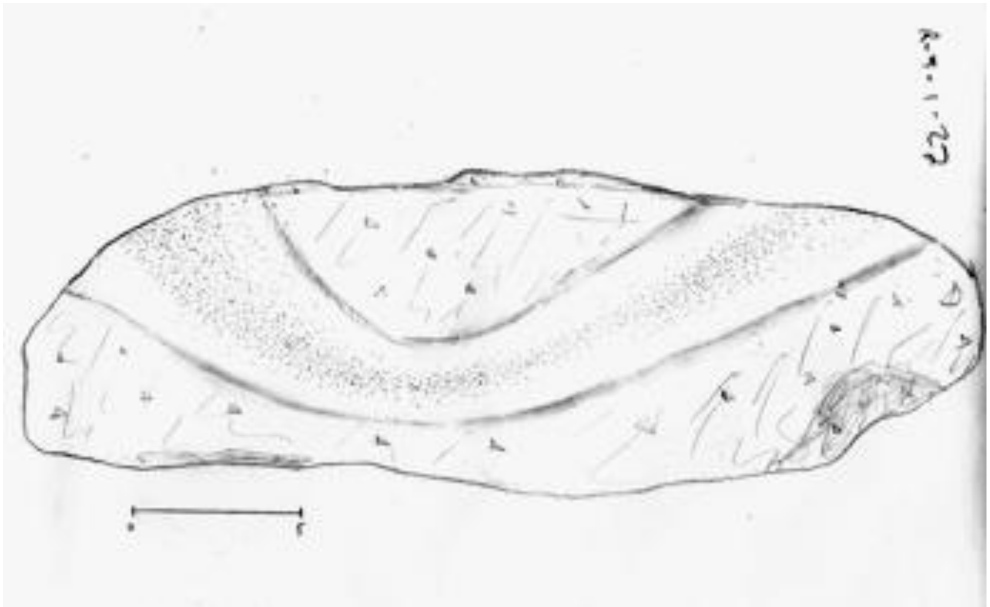


Figure 160: OC1 - Type 3 daub fragment with circular impression (5 cm scale)

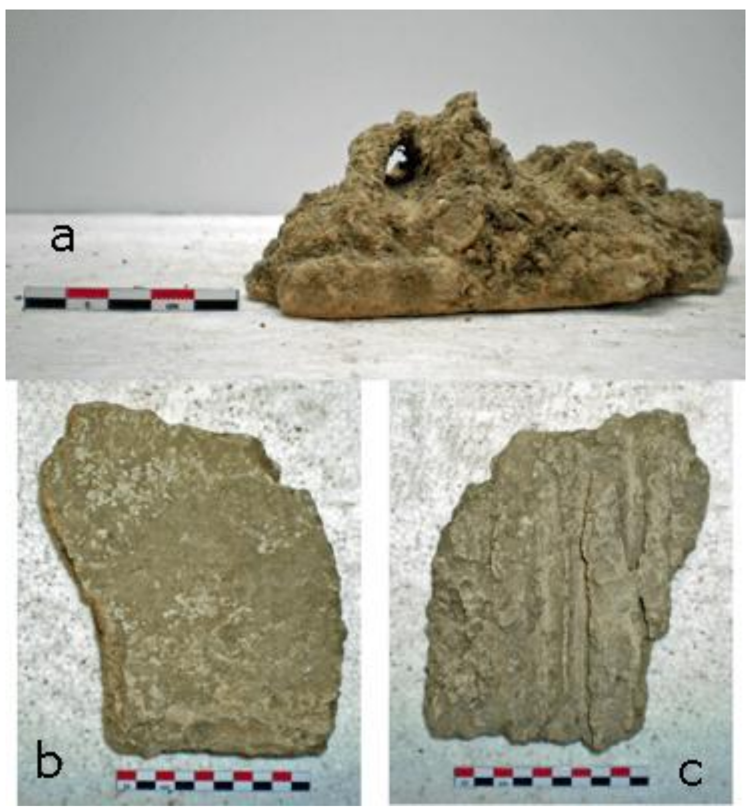


Figure 161: OC1 - Type 1 daub fragment

Figure 162: OC1 - Type 2 daub fragment

Figure 163: OC1 - Type 2 daub fragment (Photo c by T. Linger)

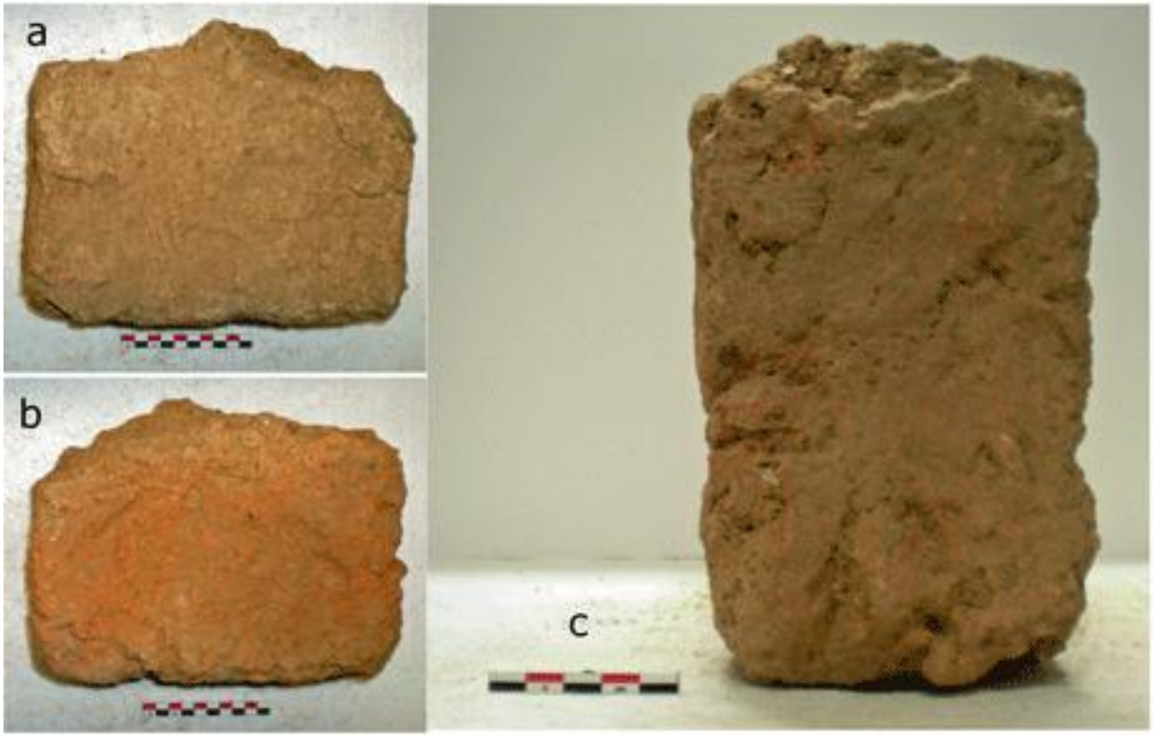


Figure 164: OC1 - Type 6 mudbrick fragment

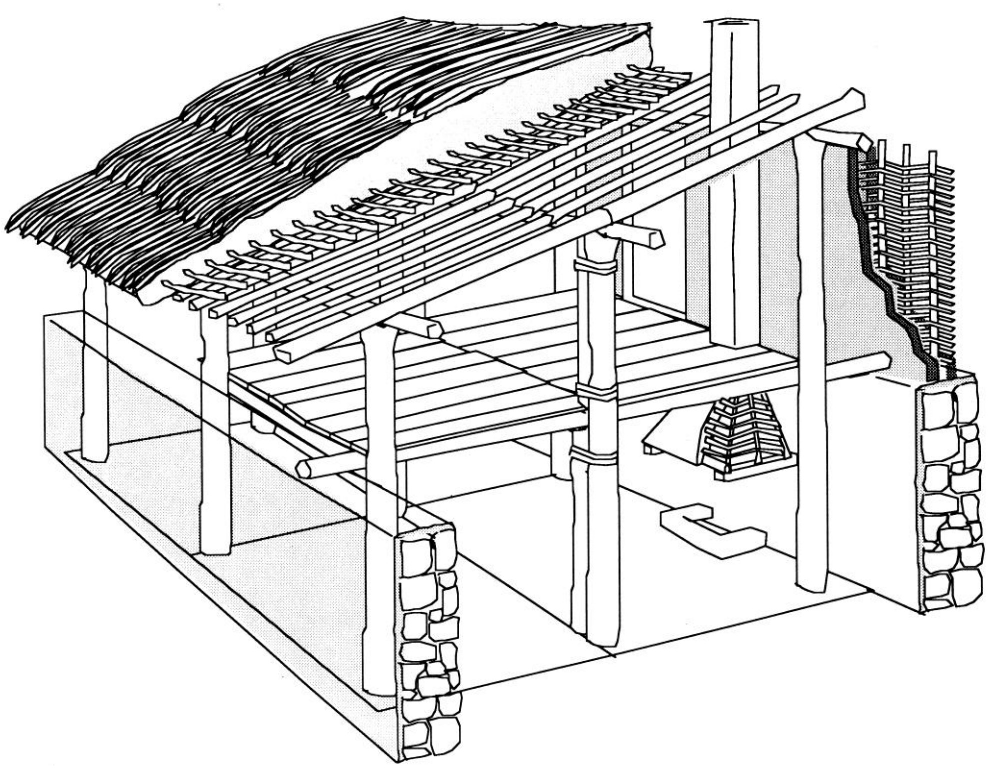


Figure 165: Monte Bibele - reconstruction of casa 14 (Vitali 1988, 115)

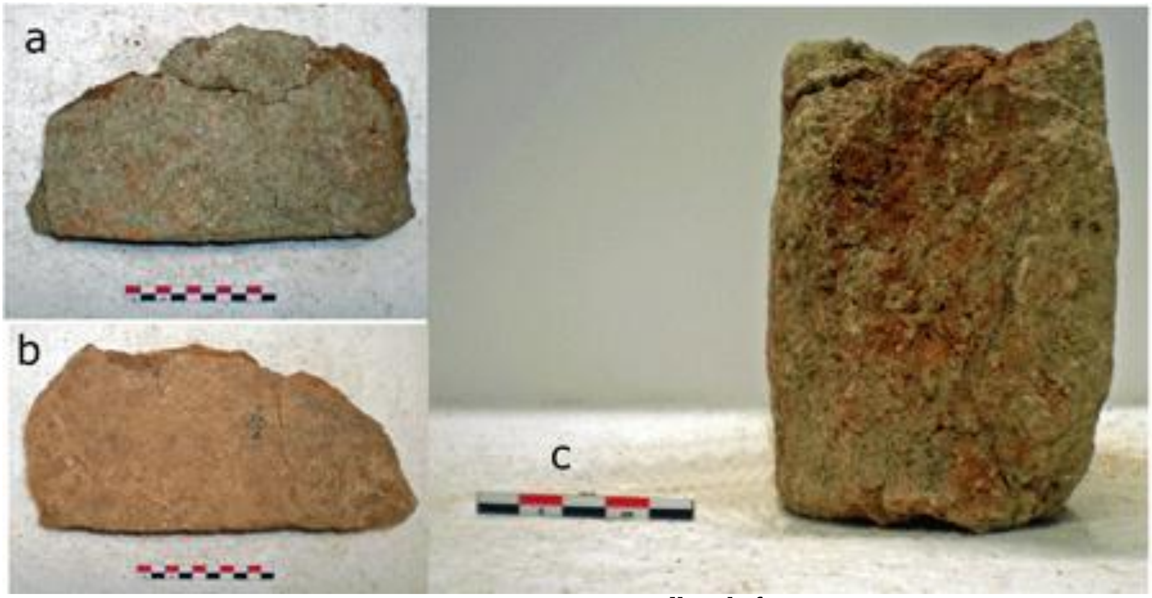


Figure 166: OC3 - Type 6 mudbrick fragment

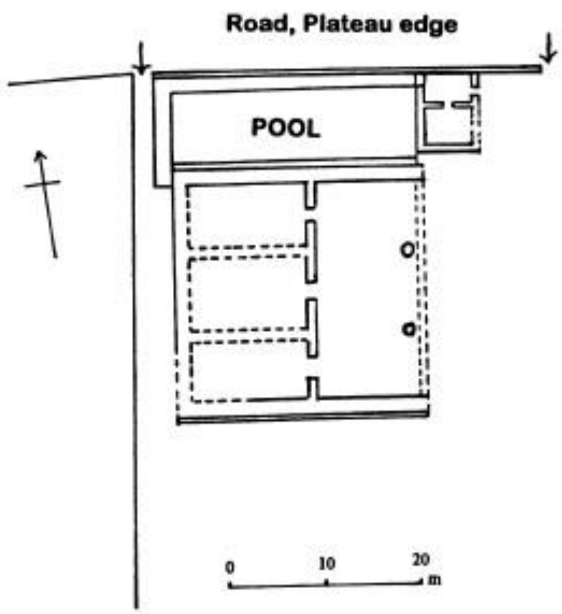


Figure 167: Portonaccio - Temple of Apollo (Turfa and Steinmayer 1996, 9)

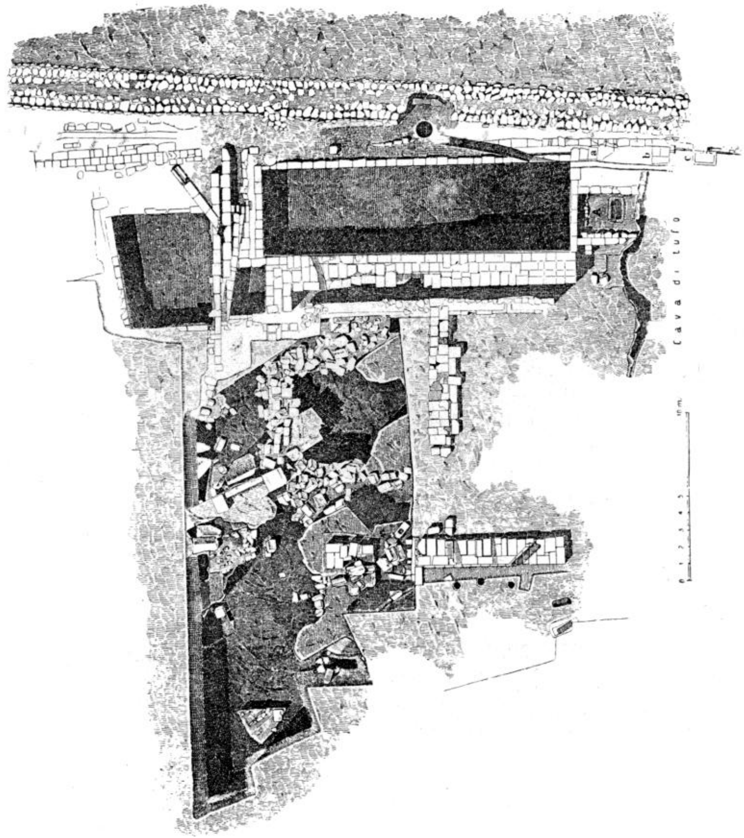


Figure 168: Portonaccio - Original state plan (Stefani 1953, 35)

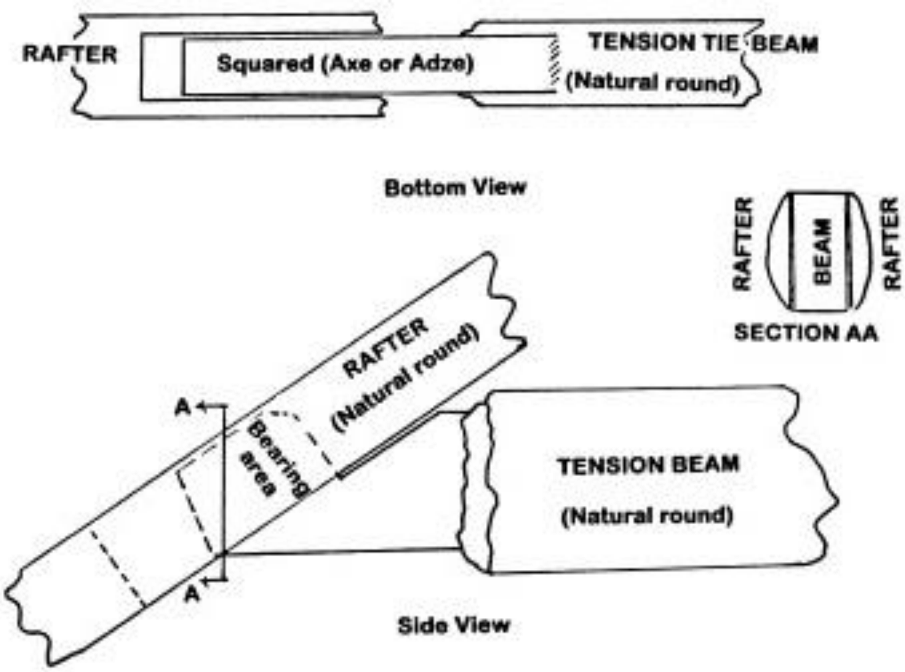


Figure 169: Hypothetical tension joint at Portonaccio (Turfa and Steinmayer 1996, 21)

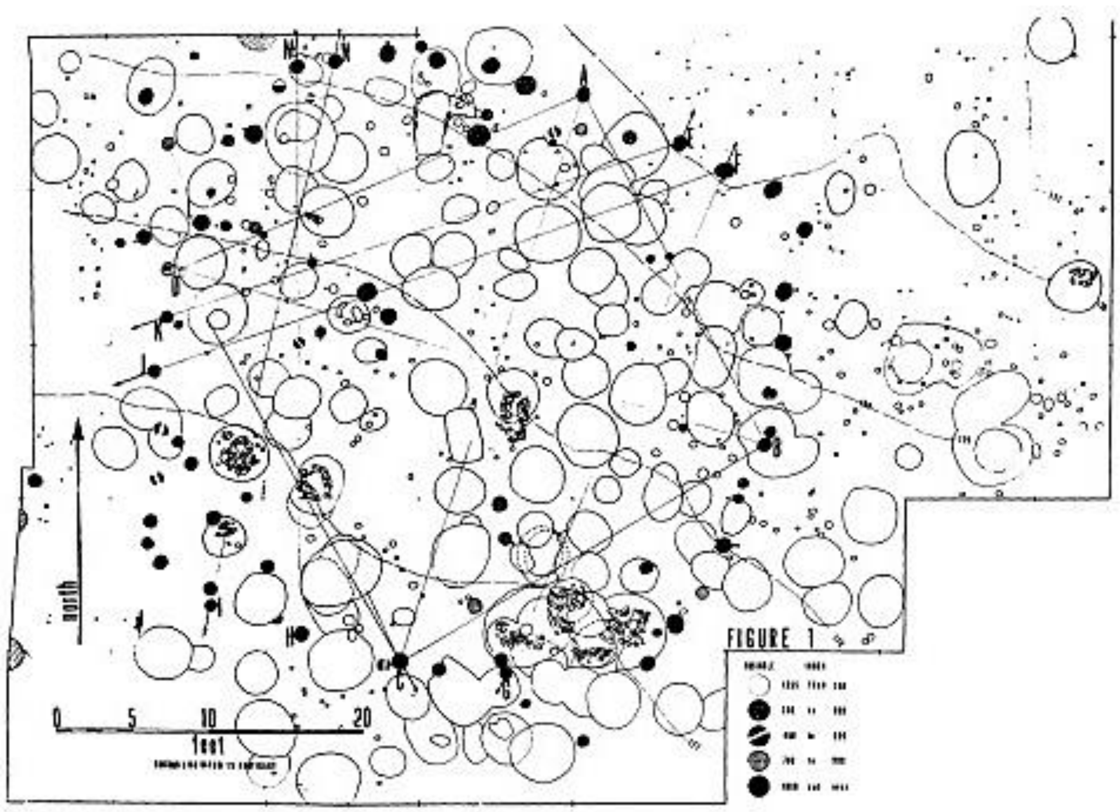


Figure 170: Illinois - Plan of Hopewell culture house (Marshall 1969, 167)

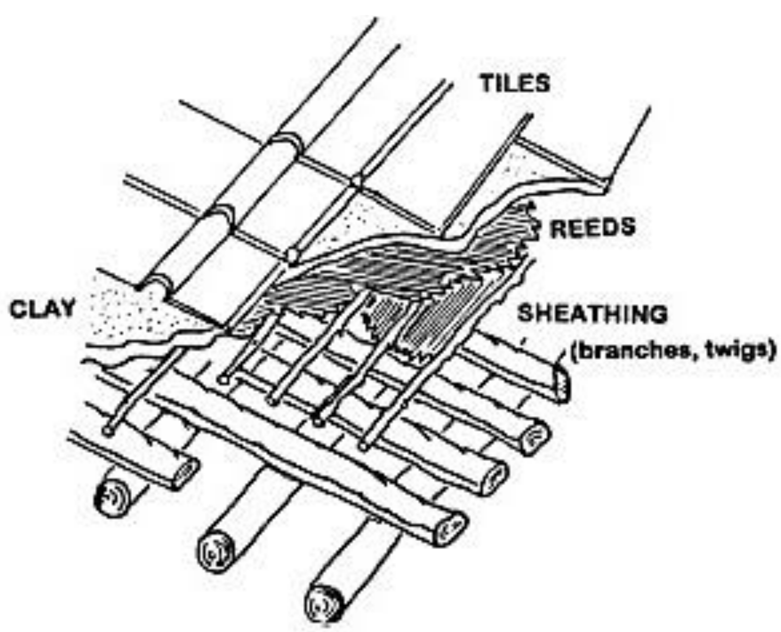


Figure 171: Hypothetical roofing bed for terracotta tiles (Turfa and Steinmayer 1996, 21)

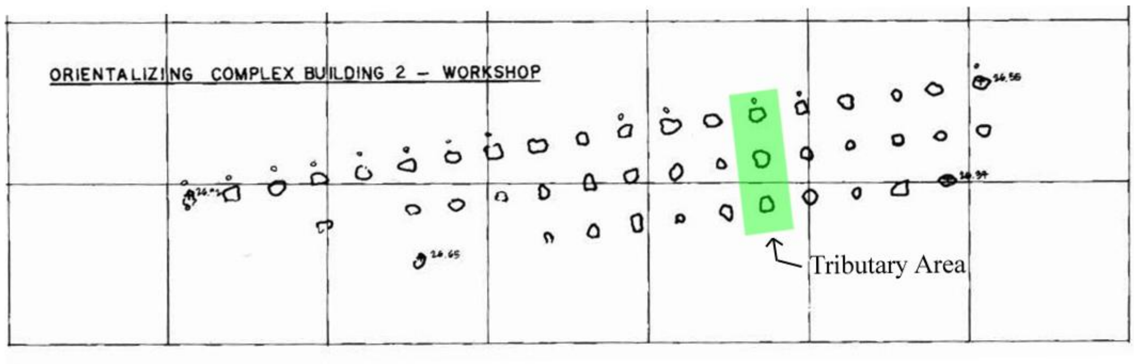


Figure 172: OC2 - Plan showing tributary area of rafters (Adapted from Nielsen and Tuck 2001, 40)

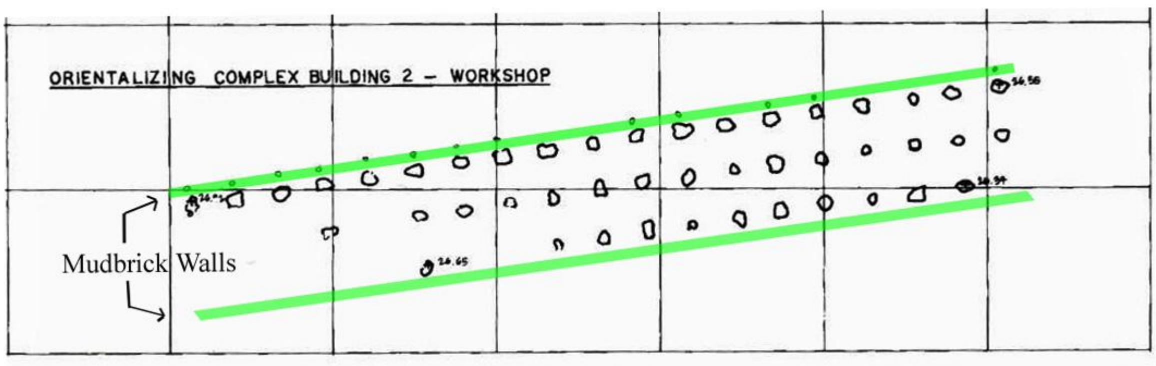


Figure 173: OC2 - Plan showing potential line of mudbrick walls outside of exterior column pads (Adapted from Nielsen and Tuck 2001, 40)

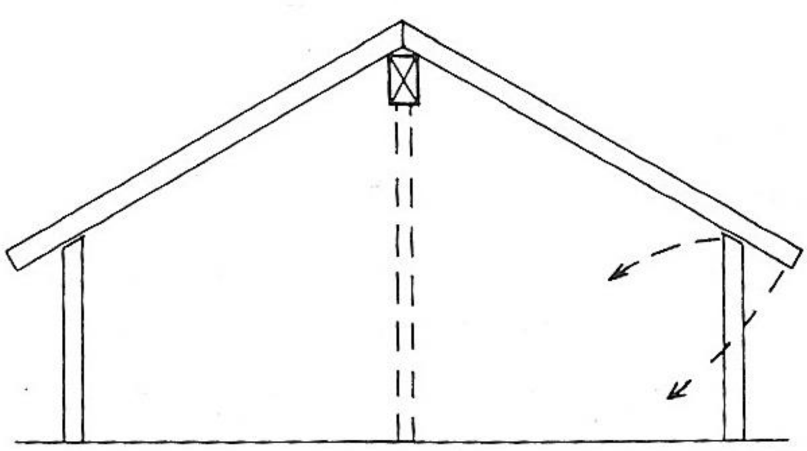


Figure 174: Rotational action of rafter of gabled roof with interior support under gravity loads (Adapted from Ambrose and Vergun 1987, 194)

Figure 175: Poggio Civitate - Grooved daub fragment associated with OC2

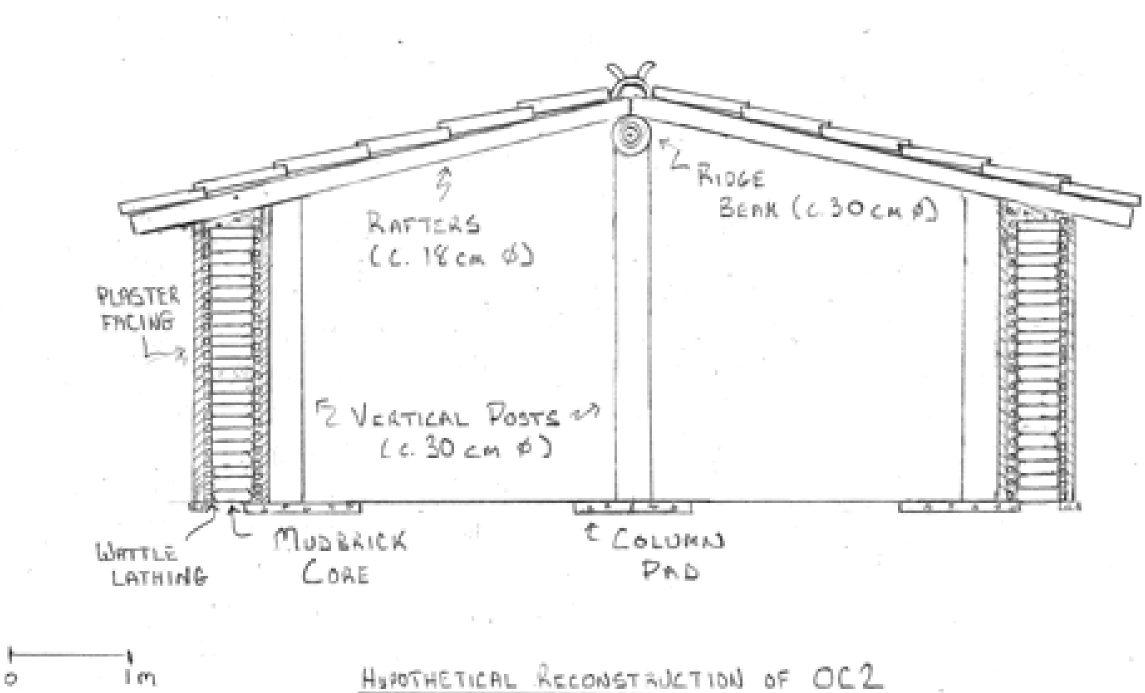


Figure 176: OC2 - Proposed Elevation for OC2

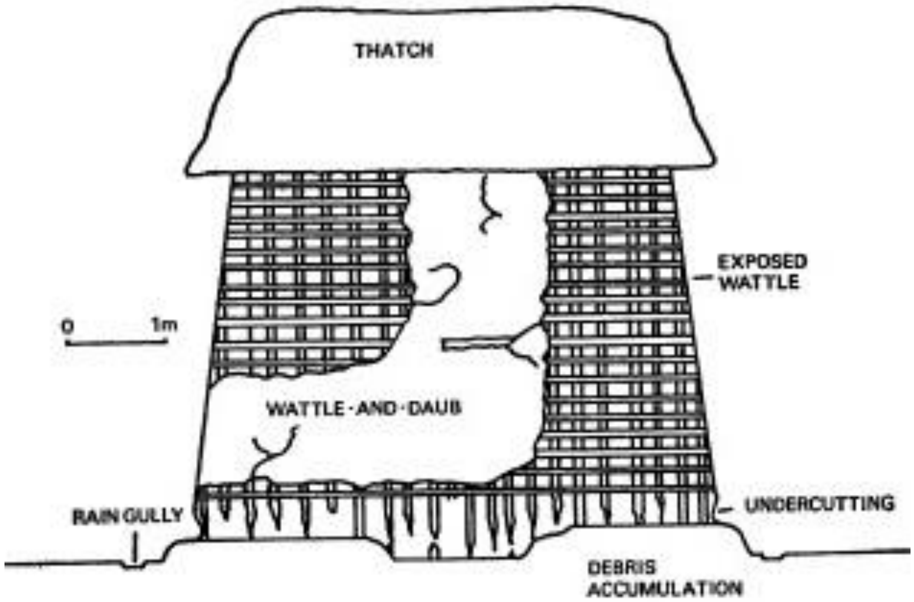


Figure 177: Elevation of decaying wattle-and-daub hut from West Africa (McIntosh 1974, 162)

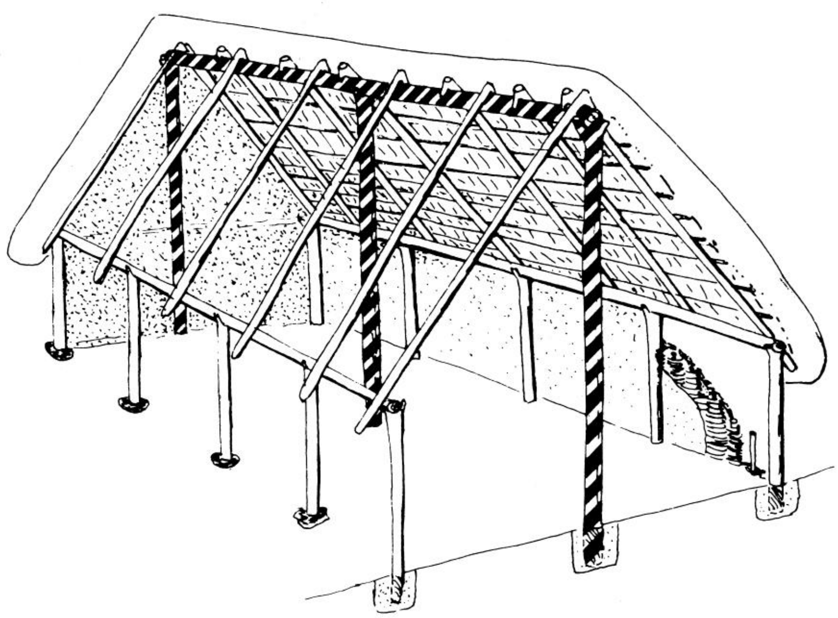


Figure 178: Reconstruction of prehistoric European long-house (Arcelin and Buchsenschutz 1985, 21)

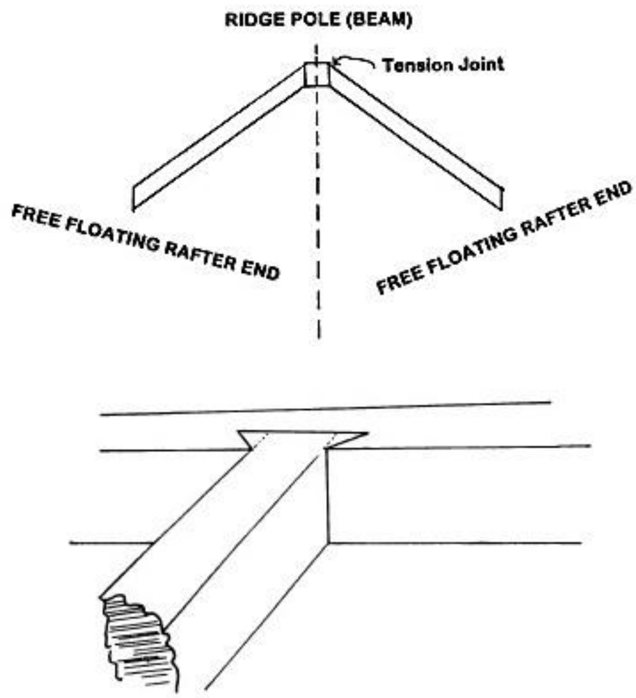


Figure 179: Tension joint scheme with hypothetical tension joint shown below. The joint would have a propensity to fail along the dotted lines where the rafter joined the top of the ridge beam (Turfa and Steinmayer 1996, 33)

Figure 180: Vulci - hut urn with criss-crossing rafters/beams atop roof (Bartoloni 1987, Tav. 16)

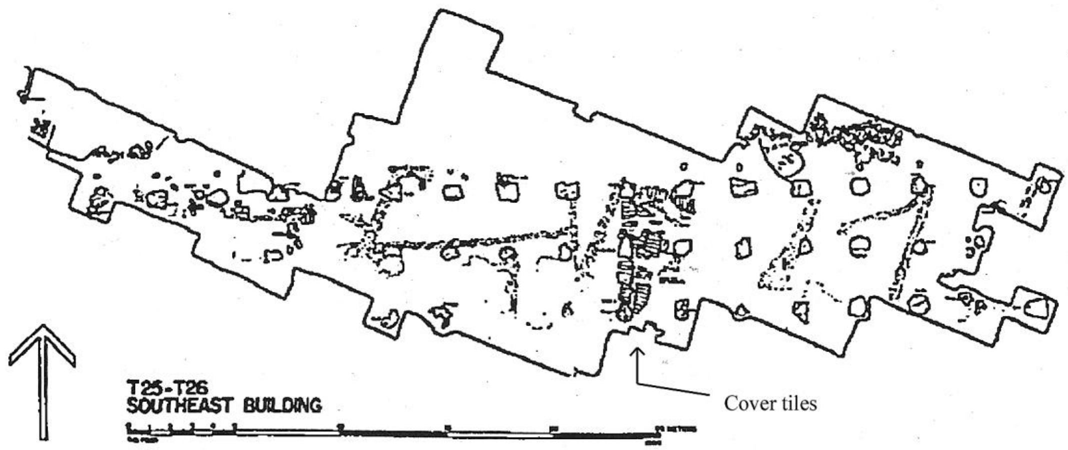
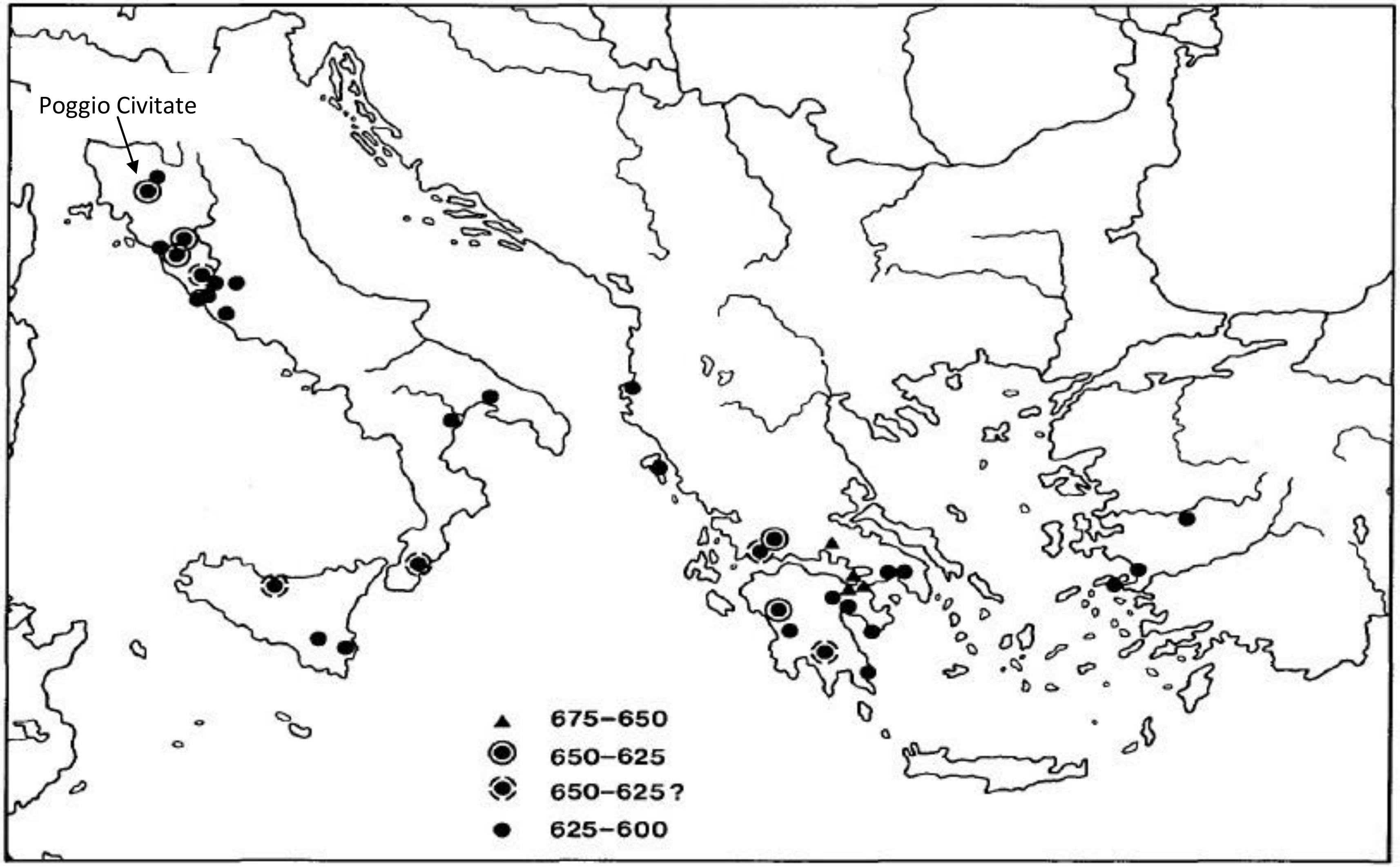


Figure 181: OC2 - Plan of building with cover tiles on floor (Adapted from Nielsen 1987, Fig. 4)

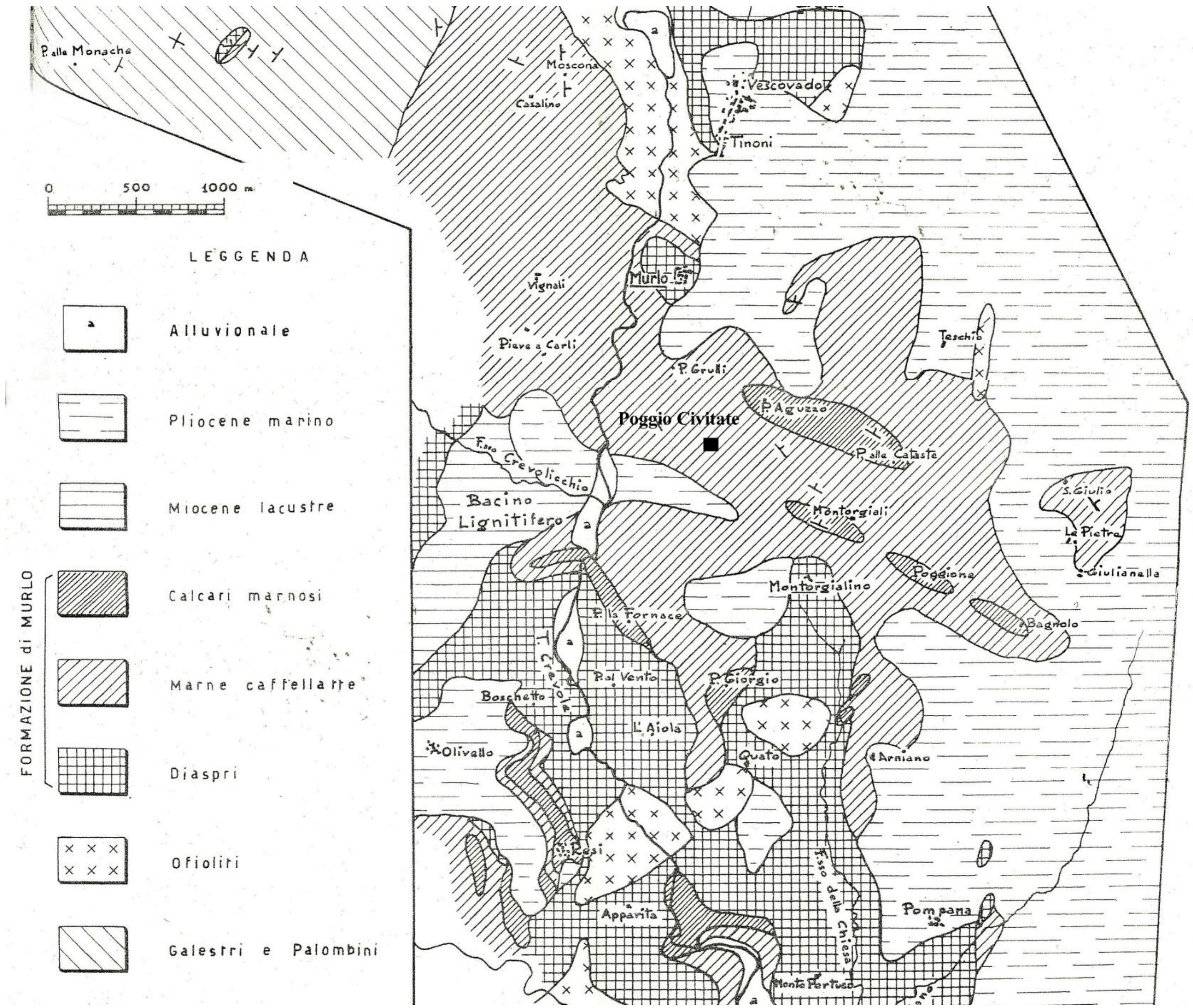
Figure 182: OC2 - Unfired cover tiles with imprint of feet (Nielsen 1987, Fig. 6)

Maps referenced in Text

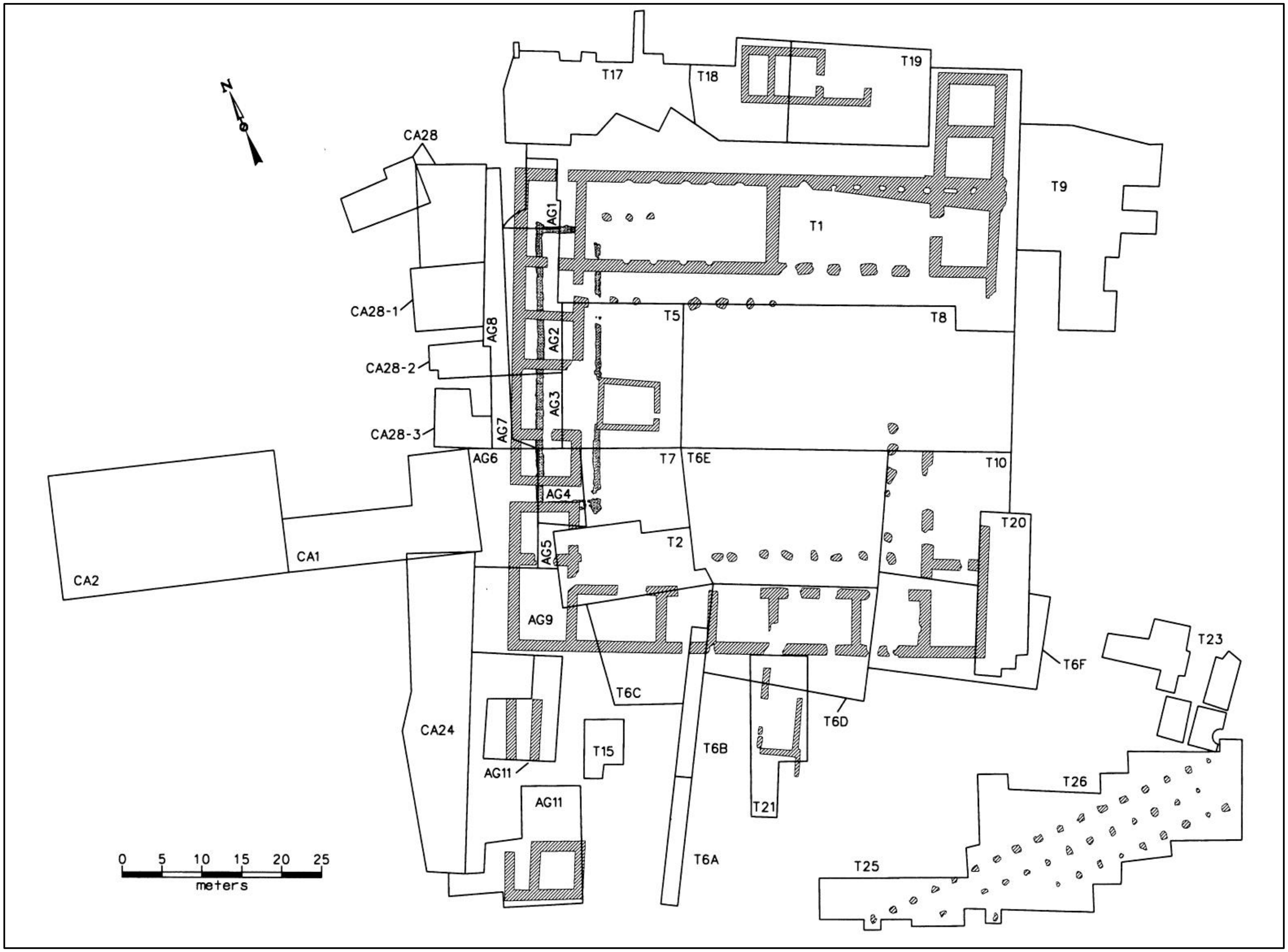


Map 1 : Spread of Terracotta tiled roofs in Mediterranean (Wikander 1990, 157)

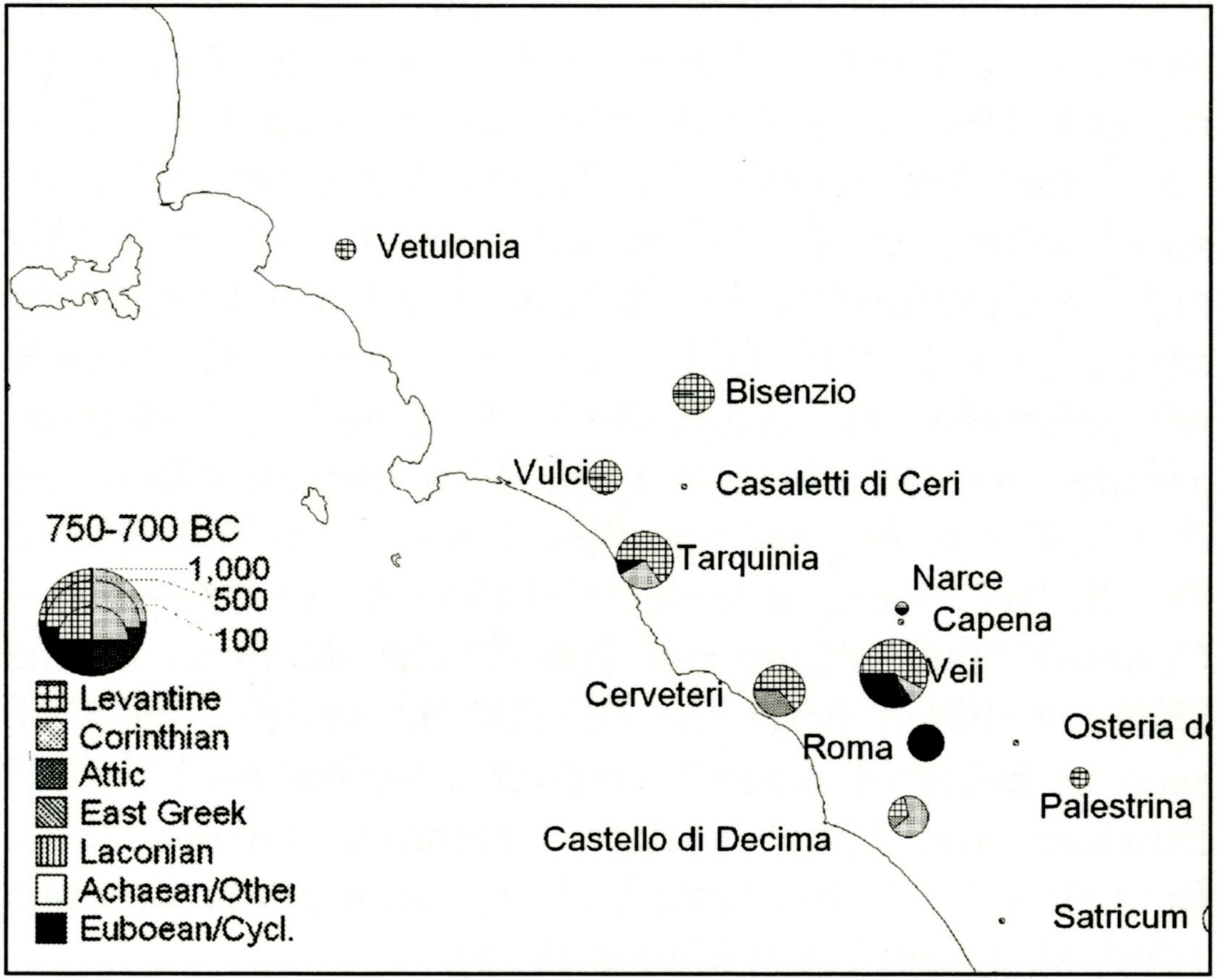
Map 2: Sites mentioned in text (Adapted from Boatwright et al. 2004, Map 1.1)



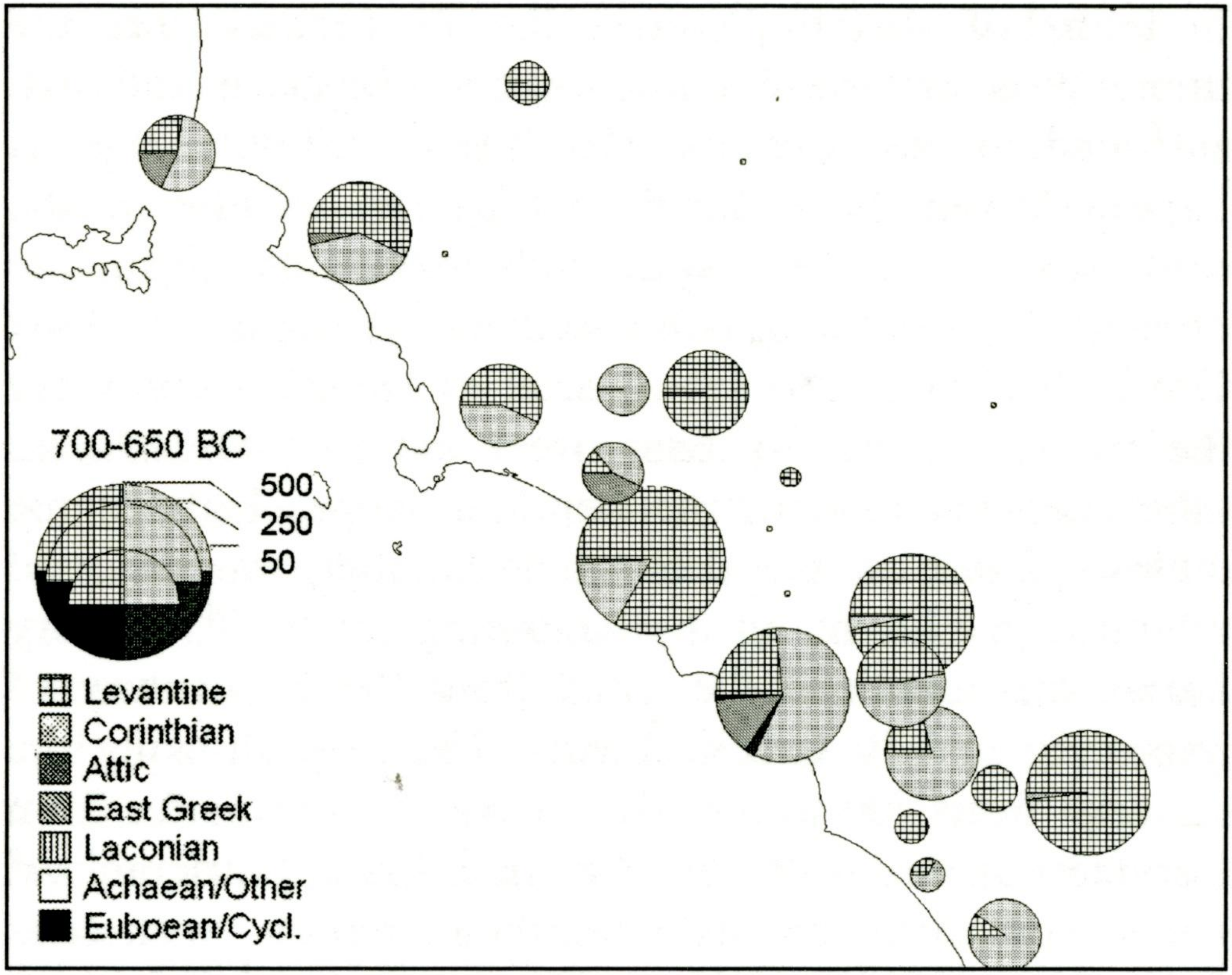
Map 3 : Geological map of area around Poggio Civitate (Signorini 1982, Tav. 1)



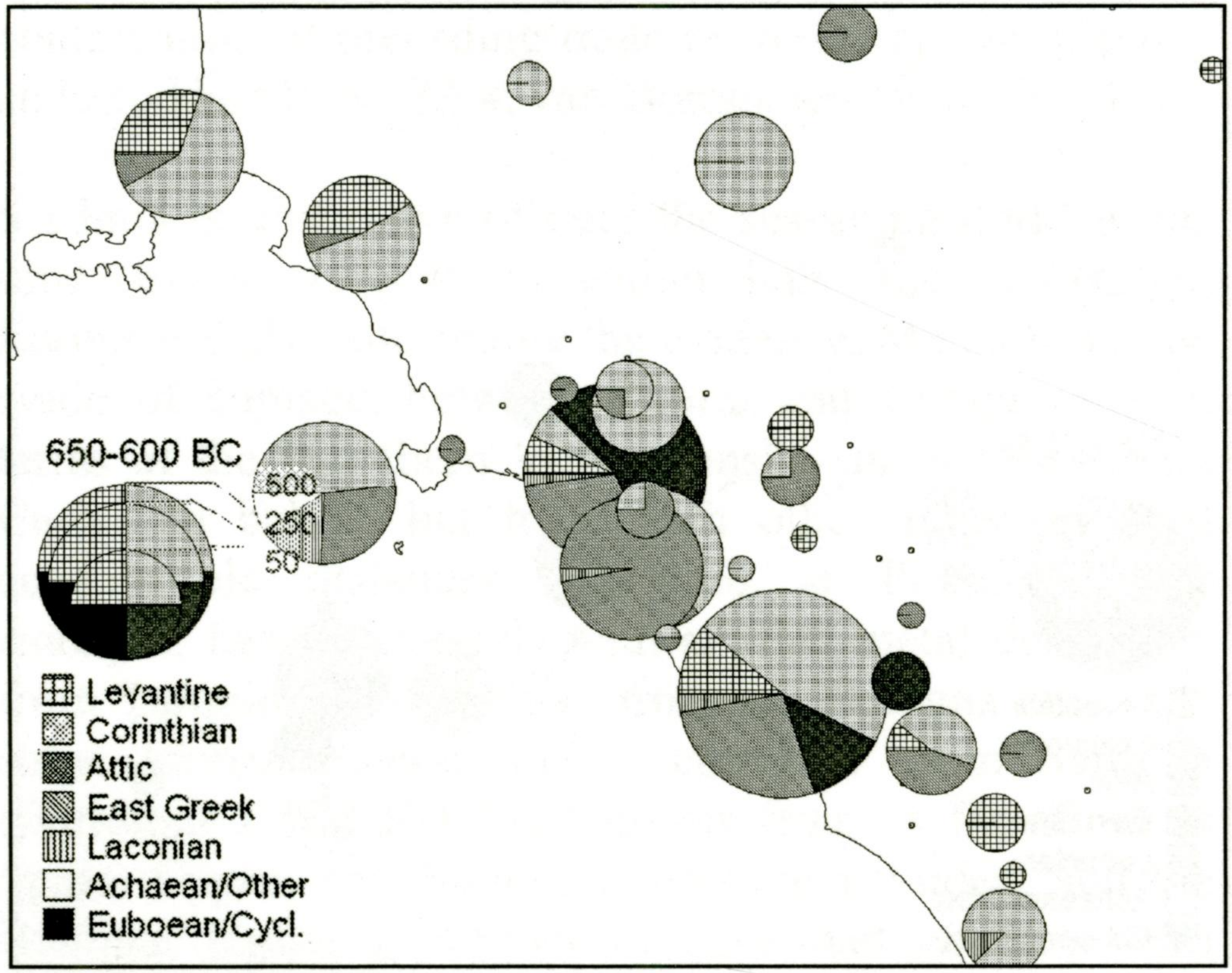
Map 4 : Trench plan for Poggio Cviitate (Berkin 2003, 19)



Map 5: Imports into Etruria and Latium from 750 -700 BC (Fletcher 2007, 56)

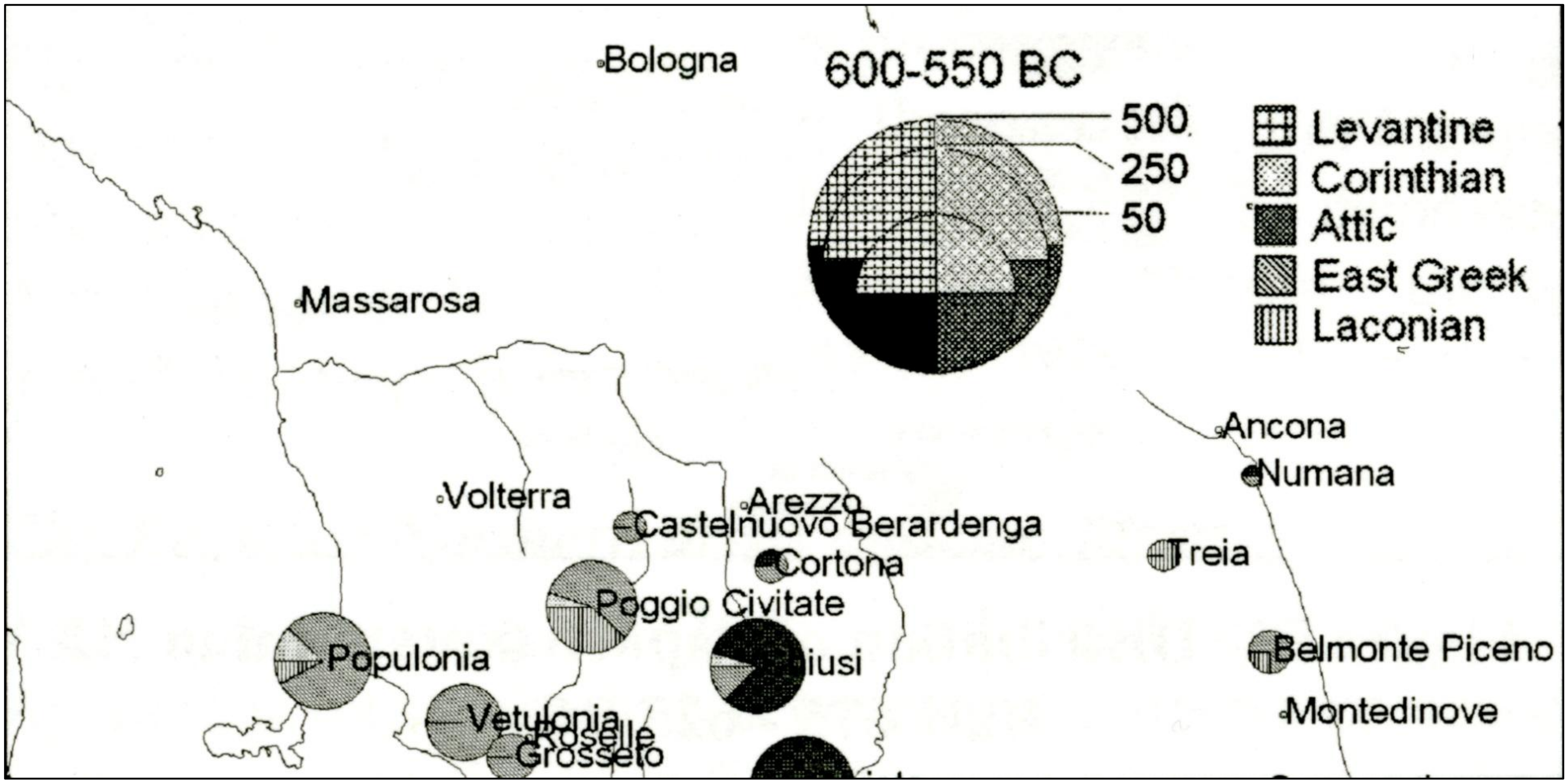


Map 6 : Imports into Etruria and Latium 700-650 BC (Fletcher 2007, 57)

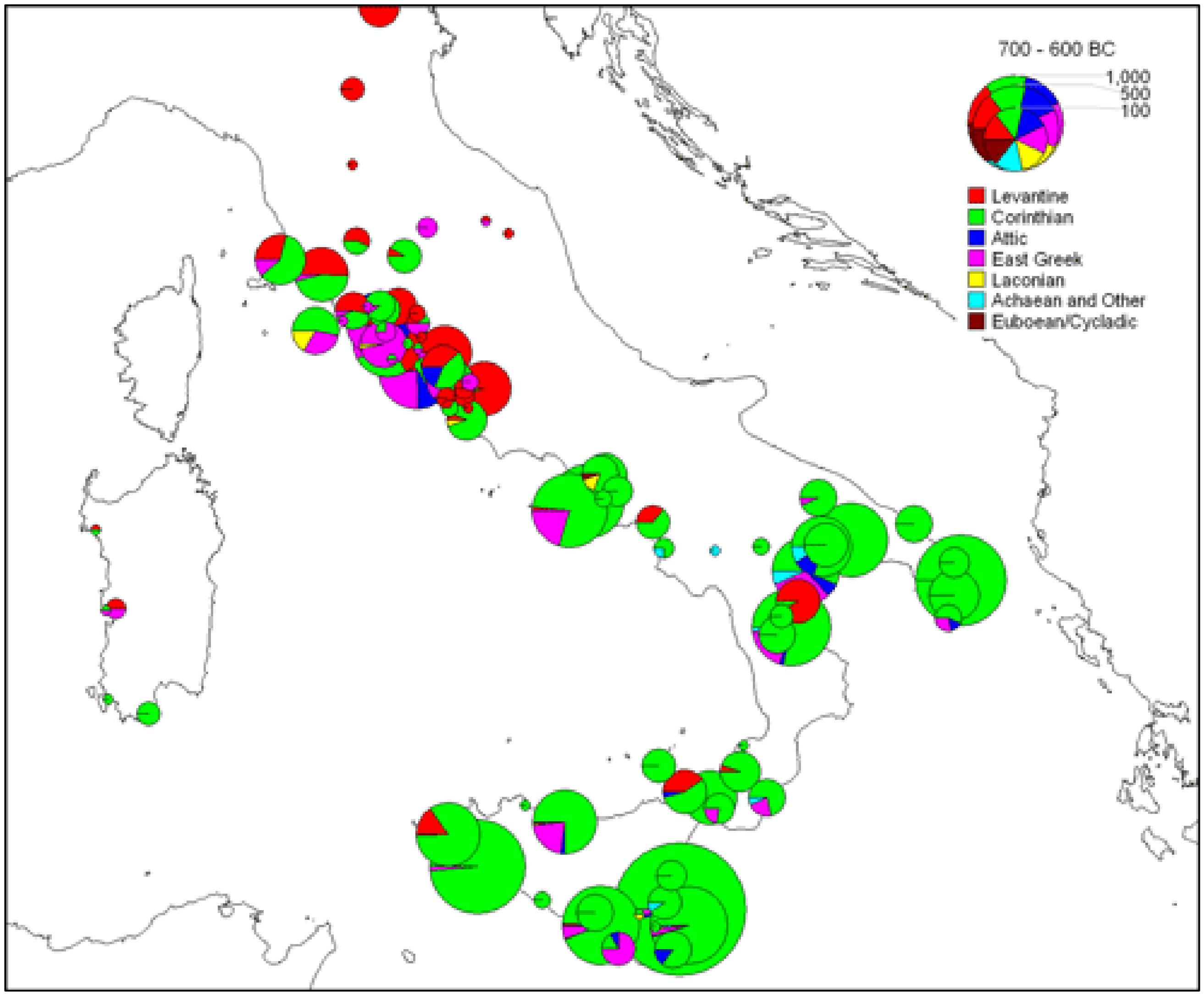


Map 7: Imports into Etruria and Latium 650-600 BC (Fletcher 2007, 58)

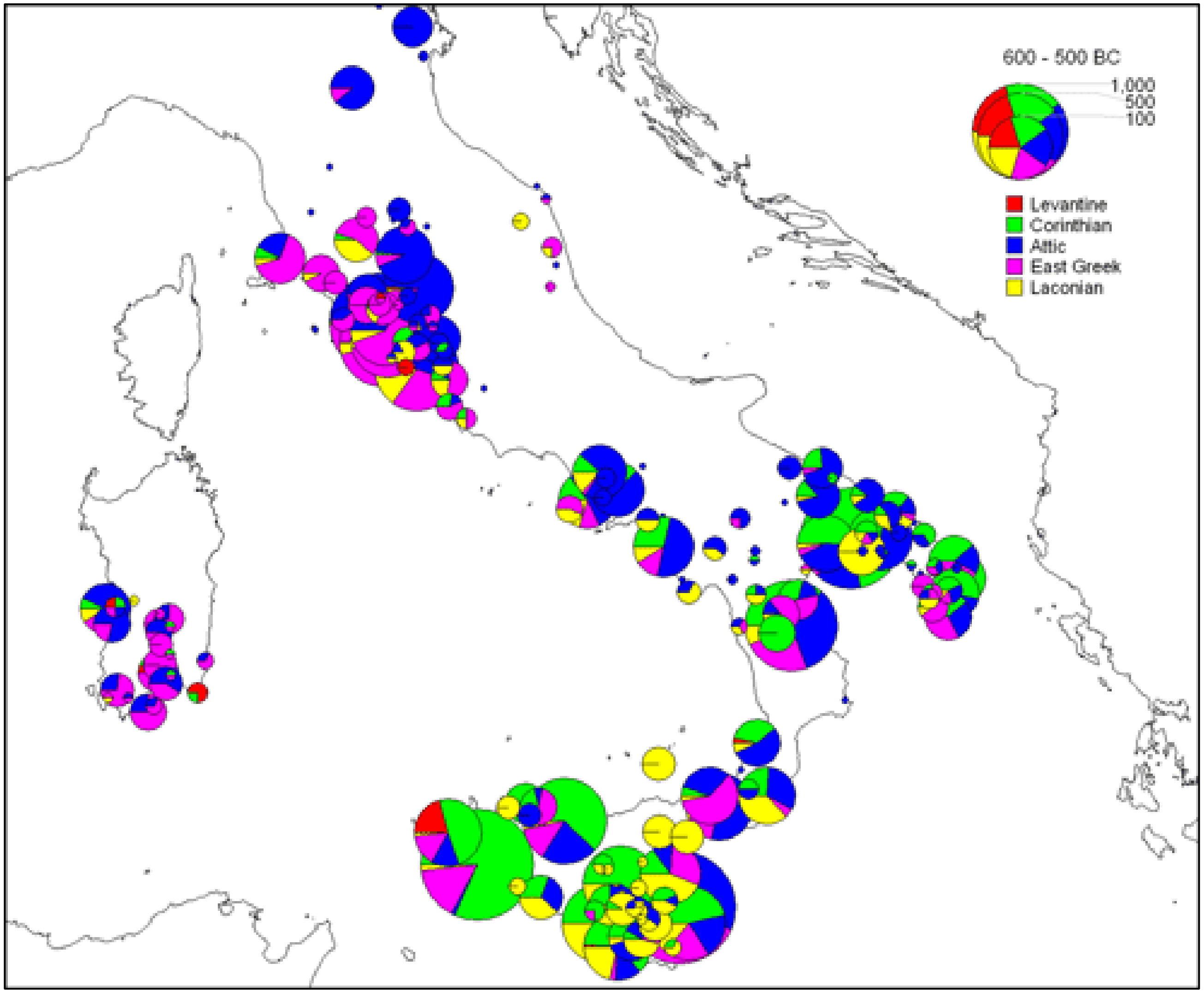
Map 8: Imports into area around Poggio Civitate 700-650 BC (Adapted from Fletcher 2007, 67)



Map 9 : Imports into area around Poggio Civitate 600-550 BC (Adapted from Fletcher 2007, 68)



Map 10 : Imports into Italy 700-600 BC (Fletcher 2007, 79)



Map 11: Imports into Italy 600-500 BC (Fletcher 2007, 80)

APPENDICES

Appendix A:

Ceramic and daub data (elemental concentrations for samples in ppm)

Sample	Trench	Date	Na	Al	Si	K
TILE1	R9	7th c. BC	4195.67	124800.69	234253.71	9334.14
TILE2	R5	7th c. BC	9037.94	94651.13	257560.18	15640.81
TILE3	T-15	7th c. BC	6918.11	117561.77	270155.61	6633.28
TILE4	T-26	7th c. BC	16423.40	106349.85	251796.28	19506.83
TILE5	T-26	7th c. BC	5253.81	140758.98	257968.17	5374.03
TILE6	T-5E	7/6th c. BC	11724.20	107868.44	261766.29	9735.39
DAUB1	T-50	7th c. BC	3255.44	142023.60	218644.73	18891.26
DAUB2	T-26	7th c. BC	2164.99	94825.95	249886.27	36468.37
DAUB3	T-18	7th c. BC	1850.87	81648.21	263811.29	22737.92
DAUB4	T-18	7th c. BC	58.90	68336.43	193317.12	7377.48
DAUB5	R5	7th c. BC	1621.00	90426.52	214280.89	17512.90
DAUB6	T-1AB	7/6th c. BC	2796.18	93505.00	248640.89	13601.26
BRICK1	T-26	7th c. BC	1875.39	116727.81	226858.95	24248.98
BRICK2	T-26	7th c. BC	13840.22	88479.24	264282.70	26089.00
PLASTER1	T-26	7th c. BC	119.82	57646.28	134867.37	4895.20
PLASTER2	T-26	7th c. BC	446.62	70799.43	144053.11	9207.72
PLASTER3	T-25	7th c. BC	471.43	63879.99	124650.81	15527.11
PLASTER4	T-18	7th c. BC	37.73	67861.14	127632.84	3028.85
PLASTER5	R5	7th c. BC	10389.85	82933.83	243991.77	11636.20
PLASTER6	T-1AB	7/6th c. BC	0.00	46619.36	88840.92	2958.73

Sample	Trench	Date	Ca	Sc	V	Cr
TILE1	R9	7th c. BC	37037.32	25.40	123.56	613.00
TILE2	R5	7th c. BC	59358.10	30.31	201.09	681.88
TILE3	T-15	7th c. BC	27509.77	35.26	146.73	725.70
TILE4	T-26	7th c. BC	41793.50	35.07	172.95	514.34
TILE5	T-26	7th c. BC	21603.08	44.06	105.53	560.15
TILE6	T-5E	7/6th c. BC	37113.40	37.82	183.29	682.81
DAUB1	T-50	7th c. BC	56482.88	32.17	216.24	246.21
DAUB2	T-26	7th c. BC	54960.44	31.88	218.59	302.65
DAUB3	T-18	7th c. BC	70317.65	31.65	161.51	244.76
DAUB4	T-18	7th c. BC	228099.65	17.64	107.83	287.81
DAUB5	R5	7th c. BC	158866.54	21.45	130.90	304.79
DAUB6	T-1AB	7/6th c. BC	95148.75	27.77	144.93	228.63
BRICK1	T-26	7th c. BC	84851.93	25.11	192.07	162.22
BRICK2	T-26	7th c. BC	31377.93	25.01	219.40	214.83
PLASTER1	T-26	7th c. BC	362389.80	17.33	97.44	132.41
PLASTER2	T-26	7th c. BC	325922.86	19.96	88.25	181.20
PLASTER3	T-25	7th c. BC	341859.59	11.82	101.85	190.37
PLASTER4	T-18	7th c. BC	341444.38	23.63	65.37	224.37
PLASTER5	R5	7th c. BC	103363.91	14.78	140.49	663.95
PLASTER6	T-1AB	7/6th c. BC	448459.97	12.33	44.82	281.27

Sample	Trench	Date	Mn	Fe	Ni	Co	Cu
TILE1	R9	7th c. BC	2603.95	102285.37	94.83	87.79	145.99
TILE2	R5	7th c. BC	1987.57	87128.96	64.89	59.15	117.75
TILE3	T-15	7th c. BC	1545.17	80184.83	61.69	49.71	104.16
TILE4	T-26	7th c. BC	2476.46	90951.98	102.76	65.03	135.46
TILE5	T-26	7th c. BC	993.56	75606.70	122.21	48.88	55.48
TILE6	T-5E	7/6th c. BC	2157.36	87080.30	70.17	60.96	99.22
DAUB1	T-50	7th c. BC	1986.27	92234.33	70.12	42.50	119.89
DAUB2	T-26	7th c. BC	3154.51	94714.72	50.87	60.96	150.79
DAUB3	T-18	7th c. BC	3277.22	92416.71	60.17	52.02	165.49
DAUB4	T-18	7th c. BC	2070.18	77861.34	15.94	32.31	75.89
DAUB5	R5	7th c. BC	1616.09	74568.12	13.95	31.82	76.78
DAUB6	T-1AB	7/6th c. BC	3972.05	80473.53	34.78	47.47	69.84
BRICK1	T-26	7th c. BC	1775.18	84675.46	39.78	39.85	85.19
BRICK2	T-26	7th c. BC	1886.84	103023.09	59.03	53.80	72.59
PLASTER1	T-26	7th c. BC	2353.26	51153.31	21.12	19.01	68.08
PLASTER2	T-26	7th c. BC	1698.08	54480.62	12.67	22.66	64.33
PLASTER3	T-25	7th c. BC	1321.30	69848.06	18.09	26.77	99.28
PLASTER4	T-18	7th c. BC	1028.32	74100.43	25.82	20.07	74.28
PLASTER5	R5	7th c. BC	1244.34	88410.17	0.00	40.84	34.03
PLASTER6	T-1AB	7/6th c. BC	1034.95	55838.19	0.00	20.05	35.13

Sample	Trench	Date	Zn	As	Rb	Sr	Y
TILE1	R9	7th c. BC	374.62	18.60	60.71	108.87	8.50
TILE2	R5	7th c. BC	265.29	26.39	98.66	130.39	7.83
TILE3	T-15	7th c. BC	172.48	36.09	47.50	91.52	6.98
TILE4	T-26	7th c. BC	359.69	17.26	141.66	149.36	4.94
TILE5	T-26	7th c. BC	120.69	10.84	30.13	91.31	6.52
TILE6	T-5E	7/6th c. BC	177.22	23.32	70.61	97.06	7.22
DAUB1	T-50	7th c. BC	245.95	27.98	119.83	125.45	13.74
DAUB2	T-26	7th c. BC	353.86	65.80	233.15	146.70	14.91
DAUB3	T-18	7th c. BC	284.84	28.03	142.40	229.61	13.98
DAUB4	T-18	7th c. BC	136.01	24.69	53.66	297.28	12.62
DAUB5	R5	7th c. BC	201.99	27.89	124.05	291.83	7.37
DAUB6	T-1AB	7/6th c. BC	184.13	18.53	102.63	300.38	11.31
BRICK1	T-26	7th c. BC	217.77	15.36	182.38	181.65	11.03
BRICK2	T-26	7th c. BC	215.80	44.10	134.84	118.56	7.30
PLASTER1	T-26	7th c. BC	123.54	35.39	30.09	725.72	9.98
PLASTER2	T-26	7th c. BC	129.03	33.46	52.13	327.78	5.51
PLASTER3	T-25	7th c. BC	234.70	24.62	102.18	496.41	8.63
PLASTER4	T-18	7th c. BC	120.68	36.89	20.24	491.82	12.34
PLASTER5	R5	7th c. BC	188.47	46.97	77.26	172.54	20.15
PLASTER6	T-1AB	7/6th c. BC	84.54	35.79	21.98	660.59	16.42

Sample	Trench	Date	Zr	Nb	Sn	Sb	Cs
TILE1	R9	7th c. BC	19.44	8.08	14.29	0.98	6.04
TILE2	R5	7th c. BC	24.84	7.44	48.39	1.88	5.82
TILE3	T-15	7th c. BC	22.97	9.49	4.63	0.83	4.46
TILE4	T-26	7th c. BC	31.35	8.43	12.71	2.21	10.24
TILE5	T-26	7th c. BC	30.40	4.58	3.17	0.56	2.67
TILE6	T-5E	7/6th c. BC	34.44	8.03	6.62	1.26	4.11
DAUB1	T-50	7th c. BC	107.81	22.65	7.04	1.64	9.95
DAUB2	T-26	7th c. BC	114.88	20.80	11.36	0.63	14.09
DAUB3	T-18	7th c. BC	51.84	13.05	27.02	1.57	8.98
DAUB4	T-18	7th c. BC	56.64	10.50	18.40	0.29	2.52
DAUB5	R5	7th c. BC	45.29	12.18	6.34	0.39	6.43
DAUB6	T-1AB	7/6th c. BC	74.72	12.24	4.63	0.61	6.76
BRICK1	T-26	7th c. BC	81.59	16.49	6.73	0.79	15.00
BRICK2	T-26	7th c. BC	72.99	22.30	5.99	1.86	6.98
PLASTER1	T-26	7th c. BC	29.99	7.48	2.82	0.52	1.95
PLASTER2	T-26	7th c. BC	24.02	7.47	8.58	0.46	3.31
PLASTER3	T-25	7th c. BC	36.85	12.44	4.89	0.48	5.21
PLASTER4	T-18	7th c. BC	42.06	10.70	7.30	1.08	2.04
PLASTER5	R5	7th c. BC	25.49	15.18	6.35	0.42	3.91
PLASTER6	T-1AB	7/6th c. BC	29.26	6.18	1.43	1.97	2.82

Sample	Trench	Date	Ba	La	Ce	Pr	Nd
TILE1	R9	7th c. BC	363.82	13.13	45.48	4.38	14.47
TILE2	R5	7th c. BC	249.31	18.17	74.44	6.43	16.90
TILE3	T-15	7th c. BC	237.18	9.85	30.80	2.93	10.82
TILE4	T-26	7th c. BC	401.16	12.46	56.74	3.39	6.74
TILE5	T-26	7th c. BC	190.29	6.69	17.69	2.43	10.62
TILE6	T-5E	7/6th c. BC	267.98	11.01	39.83	2.82	6.97
DAUB1	T-50	7th c. BC	366.50	37.01	113.11	10.00	27.94
DAUB2	T-26	7th c. BC	498.71	36.67	105.59	9.17	33.92
DAUB3	T-18	7th c. BC	430.45	29.84	96.69	7.90	25.17
DAUB4	T-18	7th c. BC	453.04	36.13	99.50	8.64	25.99
DAUB5	R5	7th c. BC	446.57	25.74	77.57	6.97	24.86
DAUB6	T-1AB	7/6th c. BC	445.30	33.26	102.65	8.57	26.59
BRICK1	T-26	7th c. BC	432.61	25.94	57.30	6.35	19.84
BRICK2	T-26	7th c. BC	349.62	18.52	78.26	6.15	19.52
PLASTER1	T-26	7th c. BC	231.07	28.41	70.12	7.15	21.02
PLASTER2	T-26	7th c. BC	264.46	19.64	56.51	6.43	15.93
PLASTER3	T-25	7th c. BC	346.06	22.99	71.41	6.72	23.96
PLASTER4	T-18	7th c. BC	275.48	26.51	64.18	7.85	29.05
PLASTER5	R5	7th c. BC	325.99	35.12	129.43	14.77	57.19
PLASTER6	T-1AB	7/6th c. BC	316.68	27.14	64.71	8.21	24.05

Sample	Trench	Date	Sm	Eu	Gd	Tb	Dy	Ti
TILE1	R9	7th c. BC	2.67	1.41	1.02	0.21	1.56	3254.82
TILE2	R5	7th c. BC	2.45	1.42	1.76	0.19	1.33	4548.44
TILE3	T-15	7th c. BC	2.70	1.20	1.11	0.09	1.34	4624.11
TILE4	T-26	7th c. BC	1.23	0.81	1.29	0.23	1.27	3854.74
TILE5	T-26	7th c. BC	1.47	1.09	0.91	0.18	0.77	4780.62
TILE6	T-5E	7/6th c. BC	2.57	1.05	2.10	0.29	1.86	4159.12
DAUB1	T-50	7th c. BC	5.69	1.58	2.94	0.68	2.74	8349.02
DAUB2	T-26	7th c. BC	4.42	2.80	3.65	0.34	2.96	7472.21
DAUB3	T-18	7th c. BC	3.79	1.72	3.08	0.29	2.38	4512.50
DAUB4	T-18	7th c. BC	4.71	1.47	2.91	0.27	2.57	3809.92
DAUB5	R5	7th c. BC	3.82	1.09	1.83	0.40	1.07	4292.40
DAUB6	T-1AB	7/6th c. BC	4.07	1.58	3.04	0.44	1.27	4841.57
BRICK1	T-26	7th c. BC	3.73	0.86	1.96	0.25	2.17	5829.09
BRICK2	T-26	7th c. BC	2.96	1.35	2.15	0.29	0.74	7637.23
PLASTER1	T-26	7th c. BC	3.30	1.42	2.11	0.36	1.34	2350.44
PLASTER2	T-26	7th c. BC	2.07	0.74	0.68	0.09	1.08	2233.99
PLASTER3	T-25	7th c. BC	4.07	1.05	2.05	0.19	1.59	3465.33
PLASTER4	T-18	7th c. BC	4.53	1.56	2.65	0.24	1.82	2965.95
PLASTER5	R5	7th c. BC	11.92	3.71	12.72	0.60	2.18	4348.88
PLASTER6	T-1AB	7/6th c. BC	5.63	1.35	2.95	0.43	2.64	1894.12

Sample	Trench	Date	Ho	Er	Tm	Yb	Lu	Mg
TILE1	R9	7th c. BC	0.27	0.78	0.05	1.41	0.02	21004.04
TILE2	R5	7th c. BC	0.17	0.95	0.13	1.56	0.30	10430.85
TILE3	T-15	7th c. BC	0.33	0.92	0.09	0.60	0.23	9699.65
TILE4	T-26	7th c. BC	0.23	0.30	0.07	0.85	0.04	7434.72
TILE5	T-26	7th c. BC	0.21	0.57	0.06	1.11	0.08	10827.21
TILE6	T-5E	7/6th c. BC	0.18	1.16	0.21	1.06	0.10	11240.96
DAUB1	T-50	7th c. BC	0.59	1.28	0.34	2.72	0.26	3376.10
DAUB2	T-26	7th c. BC	0.90	1.73	0.40	1.84	0.19	3598.26
DAUB3	T-18	7th c. BC	0.22	1.40	0.22	1.87	0.19	3087.14
DAUB4	T-18	7th c. BC	0.50	0.93	0.25	2.17	0.04	3443.82
DAUB5	R5	7th c. BC	0.28	1.08	0.23	0.85	0.12	3529.97
DAUB6	T-1AB	7/6th c. BC	0.34	1.26	0.18	1.68	0.24	3677.92
BRICK1	T-26	7th c. BC	0.25	1.43	0.18	1.53	0.20	4280.76
BRICK2	T-26	7th c. BC	0.10	0.51	0.10	0.94	0.11	4556.60
PLASTER1	T-26	7th c. BC	0.38	0.63	0.17	0.96	0.11	3918.83
PLASTER2	T-26	7th c. BC	0.21	0.58	0.11	0.35	0.01	2465.18
PLASTER3	T-25	7th c. BC	0.50	0.45	0.22	0.62	0.13	2693.16
PLASTER4	T-18	7th c. BC	0.19	1.22	0.32	1.54	0.22	1473.49
PLASTER5	R5	7th c. BC	0.75	1.96	0.17	1.70	0.02	5797.90
PLASTER6	T-1AB	7/6th c. BC	0.26	1.38	0.11	2.24	0.06	2314.67

Sample	Trench	Date	Ta	Pb	Th	U	Hf
TILE1	R9	7th c. BC	0.41	36.35	2.16	1.49	0.62
TILE2	R5	7th c. BC	0.22	47.95	2.60	3.21	0.91
TILE3	T-15	7th c. BC	0.28	35.00	2.70	1.14	0.75
TILE4	T-26	7th c. BC	0.33	50.05	2.70	2.85	1.24
TILE5	T-26	7th c. BC	0.15	10.49	2.05	1.20	0.81
TILE6	T-5E	7/6th c. BC	0.23	35.82	2.96	1.78	1.67
DAUB1	T-50	7th c. BC	1.16	51.93	10.22	6.97	2.80
DAUB2	T-26	7th c. BC	1.19	55.03	9.10	5.53	2.62
DAUB3	T-18	7th c. BC	0.54	68.58	5.01	4.48	1.01
DAUB4	T-18	7th c. BC	0.70	21.98	6.37	3.65	1.97
DAUB5	R5	7th c. BC	0.66	48.21	5.15	2.77	2.09
DAUB6	T-1AB	7/6th c. BC	0.64	17.44	6.57	2.99	1.88
BRICK1	T-26	7th c. BC	0.66	55.70	7.64	3.82	2.02
BRICK2	T-26	7th c. BC	0.90	49.46	5.07	4.72	1.97
PLASTER1	T-26	7th c. BC	0.23	20.70	3.59	2.20	0.78
PLASTER2	T-26	7th c. BC	0.37	28.43	2.45	1.99	0.78
PLASTER3	T-25	7th c. BC	0.63	37.58	4.71	2.89	1.26
PLASTER4	T-18	7th c. BC	0.32	20.99	4.91	1.76	1.96
PLASTER5	R5	7th c. BC	0.58	29.97	12.50	3.40	0.90
PLASTER6	T-1AB	7/6th c. BC	0.29	16.35	9.24	1.79	1.37

Appendix B:

Eelemental concentrations for samples from 1986 INAA study in ppm

#	Fabric/ Trench	Dy	Mn	Sm	La	Na	Eu	Ce	Cr	Sc	Fe	Co
1	Bucchero	5.5	193	6.5	38	3870	1.2	77	170	18	50000	14
2	Bucchero	3.7	392	3.7	25	7660	0.68	56	170	17	49000	16
15	Bucchero	4.1	229	4.9	32	7980	0.83	67	170	15	45000	8.5
16	Bucchero	7.1	348	6.3	36	3440	1	70	170	16	47000	51
27	Bucchero	2.9	378	3	18	8100	0.59	49	130	14	38000	14
28	Bucchero	5.8	320	5.3	36	9600	1.2	87	190	16	52000	16
50	Bucchero	0	1120	5.2	30	7940	1.2	54	250	20	64000	23
51	Bucchero	4.5	652	5.5	30	7550	1.9	60	770	14	38000	26
62	Bucchero	2.6	59	4.7	29	7270	0.84	65	160	17	43000	19
63	Bucchero	2.5	644	4.4	21	8670	1	74	250	19	48000	20
66	Bucchero	7.3	431	8.1	45	9640	1.8	100	85	23	49000	26
67	Bucchero	5.5	702	5.6	23	19500	1.7	56	260	38	57000	35
78	Bucchero	3.9	169	4.6	26	12500	0.78	45	150	15	59000	12
79	Bucchero	4.1	844	6.9	44	5650	1.3	75	140	22	57000	22
80	Bucchero	3.5	214	4.5	26	9520	0.79	46	140	13	40000	12
81	Bucchero	7.3	262	7.1	35	5930	1.4	64	190	19	60000	16
92	Bucchero	5.2	1170	3.9	24	6800	0.77	55	400	17	51000	25
93	Bucchero	5.8	1560	5.5	34	8170	1.4	75	300	21	49000	22
106	Bucchero	5.7	209	5.1	33	8350	0.99	77	210	17	51000	17
107	Bucchero	5	307	6	35	8300	1.1	79	170	17	48000	19
112	Bucchero	4.6	245	5.8	35	7550	1	73	150	19	47000	18
113	Bucchero	7.3	216	8	46	4690	2	110	230	25	54000	17
114	Bucchero	3.9	168	5.4	36	7660	0.97	76	180	17	49000	12
115	Bucchero	6.4	614	7.1	43	11600	1.3	85	210	21	54000	26
116	Bucchero	6.7	986	6.9	42	9920	1.3	90	210	19	50000	27
117	Bucchero	3.4	709	3.3	21	9140	0.66	61	150	15	44000	17
7	Greyware	4.1	768	5.1	33	7170	0.89	68	190	17	48000	40
8	Greyware	4.8	690	4.4	27	10800	0.8	57	270	19	53000	38
23	Greyware	4.6	644	5.4	29	11000	1.1	63	330	20	53000	25
24	Greyware	4.4	361	5.5	36	6880	0.97	74	180	16	49000	19
36	Greyware	3.9	542	3.9	21	11400	0.87	52	530	15	54000	35
37	Greyware	4.3	448	5.6	33	6940	0.98	74	200	17	51000	17
52	Greyware	4.7	742	4.8	27	11400	1.5	70	270	19	46000	30
53	Greyware	3.1	318	3.7	24	8170	0.82	56	540	23	50000	15

#	Fabric/ Trench	Dy	Mn	Sm	La	Na	Eu	Ce	Cr	Sc	Fe	Co
64	Greyware	2.6	723	2.9	19	3970	0.55	34	71	8.1	22000	7.2
65	Greyware	3.8	487	3.8	24	13500	0.82	43	420	19	55000	34
68	Greyware	4.1	570	4.5	30	8650	0.82	61	150	15	43000	22
69	Greyware	5.7	509	7.1	47	4220	1.2	85	140	21	53000	15
86	Greyware	3.7	555	5.1	33	7580	0.86	63	150	15	50000	22
87	Greyware	3.7	301	4.6	30	8490	0.89	60	180	17	47000	19
94	Greyware	12	210	7.7	45	2790	1.9	67	200	22	54000	16
95	Greyware	8.8	669	5.9	39	5860	0.99	78	170	18	49000	13
110	Greyware	4	166	4.4	31	7950	0.74	65	150	14	43000	16
111	Greyware	4.4	403	4.9	31	8700	0.79	56	190	15	44000	14
17	Impasto	3.6	577	3.1	16	18700	0.69	30	630	30	52000	36
18	Impasto	4.9	629	3.3	14	15900	0.84	34	380	42	49000	29
25	Impasto	5.4	1750	3.1	19	13200	0.67	45	460	19	51000	65
26	Impasto	0	969	2.2	9	22700	0.6	19	820	29	47000	46
32	Impasto	1.3	885	3.3	12	23900	0.79	28	830	30	61000	36
33	Impasto	4.8	399	4.7	30	10200	0.83	66	140	15	45000	13
44	Impasto	0	1810	2.1	5.1	16100	0.82	30	690	30	47000	47
45	Impasto	3.1	991	1.4	3.7	12200	1.2	8.5	510	25	62000	61
60	Impasto	0	951	1.6	4.8	18300	0.58	26	780	23	47000	56
61	Impasto	2.2	1020	1.9	7.1	16300	0.66	37	550	22	47000	39
74	Impasto	3.6	977	4.9	22	16200	1.4	65	260	35	65000	36
75	Impasto	4.2	385	4.4	22	16000	0.9	48	630	27	43000	20
96	Impasto	0	2620	2.8	9.6	19700	0.69	18	760	33	56000	43
97	Impasto	4.1	3590	2.9	12	18600	0.93	42	740	36	55000	47
104	Impasto	6.1	185	6.4	36	7270	1.2	76	170	17	52000	12
105	Impasto	4.6	417	4.8	31	8790	0.88	63	290	19	50000	15
9	Orangeware	3.2	868	3.5	18	20300	0.94	37	620	29	49000	32
10	Orangeware	3.2	360	4	23	15100	0.83	49	280	22	42000	20
21	Orangeware	6	1160	4.7	27	10800	0.96	61	460	26	52000	34
22	Orangeware	4.7	7.6	4.5	26	10600	0.86	56	470	24	52000	27
40	Orangeware	3.9	342	3.7	21	13100	1	52	470	20	41000	19
41	Orangeware	7	1230	4.9	25	19600	1.2	57	300	38	64000	44
42	Orangeware	2.9	547	4.3	25	11400	1.1	43	450	23	46000	28
43	Orangeware	2.7	917	3.1	18	10900	0.72	37	290	18	50000	44
58	Orangeware	3.2	474	4.2	25	17200	1.2	51	400	27	45000	27
59	Orangeware	5	663	4.4	20	21700	1.2	45	780	35	53000	30
70	Orangeware	3.7	1440	3.5	15	22300	1.1	57	620	38	55000	40
71	Orangeware	3.7	729	4.1	22	17700	0.9	42	490	29	49000	28

#	Fabric/ Trench	Dy	Mn	Sm	La	Na	Eu	Ce	Cr	Sc	Fe	Co
82	Orangeware	4.2	561	4.4	24	14000	0.84	48	410	25	45000	25
83	Orangeware	6.2	607	7.2	38	11100	1.5	87	160	19	47000	19
84	Orangeware	4.5	360	4.6	30	10500	0.84	44	240	17	44000	14
98	Orangeware	6	855	3.5	17	19000	0.82	30	610	30	45000	29
99	Orangeware	6.5	281	5.6	32	10200	1.4	58	220	16	45000	13
108	Orangeware	4.8	708	6.3	35	10400	1.1	84	190	17	55000	25
109	Orangeware	4.6	535	4.4	21	12700	1.3	57	520	26	48000	31
3	Fine Orangeware	5.3	374	6.4	39	6510	1.1	81	130	17	46000	15
4	Fine Orangeware	7.3	205	8.2	45	3790	1.5	91	180	20	50000	17
5	Fine Orangeware	6.1	276	7.4	43	4190	1.4	94	230	19	57000	17
6	Fine Orangeware	5.2	1180	6	35	8510	1.1	81	170	17	49000	25
13	Fine Orangeware	6.3	1630	8.6	42	9270	1.2	89	190	21	54000	20
14	Fine Orangeware	5	656	7	43	6240	1.3	91	180	23	57000	23
19	Fine Orangeware	7.2	757	7.1	45	7130	1.2	88	220	22	60000	24
20	Fine Orangeware	6.3	756	7.3	45	8600	1.2	87	240	21	60000	25
29	Fine Orangeware	6	763	6.6	43	4490	1.1	85	180	20	56000	20
35	Fine Orangeware	5	697	6	35	10200	1.1	82	210	21	56000	24
48	Fine Orangeware	6.2	736	6.6	39	5030	1.3	87	210	26	63000	28
49	Fine Orangeware	6.3	643	6.5	39	5730	1.5	93	230	24	52000	25
56	Fine Orangeware	3.9	1230	7.5	46	4460	1.7	91	190	25	65000	28
57	Fine Orangeware	4.8	979	6.5	40	4040	1.3	81	97	23	62000	18
76	Fine Orangeware	7.4	1120	7	47	4110	1.5	83	200	23	67000	27
77	Fine Orangeware	5.1	733	5.4	36	7270	0.99	67	160	18	45000	19
85	Fine Orangeware	4.4	961	5.3	30	8930	1.3	68	750	25	52000	34
100	Fine Orangeware	7.4	702	6.8	46	6200	1.3	92	78	22	60000	21
101	Fine Orangeware	9.4	938	7	46	8130	1.2	97	81	23	62000	25
11	Coarseware	5.1	1750	3.4	15	18900	0.91	36	920	39	73000	62
12	Coarseware	0	981	2.4	9.5	27900	0.83	22	680	24	48000	38

#	Fabric/ Trench	Dy	Mn	Sm	La	Na	Eu	Ce	Cr	Sc	Fe	Co
30	Coarseware	0	2020	3.9	26	9100	0.69	68	130	16	46000	27
31	Coarseware	4.6	850	3	12	23100	0.75	28	800	34	47000	37
46	Coarseware	4.8	869	3.5	10	20500	1.5	48	1100	43	54000	42
47	Coarseware	5	775	6.3	32	12400	1.7	73	420	27	56000	36
54	Coarseware	5.3	1760	3.1	15	22200	1.2	24	1100	36	60000	54
55	Coarseware	3.4	912	3.4	15	25200	1.2	40	710	36	49000	36
72	Coarseware	2.8	849	3.2	13	28500	0.95	41	1100	41	53000	46
73	Coarseware	2.8	882	3.2	13	23100	0.98	45	870	35	50000	40
88	Coarseware	3	718	2.6	11	19900	0.83	24	720	33	44000	41
89	Coarseware	2.7	1170	2.6	10	21100	0.95	17	540	33	61000	44
90	Coarseware	2.7	1230	2.8	10	17400	1	43	800	31	54000	64
91	Coarseware	0	2050	2.7	9.5	24300	0.95	29	1400	30	48000	55
102	Coarseware	0	2830	2.1	5.1	20100	1.1	34	1300	53	61000	100
103	Coarseware	4.1	813	2.8	10	20300	1	37	760	34	47000	40
38	Tile	3.3	1090	3.1	13	22100	0.75	26	1000	35	52000	40
118	Tile	2.8	814	1.8	7.5	20400	0.79	36	750	32	47000	43
119	Tile	2.9	773	2.4	10	19000	0.8	29	670	33	47000	53
120	Tile	3.7	632	3	12	20600	1.1	35	910	41	51000	31
121	Tile	3.4	811	2.3	10	19200	0.71	20	810	35	48000	41
122	Tile	0	5470	3.8	17	20400	0.89	66	710	35	60000	140
123	Tile	2.4	903	1.7	5.7	24500	0.66	27	670	26	41000	44
124	Tile	2.4	881	1.7	5.7	20300	0.69	40	590	25	46000	53
125	Tile	4.1	879	2.9	13	21100	0.79	27	740	31	54000	40
126	Tile	1.8	537	1.6	6.6	19700	1.6	28	500	18	40000	37
127	Tile	3.6	2920	2.5	10	19800	0.72	45	620	28	57000	110
128	Tile	7.9	2150	4.2	11	16500	1.2	48	710	33	50000	73
129	Tile	0	1150	2.1	8.8	20600	1.1	42	710	29	53000	80
130	Tile	3.5	877	2.7	11	20000	0.92	34	880	36	55000	45
131	Tile	0	698	1.9	9.2	22400	0.53	15	500	23	37000	40
132	Tile	2.6	839	2.4	9.8	19900	0.97	29	700	32	50000	51
133	Tile	4.8	920	2.9	15	23000	0.75	25	630	28	46000	32
134	Tile	4	857	1.9	7.8	21600	0.52	16	680	23	44000	42
135	Tile	0	924	1.5	6.5	19500	0.74	37	540	23	48000	58
136	Clay	9.9	3670	8.5	43	1250	2.4	110	200	36	100000	63
137	Clay	7.1	2400	7.7	39	1160	1.5	77	130	26	79000	33
138	Clay	8.9	2700	8.1	33	1100	1.7	73	100	26	87000	43
139	Clay	8.1	4000	9.1	43	1650	1.9	90	190	33	110000	77
140	Clay	5	2170	5.5	25	928	1.2	57	73	18	64000	48

#	Fabric/ Trench	Dy	Mn	Sm	La	Na	Eu	Ce	Cr	Sc	Fe	Co
141	Clay	6.3	3730	8.7	39	1280	1.7	84	120	31	100000	59
142	Clay	8	3610	8.5	39	1230	1.8	82	160	34	130000	48
143	Clay	7.5	3200	9	38	1260	1.9	78	140	32	120000	39
144	Clay	8.6	4070	8.9	42	1450	1.8	84	130	33	110000	75
145	Clay	10	2790	9.2	40	1400	2	93	160	32	120000	53
146	Clay	10	2310	9	43	1350	1.9	75	150	34	120000	34
147	Clay	11	2830	8.9	40	1250	1.9	81	140	33	160000	31
148	Clay	8.2	2310	11	41	1280	2.3	85	160	33	130000	27
149	Clay	9.7	2260	13	65	1850	2.7	130	210	47	170000	45
150	Clay	8.8	1860	14	67	1700	2.5	130	170	41	150000	42
LB171	Tile	3.8	362	3.5	12	21202	0.8	23	1117	29	37514	37
LB176	Tile	2.2	325	1.8	10	22688	0.8	26	565	22	33086	37
LB177	Tile	3.8	415	3.0	8	28723	1.0	18	1641	29	72285	61
LB178	Tile	1.0	94	0.9	6	49739	0.4	14	779	16	27322	12
LB179	Tile	4.8	375	3.5	9	40187	1.3	16	470	34	75522	43
LB180	Tile	5.7	1070	5.2	22	9888	1.5	43	716	44	96387	66
LB181	Tile	3.3	1605	3.2	12	10251	0.9	19	1121	37	68786	84
LB184	Tile	4.1	1031	3.3	7	9109	1.2	10	1028	37	81809	56
LB194	Tile	4.0	1459	3.3	13	5900	0.9	26	2785	41	69973	48
LB205	Tile	5.1	1248	3.7	9	18302	1.0	23	432	44	104687	103
Daub1	T-50	2.7	1986	5.7	37	3255	1.6	113	246	32	92234	43
Daub2	T-26	3.0	3154	4.4	36	2165	2.8	105	303	32	94714	61
Daub3	T-18	2.4	3277	3.8	29	1850	1.7	97	245	31	92416	52
Daub4	T-18	2.6	2070	4.7	36	58	1.5	99	288	18	77861	32
Daub5	R5	1.1	1616	3.8	25	1621	1.1	77	305	21	74568	32
Daub6	T-1AB	1.3	3972	4.1	33	2796	1.6	102	229	28	80473	48
Plas1	T-26	1.3	2353	3.3	28	119	1.4	70	132	17	51153	19
Plas2	T-26	1.1	1698	2.1	19	446	0.7	56	181	20	54480	23
Plas3	T-25	1.6	1321	4.1	23	471	1.1	71	190	12	69848	27
Plas4	T-18	1.8	1028	4.5	26	37	1.6	64	224	24	74100	20
Plas5	T-1AB	2.6	1035	5.6	27	0	1.3	65	281	12	55838	20
Plas6	R5	2.2	1244	12	35	10389	3.7	129	664	15	88410	41
BR1	T-26	2.2	1775	3.7	26	1875	0.9	57	162	25	84675	40
BRICK2	T-26	0.7	1887	3.0	19	13840	1.3	78	215	25	103023	54
TILE1	R9	1.6	2604	2.7	13	4195	1.4	45	613	25	102285	88
TILE2	R5	1.3	1987	2.5	18	9037	1.4	74	682	30	87129	59
TILE3	T-15	1.3	1545	2.7	10	6918	1.2	31	726	35	80184	49
TILE4	T-26	1.3	2476	1.2	12	16423	0.8	57	514	35	90952	65
TILE5	T-26	0.8	993	1.5	7	5253	1.1	18	560	44	75606	49

#	Fabric/ Trench	Dy	Mn	Sm	La	Na	Eu	Ce	Cr	Sc	Fe	Co
TILE6	T-5E	1.9	2157	2.6	11	11724	1.0	40	683	38	87080	61
BOID	R5	2.2	1048	3.9	27	12410	1.4	77	267	22	80398	33

Appendix C:

Results for SAS clustering analysis using log-transformed elemental concentrations

Sample	Dy	Mn	Sm	La	Na	Eu	Ce	Cr	Sc	Fe	Co	Cluster
Impasto17	0.56	2.76	0.49	1.20	4.27	-0.16	1.48	2.80	1.48	4.72	1.56	1
Impasto18	0.69	2.80	0.52	1.15	4.20	-0.08	1.53	2.58	1.62	4.69	1.46	1
Impasto25	0.73	3.24	0.49	1.28	4.12	-0.17	1.65	2.66	1.28	4.71	1.81	1
Impasto26	0.00	2.99	0.34	0.95	4.36	-0.22	1.28	2.91	1.46	4.67	1.66	1
Impasto32	0.11	2.95	0.52	1.08	4.38	-0.10	1.45	2.92	1.48	4.79	1.56	1
Impasto33	0.00	3.26	0.32	0.71	4.21	-0.09	1.48	2.84	1.48	4.67	1.67	1
Impasto44	0.49	3.00	0.15	0.57	4.09	0.08	0.93	2.71	1.40	4.79	1.79	1
Impasto45	0.00	2.98	0.20	0.68	4.26	-0.24	1.41	2.89	1.36	4.67	1.75	1
Impasto60	0.34	3.01	0.28	0.85	4.21	-0.18	1.57	2.74	1.34	4.67	1.59	1
Impasto61	0.00	3.42	0.45	0.98	4.29	-0.16	1.26	2.88	1.52	4.75	1.63	1
Impasto74	0.61	3.56	0.46	1.08	4.27	-0.03	1.62	2.87	1.56	4.74	1.67	1
Orangeware22	0.51	2.94	0.54	1.26	4.31	-0.03	1.57	2.79	1.46	4.69	1.51	1
Orangeware70	0.43	2.96	0.49	1.26	4.04	-0.14	1.57	2.46	1.26	4.70	1.64	1
Orangeware82	0.70	2.82	0.64	1.30	4.34	0.08	1.65	2.89	1.54	4.72	1.48	1
Orangeware83	0.57	3.16	0.54	1.18	4.35	0.04	1.76	2.79	1.58	4.74	1.60	1
Orangeware98	0.57	2.86	0.61	1.34	4.25	-0.05	1.62	2.69	1.46	4.69	1.45	1
Orangeare109	0.78	2.93	0.54	1.23	4.28	-0.09	1.48	2.79	1.48	4.65	1.46	1
Coarseware11	0.71	3.24	0.53	1.18	4.28	-0.04	1.56	2.96	1.59	4.86	1.79	1
Coarseware12	0.00	2.99	0.38	0.98	4.45	-0.08	1.34	2.83	1.38	4.68	1.58	1
Coarseware31	0.66	2.93	0.48	1.08	4.36	-0.12	1.45	2.90	1.53	4.67	1.57	1
Coarseware46	0.68	2.94	0.54	1.00	4.31	0.18	1.68	3.04	1.63	4.73	1.62	1
Coarseware54	0.72	3.25	0.49	1.18	4.35	0.08	1.38	3.04	1.56	4.78	1.73	1
Coarseware55	0.53	2.96	0.53	1.18	4.40	0.08	1.60	2.85	1.56	4.69	1.56	1
Coarseware72	0.45	2.93	0.51	1.11	4.45	-0.02	1.61	3.04	1.61	4.72	1.66	1
Coarseware73	0.45	2.95	0.51	1.11	4.36	-0.01	1.65	2.94	1.54	4.70	1.60	1
Coarseware88	0.48	2.86	0.41	1.04	4.30	-0.08	1.38	2.86	1.52	4.64	1.61	1
Coarseware89	0.43	3.07	0.41	1.00	4.32	-0.02	1.23	2.73	1.52	4.79	1.64	1
Coarseware90	0.43	3.09	0.45	1.00	4.24	0.00	1.63	2.90	1.49	4.73	1.81	1
Coarseware91	0.00	3.31	0.43	0.98	4.39	-0.02	1.46	3.15	1.48	4.68	1.74	1
Coarseware 102	0.00	3.45	0.32	0.71	4.30	0.04	1.53	3.11	1.72	4.79	2.00	1
Coarseware 103	0.61	2.91	0.45	1.00	4.31	0.00	1.57	2.88	1.53	4.67	1.60	1
Tile38	0.52	3.04	0.49	1.11	4.34	-0.12	1.41	3.00	1.54	4.72	1.60	1
Tile118	0.45	2.91	0.26	0.88	4.31	-0.10	1.56	2.88	1.51	4.67	1.63	1

Sample	Dy	Mn	Sm	La	Na	Eu	Ce	Cr	Sc	Fe	Co	Cluster
Tile119	0.46	2.89	0.38	1.00	4.28	-0.10	1.46	2.83	1.52	4.67	1.72	1
Tile120	0.57	2.80	0.48	1.08	4.31	0.04	1.54	2.96	1.61	4.71	1.49	1
Tile121	0.53	2.91	0.36	1.00	4.28	-0.15	1.30	2.91	1.54	4.68	1.61	1
Tile122	0.00	3.74	0.58	1.23	4.31	-0.05	1.82	2.85	1.54	4.78	2.15	1
Tile123	0.38	2.96	0.23	0.76	4.39	-0.18	1.43	2.83	1.41	4.61	1.64	1
Tile124	0.38	2.94	0.23	0.76	4.31	-0.16	1.60	2.77	1.40	4.66	1.72	1
Tile125	0.61	2.94	0.46	1.11	4.32	-0.10	1.43	2.87	1.49	4.73	1.60	1
Tile126	0.26	2.73	0.20	0.82	4.29	0.20	1.45	2.70	1.26	4.60	1.57	1
Tile127	0.56	3.47	0.40	1.00	4.30	-0.14	1.65	2.79	1.45	4.76	2.04	1
Tile128	0.90	3.33	0.62	1.04	4.22	0.08	1.68	2.85	1.52	4.70	1.86	1
Tile129	0.00	3.06	0.32	0.94	4.31	0.04	1.62	2.85	1.46	4.72	1.90	1
Tile130	0.54	2.94	0.43	1.04	4.30	-0.04	1.53	2.94	1.56	4.74	1.65	1
Tile132	0.41	2.92	0.38	0.99	4.30	-0.01	1.46	2.85	1.51	4.70	1.71	1
Tile133	0.68	2.96	0.46	1.18	4.36	-0.12	1.40	2.80	1.45	4.66	1.51	1
Tile134	0.60	2.93	0.28	0.89	4.33	-0.28	1.20	2.83	1.36	4.64	1.62	1
Tile135	0.00	2.97	0.18	0.81	4.29	-0.13	1.57	2.73	1.36	4.68	1.76	1
LB0171	0.58	2.56	0.55	1.08	4.33	-0.08	1.37	3.05	1.47	4.57	1.58	1
LB0177	0.58	2.62	0.48	0.91	4.46	-0.02	1.27	3.22	1.47	4.86	1.79	1
LB0179	0.68	2.57	0.54	0.97	4.60	0.10	1.21	2.67	1.53	4.88	1.63	1
LB0180	0.76	3.03	0.72	1.35	4.00	0.19	1.63	2.85	1.64	4.98	1.82	1
LB0181	0.52	3.21	0.50	1.11	4.01	-0.05	1.27	3.05	1.57	4.84	1.92	1
LB0184	0.62	3.01	0.52	0.89	3.96	0.08	1.02	3.01	1.57	4.91	1.75	1
LB0194	0.60	3.16	0.52	1.12	3.77	-0.03	1.42	3.44	1.61	4.84	1.68	1
LB0205	0.71	3.10	0.57	0.99	4.26	0.01	1.36	2.64	1.64	5.02	2.01	1
Tile1	0.19	3.42	0.43	1.12	3.62	0.15	1.66	2.79	1.40	5.01	1.94	1
Tile2	0.12	3.30	0.39	1.26	3.96	0.15	1.87	2.83	1.48	4.94	1.77	1
Tile3	0.13	3.19	0.43	0.99	3.84	0.08	1.49	2.86	1.55	4.90	1.70	1
Tile6	0.27	3.33	0.41	1.04	4.07	0.02	1.60	2.83	1.58	4.94	1.79	1
Brick2	-0.13	3.28	0.47	1.27	4.14	0.13	1.89	2.33	1.40	5.01	1.73	1
Tile4	0.10	3.39	0.09	1.10	4.22	-0.09	1.75	2.71	1.54	4.96	1.81	1
Tile5	-0.12	3.00	0.17	0.83	3.72	0.04	1.25	2.75	1.64	4.88	1.69	1
Clay136	1.00	3.56	0.93	1.63	3.10	0.38	2.04	2.30	1.56	5.00	1.80	2
Clay137	0.85	3.38	0.89	1.59	3.06	0.18	1.89	2.11	1.41	4.90	1.52	2
Clay138	0.95	3.43	0.91	1.52	3.04	0.23	1.86	2.00	1.41	4.94	1.63	2
Clay139	0.91	3.60	0.96	1.63	3.22	0.28	1.95	2.28	1.52	5.04	1.89	2
Clay140	0.70	3.34	0.74	1.40	2.97	0.08	1.76	1.86	1.26	4.81	1.68	2
Clay141	0.80	3.57	0.94	1.59	3.11	0.23	1.92	2.08	1.49	5.00	1.77	2
Clay142	0.90	3.56	0.93	1.59	3.09	0.26	1.91	2.20	1.53	5.11	1.68	2

Sample	Dy	Mn	Sm	La	Na	Eu	Ce	Cr	Sc	Fe	Co	Cluster
Clay143	0.88	3.51	0.95	1.58	3.10	0.28	1.89	2.15	1.51	5.08	1.59	2
Clay144	0.93	3.61	0.95	1.62	3.16	0.26	1.92	2.11	1.52	5.04	1.88	2
Clay145	1.00	3.45	0.96	1.60	3.15	0.30	1.97	2.20	1.51	5.08	1.72	2
Clay146	1.00	3.36	0.95	1.63	3.13	0.28	1.88	2.18	1.53	5.08	1.53	2
Clay147	1.04	3.45	0.95	1.60	3.10	0.28	1.91	2.15	1.52	5.20	1.49	2
Clay148	0.91	3.36	1.04	1.61	3.11	0.36	1.93	2.20	1.52	5.11	1.43	2
Clay149	0.99	3.35	1.11	1.81	3.27	0.43	2.11	2.32	1.67	5.23	1.65	2
Clay150	0.94	3.27	1.15	1.83	3.23	0.40	2.11	2.23	1.61	5.18	1.62	2
Daub1	0.44	3.30	0.76	1.57	3.51	0.20	2.05	2.39	1.51	4.96	1.63	2
Daub2	0.47	3.50	0.65	1.56	3.34	0.45	2.02	2.48	1.50	4.98	1.79	2
Plaster2	0.03	3.23	0.32	1.29	2.65	-0.13	1.75	2.26	1.30	4.74	1.36	2
Plaster3	0.20	3.12	0.61	1.36	2.67	0.02	1.85	2.28	1.07	4.84	1.43	2
Daub3	0.38	3.52	0.58	1.47	3.27	0.23	1.99	2.39	1.50	4.97	1.72	2
Daub6	0.10	3.60	0.61	1.52	3.45	0.20	2.01	2.36	1.44	4.91	1.68	2
Daub5	0.03	3.21	0.58	1.41	3.21	0.04	1.89	2.48	1.33	4.87	1.50	2
Brick1	0.34	3.25	0.57	1.41	3.27	-0.07	1.76	2.21	1.40	4.93	1.60	2
Bucchero62	0.41	1.77	0.67	1.46	3.86	-0.08	1.81	2.20	1.23	4.63	1.28	3
Orangeware22	0.67	0.88	0.65	1.41	4.03	-0.07	1.75	2.67	1.38	4.72	1.43	3
Tile131	0.00	2.84	0.28	0.96	4.35	-0.28	1.18	2.70	1.36	4.57	1.60	4
LB0176	0.34	2.51	0.26	1.01	4.36	-0.08	1.42	2.75	1.34	4.52	1.57	4
LB0178	0.01	1.98	-0.04	0.79	4.70	-0.45	1.14	2.89	1.20	4.44	1.09	4
Bucchero1	0.74	2.29	0.81	1.58	3.59	0.08	1.89	2.23	1.26	4.70	1.15	5
Bucchero2	0.57	2.59	0.57	1.40	3.88	-0.17	1.75	2.23	1.23	4.69	1.20	5
Bucchero15	0.61	2.36	0.69	1.51	3.90	-0.08	1.83	2.23	1.18	4.65	0.93	5
Bucchero16	0.85	2.54	0.80	1.56	3.54	0.00	1.85	2.23	1.20	4.67	1.71	5
Bucchero27	0.46	2.58	0.48	1.26	3.91	-0.23	1.69	2.11	1.15	4.58	1.15	5
Bucchero28	0.76	2.51	0.72	1.56	3.98	0.08	1.94	2.28	1.20	4.72	1.20	5
Bucchero50	0.00	3.05	0.72	1.48	3.90	0.08	1.73	2.40	1.30	4.81	1.36	5
Bucchero51	0.65	2.81	0.74	1.48	3.88	0.28	1.78	2.89	1.15	4.58	1.41	5
Bucchero63	0.40	2.81	0.64	1.32	3.94	0.00	1.87	2.40	1.28	4.68	1.30	5
Bucchero66	0.86	2.63	0.91	1.65	3.98	0.26	2.00	1.93	1.36	4.69	1.41	5
Bucchero67	0.74	2.85	0.75	1.36	4.29	0.23	1.75	2.41	1.58	4.76	1.54	5
Bucchero78	0.59	2.23	0.66	1.41	4.10	-0.11	1.65	2.18	1.18	4.77	1.08	5
Bucchero79	0.61	2.93	0.84	1.64	3.75	0.11	1.88	2.15	1.34	4.76	1.34	5
Bucchero80	0.54	2.33	0.65	1.41	3.98	-0.10	1.66	2.15	1.11	4.60	1.08	5
Bucchero81	0.86	2.42	0.85	1.54	3.77	0.15	1.81	2.28	1.28	4.78	1.20	5
Bucchero92	0.72	3.07	0.59	1.38	3.83	-0.11	1.74	2.60	1.23	4.71	1.40	5
Bucchero93	0.76	3.19	0.74	1.53	3.91	0.15	1.88	2.48	1.32	4.69	1.34	5

Sample	Dy	Mn	Sm	La	Na	Eu	Ce	Cr	Sc	Fe	Co	Cluster
Bucchero106	0.76	2.32	0.71	1.52	3.92	0.00	1.89	2.32	1.23	4.71	1.23	5
Bucchero107	0.70	2.49	0.78	1.54	3.92	0.04	1.90	2.23	1.23	4.68	1.28	5
Bucchero112	0.66	2.39	0.76	1.54	3.88	0.00	1.86	2.18	1.28	4.67	1.26	5
Bucchero113	0.86	2.33	0.90	1.66	3.67	0.30	2.04	2.36	1.40	4.73	1.23	5
Bucchero114	0.59	2.23	0.73	1.56	3.88	-0.01	1.88	2.26	1.23	4.69	1.08	5
Bucchero115	0.81	2.79	0.85	1.63	4.06	0.11	1.93	2.32	1.32	4.73	1.41	5
Bucchero116	0.83	2.99	0.84	1.62	4.00	0.11	1.95	2.32	1.28	4.70	1.43	5
Bucchero117	0.53	2.85	0.52	1.32	3.96	-0.18	1.79	2.18	1.18	4.64	1.23	5
Greyware7	0.61	2.89	0.71	1.52	3.86	-0.05	1.83	2.28	1.23	4.68	1.60	5
Greyware8	0.68	2.84	0.64	1.43	4.03	-0.10	1.76	2.43	1.28	4.72	1.58	5
Greyware23	0.66	2.81	0.73	1.46	4.04	0.04	1.80	2.52	1.30	4.72	1.40	5
Greyware24	0.64	2.56	0.74	1.56	3.84	-0.01	1.87	2.26	1.20	4.69	1.28	5
Greyware36	0.59	2.73	0.59	1.32	4.06	-0.06	1.72	2.72	1.18	4.73	1.54	5
Greyware37	0.63	2.65	0.75	1.52	3.84	-0.01	1.87	2.30	1.23	4.71	1.23	5
Greyware52	0.67	2.87	0.68	1.43	4.06	0.18	1.85	2.43	1.28	4.66	1.48	5
Greyware53	0.49	2.50	0.57	1.38	3.91	-0.09	1.75	2.73	1.36	4.70	1.18	5
Greyware64	0.41	2.86	0.46	1.28	3.60	-0.26	1.53	1.85	0.91	4.34	0.86	5
Greyware65	0.58	2.69	0.58	1.38	4.13	-0.09	1.63	2.62	1.28	4.74	1.53	5
Greyware68	0.61	2.76	0.65	1.48	3.94	-0.09	1.79	2.18	1.18	4.63	1.34	5
Greyware69	0.76	2.71	0.85	1.67	3.63	0.08	1.93	2.15	1.32	4.72	1.18	5
Greyware86	0.57	2.74	0.71	1.52	3.88	-0.07	1.80	2.18	1.18	4.70	1.34	5
Greyware87	0.57	2.48	0.66	1.48	3.93	-0.05	1.78	2.26	1.23	4.67	1.28	5
Greyware94	1.08	2.32	0.89	1.65	3.45	0.28	1.83	2.30	1.34	4.73	1.20	5
Greyware95	0.94	2.83	0.77	1.59	3.77	0.00	1.89	2.23	1.26	4.69	1.11	5
Greyware110	0.60	2.22	0.64	1.49	3.90	-0.13	1.81	2.18	1.15	4.63	1.20	5
Greyware111	0.64	2.61	0.69	1.49	3.94	-0.10	1.75	2.28	1.18	4.64	1.15	5
Impasto33	0.68	2.60	0.67	1.48	4.01	-0.08	1.82	2.15	1.18	4.65	1.11	5
Impasto74	0.56	2.99	0.69	1.34	4.21	0.15	1.81	2.41	1.54	4.81	1.56	5
Impasto75	0.62	2.59	0.64	1.34	4.20	-0.05	1.68	2.80	1.43	4.63	1.30	5
Impasto104	0.79	2.27	0.81	1.56	3.86	0.08	1.88	2.23	1.23	4.72	1.08	5
Impasto105	0.66	2.62	0.68	1.49	3.94	-0.06	1.80	2.46	1.28	4.70	1.18	5
Orangeware10	0.51	2.56	0.60	1.36	4.18	-0.08	1.69	2.45	1.34	4.62	1.30	5
Orangeware21	0.78	3.06	0.67	1.43	4.03	-0.02	1.79	2.66	1.41	4.72	1.53	5
Orangeware40	0.59	2.53	0.57	1.32	4.12	0.00	1.72	2.67	1.30	4.61	1.28	5
Orangeware41	0.85	3.09	0.69	1.40	4.29	0.08	1.76	2.48	1.58	4.81	1.64	5
Orangeware42	0.46	2.74	0.63	1.40	4.06	0.04	1.63	2.65	1.36	4.66	1.45	5
Orangeware58	0.51	2.68	0.62	1.40	4.24	0.08	1.71	2.60	1.43	4.65	1.43	5
Orangeware82	0.62	2.75	0.64	1.38	4.15	-0.08	1.68	2.61	1.40	4.65	1.40	5

Sample	Dy	Mn	Sm	La	Na	Eu	Ce	Cr	Sc	Fe	Co	Cluster
Orangeware83	0.79	2.78	0.86	1.58	4.05	0.18	1.94	2.20	1.28	4.67	1.28	5
Orangeware84	0.65	2.56	0.66	1.48	4.02	-0.08	1.64	2.38	1.23	4.64	1.15	5
Orangeware99	0.81	2.45	0.75	1.51	4.01	0.15	1.76	2.34	1.20	4.65	1.11	5
Orangeware 108	0.68	2.85	0.80	1.54	4.02	0.04	1.92	2.28	1.23	4.74	1.40	5
Orangeware 109	0.66	2.73	0.64	1.32	4.10	0.11	1.76	2.72	1.41	4.68	1.49	5
Fine Orangeware3	0.72	2.57	0.81	1.59	3.81	0.04	1.91	2.11	1.23	4.66	1.18	5
Fine Orangeware4	0.86	2.31	0.91	1.65	3.58	0.18	1.96	2.26	1.30	4.70	1.23	5
Fine Orangeware5	0.79	2.44	0.87	1.63	3.62	0.15	1.97	2.36	1.28	4.76	1.23	5
Fine Orangeware6	0.72	3.07	0.78	1.54	3.93	0.04	1.91	2.23	1.23	4.69	1.40	5
Fine Orangeware13	0.80	3.21	0.93	1.62	3.97	0.08	1.95	2.28	1.32	4.73	1.30	5
Fine Orangeware14	0.70	2.82	0.85	1.63	3.80	0.11	1.96	2.26	1.36	4.76	1.36	5
Fine Orangeware19	0.86	2.88	0.85	1.65	3.85	0.08	1.94	2.34	1.34	4.78	1.38	5
Fine Orangeware20	0.80	2.88	0.86	1.65	3.93	0.08	1.94	2.38	1.32	4.78	1.40	5
Fine Orangeware29	0.78	2.88	0.82	1.63	3.65	0.04	1.93	2.26	1.30	4.75	1.30	5
Fine Orangeware35	0.70	2.84	0.78	1.54	4.01	0.04	1.91	2.32	1.32	4.75	1.38	5
Fine Orangeware48	0.79	2.87	0.82	1.59	3.70	0.11	1.94	2.32	1.41	4.80	1.45	5
Fine Orangeware49	0.80	2.81	0.81	1.59	3.76	0.18	1.97	2.36	1.38	4.72	1.40	5
Fine Orangeware56	0.59	3.09	0.88	1.66	3.65	0.23	1.96	2.28	1.40	4.81	1.45	5
Fine Orangeware57	0.68	2.99	0.81	1.60	3.61	0.11	1.91	1.99	1.36	4.79	1.26	5
Fine Orangeware76	0.87	3.05	0.85	1.67	3.61	0.18	1.92	2.30	1.36	4.83	1.43	5
Fine Orangeware77	0.71	2.87	0.73	1.56	3.86	0.00	1.83	2.20	1.26	4.65	1.28	5
Fine Orangeware85	0.64	2.98	0.72	1.48	3.95	0.11	1.83	2.88	1.40	4.72	1.53	5
Fine Orangeware 100	0.87	2.85	0.83	1.66	3.79	0.11	1.96	1.89	1.34	4.78	1.32	5
Fine Orangeware 101	0.97	2.97	0.85	1.66	3.91	0.08	1.99	1.91	1.36	4.79	1.40	5
Coarseware30	0.00	3.31	0.59	1.41	3.96	-0.16	1.83	2.11	1.20	4.66	1.43	5
Coarseware47	0.70	2.89	0.80	1.51	4.09	0.23	1.86	2.62	1.43	4.75	1.56	5
Plaster6	0.34	3.09	1.08	1.55	4.02	0.57	2.11	2.82	1.17	4.95	1.61	5
Buccheroid	0.35	3.02	0.59	1.44	4.09	0.14	1.89	2.43	1.33	4.91	1.52	5

Sample	Dy	Mn	Sm	La	Na	Eu	Ce	Cr	Sc	Fe	Co	Cluster
Plaster1	0.13	3.37	0.52	1.45	2.08	0.15	1.85	2.12	1.24	4.71	1.28	6
Plaster4	0.26	3.01	0.66	1.42	1.58	0.19	1.81	2.35	1.37	4.87	1.30	6
Daub4	0.41	3.32	0.67	1.56	1.77	0.17	2.00	2.46	1.25	4.89	1.51	6
Plaster5	0.42	3.01	0.75	1.43	0.00	0.13	1.81	2.45	1.09	4.75	1.30	6

Appendix D:

Daub and mudbrick fragments from T-26

Box	ID	CAT	L	H	Th	Plaster	Wattles	D	Spacing	Plane	Finished Edge	Impression Type	D/W	L
1	1	2	18.5	15.5	6.2	-	3	1	<1	Woven	-	-	-	-
1	1a	3	18.5	15.5	6.2	-	-	-	-	-	-	Circular	5.6	-
1	2	1	9	11	3.6	Y	1	1.6	-	-	-	-	-	-
1	3	1	7.5	8.2	2.9	Y	3	1.3	1	Parallel	Parallel	-	-	-
1	4	1	5.9	9.6	2.8	Y	2	1.8	1.5	Parallel	Perpendicular	-	-	-
1	5	5	7.4	5.5	5.1	-	-	-	-	-	-	-	-	-
1	6	1	7.6	8.3	3	Y	2	1.5	1	Parallel	Perpendicular	-	-	-
1	7	3	17	10.1	9.4	-	-	-	-	-	-	Circular	14	-
1	8	1	11.1	9.5	6.8	-	1	1.2	-	-	-	-	-	-
1	8	3	11.1	9.5	6.8	-	-	-	-	-	-	Circular	7.7	-
1	8a	4	11.1	9.5	6.8	-	-	-	-	-	-	Flat	2	6
1	9	3	11.9	13.5	7.4	-	-	-	-	-	-	Circular	8.2	-
1	10	1	12.5	10.8	3.8	Y	5	1.3	<1	Parallel	-	-	-	-
1	11	1	20.5	16.4	6.4	-	1	1.6	-	-	-	-	-	-
1	12	1	8.5	15.4	9.8	-	2	2	0.7	Parallel	-	-	-	-
1	12a	4	8.5	15.4	9.8	-	-	-	-	-	-	Flat	4.9	6
1	12c	3	8.5	15.4	9.8	-	-	-	-	-	-	Circular	6	-
1	12b	3	8.5	15.4	9.8	-	-	-	-	-	-	Circular	12.5	-
2	1	1	11.9	9.7	5.1	Y	1	2.1	-	-	-	-	-	-
2	2	2	19.5	15.8	7	Y	5	2	1.5	Woven	Parallel	-	-	-
2	3	2	15.7	10.5	7.2	-	2	1	1	Woven	-	-	-	-
2	4	5	13.3	12.8	12.3	-	-	-	-	-	-	-	-	-
2	5	5	12.2	11	5.1	Y	-	-	-	-	-	-	-	-

Box	ID	CAT	L	H	Th	Plaster	Wattles	D	Spacing	Plane	Finished Edge	Impression Type	D/W	L
2	6	5	18.5	17	5.8	-	-	-	-	-	-	-	-	-
2	7	5	11.5	12.4	6	Y	-	-	-	-	-	-	-	-
2	8	5	16.2	9.5	5.6	Y	-	-	-	-	-	-	-	-
2	9	1	6	14.4	6	Y	1	1.5	-	-	-	-	-	-
2	10	1	9	8.6	5.6	Y	1	1.5	-	-	-	-	-	-
2	11	1	12.9	15.5	5.2	Y	2	1.8	1.3	Parallel	-	-	-	-
2	12	1	12.8	7.5	8.8	-	1	1.4	-	-	-	-	-	-
2	13	1	14.2	11.5	4	Y	2	2	2	Parallel	-	-	-	-
2	14	1	7.7	11.9	7.9	Y	1	2	-	-	-	-	-	-
2	14	4	9	9.1	5.5	Y	-	-	-	-	-	Flat	1.5	10
2	14	4	9	9.1	5.5		-	-	-	-	-	Flat	1	7
2	15	5	12.4	11	5.2	-	-	-	-	-	-	-	-	-
2	16	6	10	6.8	3.5	-	-	-	-	-	-	-	-	-
2	17	6	8.8	8.8	3.7	-	-	-	-	-	-	-	-	-
2	18	1	8.5	8.6	2.4	-	1	1.6	-	-	-	-	-	-
2	19	1	9.2	12.5	2.8	Y	1	1.3	-	-	-	-	-	-
2	20	6	18.5	14.4	7.6	Y	-	-	-	-	-	-	-	-
2	21	4	12.8	4.2	12.8	-	-	-	-	-	-	Flat	6	14
2	21a	4	12.8	8.9	12.8	-	-	-	-	-	-	Curvilinear	12	-
3	1	1	12.6	15.2	5.1	-	1	1.5	-	-	-	-	-	-
3	2	5	8.9	12.5	6.4	-	-	-	-	-	-	-	-	-
3	3	3	7.2	6.9	5.2	-	-	-	-	-	-	Circular	5.2	-
3	4	5	7.5	10.5	2.2	Y	-	-	-	-	-	-	-	-
3	5	1	7.8	8.4	4.1	Y	1	1.5	-	-	-	-	-	-

Box	ID	CAT	L	H	Th	Plaster	Wattles	D	Spacing	Plane	Finished Edge	Impression Type	D/W	L
3	6	1	9.2	6.5	3.7	-	1	1	-	-	Parallel	-	-	-
3	7	1	6.5	6.3	4.6	-	1	1.5	-	-	-	-	-	-
3	8	5	8.6	7	3.9	-	-	-	-	-	-	-	-	-
3	9	5	6.3	10.5	4.1	Y	-	-	-	-	-	-	-	-
3	10	1	6	5.4	3.5	-	1	1	-	-	-	-	-	-
3	11	1	3.5	6.5	2.5	-	1	2	-	-	-	-	-	-
3	12	1	6	5	2.9	-	1	1	-	-	-	-	-	-
3	13	1	7.4	5	3.3	-	2	1.6	1	Parallel	-	-	-	-
3	14	1	9.8	6.4	3.3	-	1	1.5	-	-	Perpendicular	-	-	-
3	15	1	5	3.4	3.3	-	1	1.8	-	-	-	-	-	-
3	16	1	5.6	9.5	4	-	1	1.8	-	-	-	-	-	-
3	16	3	5.6	9.5	4	-			-	-	-	Circular	8.2	-
3	17	5	4	5	3.8	-	-	-	-	-	-	-	-	-
3	18	4	8.4	5.9	4.1	-	-	-	-	-	-	Curvilinear	8	-
3	19	1	7.6	6.9	4.2	-	1	1	-	-	-	-	-	-
3	20	2	12.5	9	2.4	-	3	1.3	<1	Woven	-	-	-	-
3	21	1	10.5	14.2	5.9	-	1	1.4	-	-	-	-	-	-
3	22	2	11.8	11.5	3.4	Y	4	1.4	<1	Woven	-	-	-	-
3	23	1	4.5	5.8	3	-	1	0.8	-	-	-	-	-	-
3	24	5	4.6	9.8	4.7	-	-	-	-	-	-	-	-	-
3	25	1	8.9	10.5	4.3	-	1	1.8	-	-	-	-	-	-
3	26	1	6	7.4	5.6	-	1	1.6	-	-	-	-	-	-
3	27	1	5.7	5.3	4.3	-	1	1.3	-	-	-	-	-	-
3	28	1	14.5	15.7	8	Y	1	1.4	-	-	-	-	-	-

Box	ID	CAT	L	H	Th	Plaster	Wattles	D	Spacing	Plane	Finished Edge	Impression Type	D/W	L
3	29	2	10.4	11.5	5.2	Y	6	1.5	<1	Woven	Parallel	-	-	-
3	30	1	8.4	7	2.6	-	1	1.4	-	-	Perpendicular	-	-	-
3	31	1	5.6	9.7	3	-	4	1.4	1	Parallel	Perpendicular	-	-	-
3	32	1	4.8	3.2	2.7	-	1	1.5	-	-	-	-	-	-
3	33	1	6.5	10.1	3.4	-	3	1.8	1	Parallel	Parallel	-	-	-
3	34	1	4.6	6.8	4.5	-	1	1.3	-	-	-	-	-	-
3	35	5	8.4	6.9	4.5	-	-	-	-	-	-	-	-	-
3	36	1	12.8	6.4	3.4	Y	1	1	-	-	Parallel	-	-	-
3	37	6	10.2	9.2	6.7	-	-	-	-	-		-	-	-
3	38	1	5.1	3.9	3.1	-	1	1	-	-	-	-	-	-
3	39	1	10.2	9.5	4.6	Y	1	1.5	-	-	-	-	-	-
3	40	1	10.6	12.5	5.7	-	5	1.3	1	Parallel	-	-	-	-
3	41	2	16	20	5.8	-	7	1.3	<1	Woven	-	-	-	-
3	42	1	5.5	8.4	3.6	-	2	1.4	1	Parallel	Parallel	-	-	-
3	43	1	5.6	6.6	3.8	-	1	1.1	-	-	-	-	-	-
3	44	1	5.5	10.8	3.9	-	4	1.5	<1	Parallel	Perpendicular	-	-	-
3	45	1	11.5	9.5	2.9	Y	3	1.6	1.5	Parallel	Perpendicular	-	-	-
3	46	1	7	9	7	-	2	1	1	-	-	-	-	-
3	47	1	6	10	8	-	1	1	1	-	Parallel	-	-	-
3	47	3	6	10	8	-				-		Circular	6.6	-
3	48	4	10	10	5	-	-	-	-	-	-	Flat	4	10
4	1	2	16	7	4	Y	2	1	<1	Woven	Parallel	-	-	-
4	2	5	4	5	3	-	-	-	-	-	-	-	-	-
4	3	5	8	8	3	-	-	-	-	-	-	-	-	-

Box	ID	CAT	L	H	Th	Plaster	Wattles	D	Spacing	Plane	Finished Edge	Impression Type	D/W	L
4	4	4	9	16	9	-	-	-	-	-	-	Flat	8	13
4	4a	3	9	16	9	-	-	-	-	-	-	Circular	8.5	-
4	5	1	7	11	2	-	4	1.4	1	Parallel	Perpendicular	-	-	-
4	6	5	16	12	5	-	-	-	-	-	-	-	-	-
4	7	3	18	12	7	-	-	-	-	-	-	Circular	8	-
4	8	1	21	11	10	Y	2	2	2	Parallel	-	-	-	-
5	1	5	33	11	22	-	-	-	-	-	-	-	-	-
6	1	1	6	5.9	4	-	2	1.3	1.2	Parallel	Perpendicular	-	-	-
6	1a	3	6	5.9	4	-	-	-	-	-	-	Circular	3.5	-
6	2	1	5	6	5	-	1	1	1.5	-	-	-	-	-
6	3	1	13.8	7	5	-	2	1.2	1	-	-	-	-	-
6	4	5	6.5	5	4.3	-	-	-	-	-	-	-	-	-
6	5	5	16.6	12	10.5	-	-	-	-	-	-	-	-	-
6	6	1	8	12	2	-	4	1.6	1.4	Parallel	Parallel	-	-	-
6	7	2	12	5	2	-	3	1.7	<1	Woven	-	-	-	-
6	8	1	6	9	3	-	5	1.3	1	Parallel	Parallel			-
6	8a	3	6	9	3	-	-	-	-	-	-	Circular	6	-
6	9	1	9	3	7	-	2	1.3	1	Parallel	Perpendicular	-	-	-
6	10	5	10	8	5	-	-	-	-	-	-	-	-	-
6	11	1	10	3	5	-	2	1.5	1	Parallel	-	-	-	-
6	12	3	5	7	4	-	-	-	-	-	-	Circular	6.1	-
6	13	5	6	5	5	Y	-	-	-	-	-	-	-	-
6	14	1	5	7	2	-	1	1.7	-	-	Perpendicular	-	-	-
6	15	6	5	6	2	-	-	-	-	-	-	-	-	-

Box	ID	CAT	L	H	Th	Plaster	Wattles	D	Spacing	Plane	Finished Edge	Impression Type	D/W	L
6	16	1	7	4	5	-	1	1.4	-	-	-	-	-	-
6	17	1	4	4	5	-	1	1.4	-	-	-	-	-	-
7	1	1	5.2	7.8	2.4	Y	3	1.5	1.2	Parallel	Perpendicular	-	-	-
8	1	4	5	12	4.5	-	-	-	-	-	-	Flat	4.5	12
8	2	5	7.5	8.5	4	-	-	-	-	-	-	-	-	
8	3	3	10	4.5	5	-	1	-	-	-	-	Circular	6.3	
8	3a	4	10	4.5	5	-	-	-	-	-	-	Flat	5	8
8	4	1	8	4	4	-	3	1.4	0.8	Parallel	Perpendicular	-	-	
8	5	1	28.5	12.5	6	-	1	1.5	-	-	-	-	-	
8	5a	4	28.5	12.5	6	-	-	-	-	-	-	Flat	12	28
8	6	2	13	10.5	3	-	2	1.7	<1	Woven	-	-		
8	6a	4	13	10.5	3	-	-	-	-	-	-	Flat	10	13
8	7	5	8.5	8	4	-	-	-	-	-	-	-	-	
8	7a	4	8.5	8	4	-	-	-	-	-	-	Flat	8	8.5
8	8	1	8	14.5	5	Y	2	1.3	1	Parallel	-	-	-	-
8	9	5	10	5.5	4	-	-	-	-	-	-	-	-	-
8	10	2	15	9	3	Y	6	1	<1	Woven	Perpendicular	-	-	-
8	11	2	16	10	5.5	Y	4	2	<1	Woven	-	-	-	-
9	1	2	10.1	13.5	3.8	Y	4	1.1	<1	Woven	Paralllel	-	-	-
9	2	1	9.5	15	7	-	2	1.5	1.5	Parallel	-	-	-	-
9	2a	4	9.5	15	7	-	-	-	-	-	-	Flat	5	6
9	2a	4	9.5	15	7	-	-	-	-	-	-	Flat	4	5
9	3	1	12.6	9.4	5.5	-	1	1.4	-	-	-	-	-	-
9	4	1	19.5	17.5	7	-	4	2.2	2	Parallel	-	-	-	-

Box	ID	CAT	L	H	Th	Plaster	Wattles	D	Spacing	Plane	Finished Edge	Impression Type	D/W	L
9	5	1	7.2	10.2	4.9	-	4	1.6	1.4	Parallel	Perpendicular	-	-	-
9	6	1	6.9	6	3.5	-	2	1.4	1	Parallel	-	-	-	-
9	7	3	8	7.8	5.2	-	-	-	-	-	-	Circular	6	-
9	8	5	8	9	4.9	-	-	-	-	-	-	-	-	-
9	9	1	9.3	4	4.3	-	3	1.6	1	Parallel	Paralllel	-	-	-
9	10	5	5.7	4.8	3.8	-	-	-	-	-	-	-	-	-
9	11	2	16.5	23.5	9	Y	4	2	1	Woven	-	-	-	-
9	12	5	5.2	4	3.3	Y	-	-	-	-	-	-	-	-
9	13	5	6.5	6	4.3	Y	-	-	-	-	-	-	-	-
9	14	1	3.4	5.6	1.3	-	1	1.4	-	-	Paralllel	-	-	-
9	15	1	6	5	3.4	-	2	1.6	2	Parallel	Paralllel	-	-	-
9	16	6	5.5	6	4	-	-	-	-	-	-	-	-	-
9	17	1	9	5.1	3.4	-	2	1.8	2	Parallel	-	-	-	-
9	18	1	6	4.3	2.3	-	1	1.6	-	-	-	-	-	-
9	19	5	6	5.9	4	Y	-	-	-	-	-	-	-	-
9	20	1	5.6	4.2	4	-	1	1.3	-	-	-	-	-	-
9	21	1	5.6	6.2	3.8	-	1	1.3		-	Perpendicular	-	-	-
11	1	5	5.5	7	5	-	-	-	-	-	-	-	-	-
11	1a	4	5.5	7	5	-	-	-	-	-	-	Flat	4	7
11	1b	4	5.5	7	5	-	-	-	-	-	-	Flat	6	7
11	2	1	3.5	4	3.5	-	1	1.5	-	-	-	-	-	-
11	3	1	12.5	9	3.5	-	2	1.4	0.7	Parallel	-	-	-	-
11	4	4	18	10	8.5	-	-	-	-	-	-	Flat	6	10
11	5	5	7.5	8	5	-	-	-	-	-	-	-	-	-

Box	ID	CAT	L	H	Th	Plaster	Wattles	D	Spacing	Plane	Finished Edge	Impression Type	D/W	L
11	6	1	5	4	4	-	1	1.5	-	-	-	-	-	-
11	7	2	13	13	4.5	Y	5	1.5	<1	Woven	Parallel	-	-	-
11	8	1	6.5	7.5	4	-	2	1.5	1	Parallel	-	-	-	-
11	9	1	6	4	2.5	-	1	1.5	-	-	-	-	-	-
11	10	6	20	9.5	12.5	-	-		-	-	-	-	-	-
11	11	1	7	5	2.5	-	1	1.5	-	-	-	-	-	-
11	12	3	12.5	13.5	6.5	-	-		-	-	-	Circular	6	
11	13	1	7	7	2.5	Y	2	1.4	1.3	Parallel	-	-	-	-
11	14	5	10	8.5	6.5	-	-	-	-	-	-	-	-	-
11	15	1	5	6	3	-	1	2	-	-	-	-	-	-
11	16	1	5	4.5	3.5	-	1	1.7	-	-	-	-	-	-
11	17	6	6	6.5	4	-	-	-	-	-	-	-	-	-
11	18	5	5.5	6	2.5	-	-	-	-	-	-	-	-	-
11	19	1	6	6	3.5	-	1	1	-	-	Perpendicular	-	-	-
11	20	5	7	5	4	-	-	-	-	-	-	-	-	-
11	21	5	5.5	2.5	3.5	-	-	-	-	-	-	-	-	-
11	22	1	5	9	3.5	-	3	1.8	0.5	Parallel	-	-	-	-
11	23	5	6.5	5	3	-	-	-	-	-	-	-	-	-
11	24	5	5	4	3.5	-	-	-	-	-	-	-	-	-
11	25	3	10.5	7	4.5	-	-	-	-	-	-	Circular	5.8	-
11	26	5	7	6.5	4	-	-	-	-	-	-	-	-	-
11	27	5	7	4.5	4	-	-	-	-	-	-	-	-	-
11	28	6	3.5	3	3	-	-	-	-	-	-	-	-	-
11	29	1	3.5	4	4	-	1	1.5	-	-	-	-	-	-

Box	ID	CAT	L	H	Th	Plaster	Wattles	D	Spacing	Plane	Finished Edge	Impression Type	D/W	L
11	30	6	4.5	3.5	2	-	-	-	-	-	-	-	-	-
12a	1	6	13.5	8	8	-	-	-	-	-	-	-	-	-
12a	2	1	10	15	4.3	Y	6	1.4	1	Parallel	Perpendicular	-	-	-
12a	3	1	10.8	12	3.6	-	3	1.5	1.5	Parallel	Perpendicular	-	-	-
12a	4	1	8.5	5	4.3	-	2	1.8	1.2	Parallel	-	-	-	-
12a	5	6	10.5	8.8	5.3	-	-	-	-	-	-	-	-	-
12a	6	5	15.5	11.8	5.9	-	-	-	-	-	-	-	-	-
12a	7	5	9	5.8	5.7	-	-	-	-	-	-	-	-	-
12a	8	1	7	8.5	3	Y	3	1	<1	Parallel	-	-	-	-
12a	9	1	7.5	6.1	2.6	-	4	1.4	1.2	Parallel	-	-	-	-
12a	10	1	13.2	7	5.8	-	1	2	-	-	-	-	-	-
12a	11	1	11.5	9.1	3.1	-	4	1	<1	Parallel	Perpendicular	-	-	-
12a	12	1	11.5	6.3	3.5	Y	3	1.4	1.2	Parallel	Perpendicular	-	-	-
12a	13	1	15	14	5.3	Y	2	1.8	2	Parallel	-	-	-	-
12a	14	1	8.1	6.7	2.9	Y	5	1.4	1.2	Parallel	-	-	-	-
12a	15	1	7.5	5.5	5	-	2	1.1	2	Parallel	-	-	-	-
12a	16	1	7.3	6.7	2.7	-	4	1.4	1	Parallel	-	-	-	-
12a	17	1	7.9	4.2	4.2	Y	3	1.5	1	Parallel	-	-	-	-
12a	18	5	8.8	7	4.6	-	-	-	-	-	-	-	-	-
12a	19	1	6.5	8.2	2.9	-	4	1.2	<1	Parallel	Perpendicular	-	-	-
12a	20	1	7.5	8.5	3.9	Y	1	1		N	Perpendicular	-	-	-
12a	21	1	5.5	7.6	4.2	-	3	1.3	1	Parallel	Perpendicular	-	-	-
12a	22	5	8.3	10	6.6	-	-	-	-	-	-	-	-	-
12a	23	5	8.2	5.2	3.7	Y	-	-	-	-	-	-	-	-

Box	ID	CAT	L	H	Th	Plaster	Wattles	D	Spacing	Plane	Finished Edge	Impression Type	D/W	L
12a	24	1	4.4	11.2	3.9	-	4	1.7	<1	Parallel	-	-	-	-
12a	25	5	8.6	7.4	4.8	-	-	-	-	-	-	-	-	-
12a	26	5	7.2	7.8	3.8	Y	-	-	-	-	-	-	-	-
12a	27	5	6.6	5.5	4.9	-	-	-	-	-	-	-	-	-
12a	28	1	5.6	5.3	2	-	2	1.9	<1	Parallel	-	-	-	-
12a	27	3	5.6	5.3	2	-	-	-	-	-	-	Circular	3.9	-
12a	29	1	4.5	5	2.3	-	4	1.4	<1	Parallel	Paralllel	-	-	-
12a	30	5	10.4	4.6	4.4	-	-	-	-	-	-	-	-	-
12a	31	3	5.5	5.5	3.1	-	-	-	-	-	-	Circular	3.6	-
12a	32	1	6	11.1	5	Y	1	2.2	-	-	-	-	-	-
12a	33	5	10.5	10.6	5.8	Y	-	-	-	-	-	-	-	-
12a	34	1	6.4	8	2.7	-	3	1.4	1	Parallel	Perpendicular	-	-	-
12a	35	1	6.6	3.4	3.6	-	4	1.4	<1	Parallel	-	-	-	-
12b	1	6	18.5	19	11.5	-	-	-	-	-	-	-	-	-
12b	2	6	14.5	11	7	-	-	-	-	-	-	-	-	-
12b	3	6	15.5	9	6	-	-	-	-	-	-	-	-	-
12b	4	3	15	15	11.5	-	-	-	-	-	-	Circular	7.5	-
12b	5	6	12	10	5	Y	-	-	-	-	-	-	-	-
12b	6	1	13	12	6	-	1	1.5	-	-	-	-	-	-
12b	7	6	11.5	14.5	10	-	-	-	-	-	-	-	-	-
12b	8	6	12.5	13	8.5	-	-	-	-	-	-	-	-	-
12b	9	4	13	12	6	-	-	-	-	-	-	Flat	10	8
12b	10	6	10.5	13.5	8	-	-	-	-	-	-	-	-	-
13	1	5	16	5	6	-	-	-	-	-	-	-	-	-

Box	ID	CAT	L	H	Th	Plaster	Wattles	D	Spacing	Plane	Finished Edge	Impression Type	D/W	L
13	2	6	10	16	10	-	-	-	-	-	-	-	-	-
13	3	1	17	11	6	-	2	1.5	1.5	Parallel	-	-	-	-
13	3a	3	17	11	6	Y	-	-	-	-	-	Circular	8.2	
13	4	5	16	2	10	-	-	-	-	-	-	-	-	-
13	5	1	17	9	8	-	1	1.4		-	-	-	-	-
13	6	6	12	6	13	-	-	-	-	-	-	-	-	-
13	7	4	9	8	7	-	-	-	-	-	-	Flat	8	11
13	7a	4	9	8	7	-	-	-	-	-	-	Flat	9	11
13	7b	4	9	8	7	-	-	-	-	-	-	Curvilinear	11	-
13	8	1	10	8	3	-	1	1.5		-	-	-	-	-
13	9	1	5	9	6	-	2	1.5	4	Parallel	-	-	-	-
13	10	5	9	6	4	-	-	-	-	-	-	-	-	-
13	11	1	8	8	2	-	3	2.2	0.5	Parallel	-	-	-	-
13	12	5	7	4	2	-	-	-	-	-	-	-	-	-
13	13	1	6	5	4	-	1	1	-	-	-	-	-	-
13	14	1	8	9	3	-	3	1.5	1	Parallel	Perpendicular	-	-	-
13	15	1	10	12	4	-	3	2	1	Parallel	Perpendicular	-	-	-
13	16	1	7	8	4	-	1	1.5	-	-	-	-	-	-
13	17	1	8	8	3	-	4	1.5	1	Parallel	Parallel	-	-	-
13	18	1	7	4	2	-	1	1.1	-	-	Parallel	-	-	-
13	19	1	4	6	2	-	1	1.7	-	-	-	-	-	-
13	20	1	6	3	3	-	1	2	-	-	-	-	-	-
13	21	1	3	5	4	-	1	2	-	-	-	-	-	-
13	22	1	4	5	4	-	3	1.5	1	Parallel	Perpendicular	-	-	-

Box	ID	CAT	L	H	Th	Plaster	Wattles	D	Spacing	Plane	Finished Edge	Impression Type	D/W	L
13	23	1	4	5	2	-	1	1.3	-	-	-	-	-	-
13	24	1	4	3	5	-	1	1.3	-	-	-	-	-	-
13	25	5	4	5	2	-	-	-	-	-	-	-	-	-
13	26	5	5	3	1	-	-	-	-	-	-	-	-	-
13	27	1	11	10	5	-	4	0.7	<1	Parallel	Parallel	-	-	-
13	28	5	2	2	2	-	-	-	-	-	-	-	-	-
13	29	5	2	2	3	-	-	-	-	-	-	-	-	-
13	30	5	3	2	2	-	-	-	-	-	-	-	-	-
14	1	1	5	6.5	3.5	-	2	1	<1	Parallel	Perpendicular	-	-	-
14	2	2	9.5	6.5	2.5	-	6	1.5	<1	Woven	-	-	-	-
14	3	1	9.5	6.5	2.3	-	3	1.5	<1	Parallel	Perpendicular	-	-	-
14	4	6	23	14	9	-	-	-	-	-	-	-	-	-
14	5	5	12	10	7	-	-	-	-	-	-	-	-	-
14	6	1	12	7.5	6.5	-	2	2	2	Parallel	-	-	-	-
14	7	3	10	11	6.5	-	-	-	-	-	-	Circular	6.4	-
14	8	1	4.5	3	4.5	-	1	1		-	-	-	-	-
15	1	5	14.5	8.9	3.5	-	-	-	-	-	-	-	-	-
15	2	2	7.4	4.1	4.2	-	2	1.3	<1	Woven	Parallel	-	-	-
15	3	1	12.4	9.8	3.7	Y	3	1.5	1.5	Parallel	-	-	-	-
15	4	1	6.6	4.8	2.4	-	1	1.3		-	-	-	-	-
15	5	5	11.4	10.2	4.9	-	-	-	-	-	-	-	-	-
16	1	1	5.5	8	3.75	-	2	1.5	<1	Parallel	Perpendicular	-	-	-
16	2	2	10	7	4	-	3	1	<1	Woven	Perpendicular	-	-	-
16	3	5	10	7	4.5	-	-	-	-	-	-	-	-	-

Box	ID	CAT	L	H	Th	Plaster	Wattles	D	Spacing	Plane	Finished Edge	Impression Type	D/W	L
16	4	4	12	3	7.5	-	-	-	-	-	-	Curvilinear	7	
16	4a	4	12	3	7.5	-	-	-	-	-	-	Flat	3	7
16	4b	4	12	3	7.5	-	-	-	-	-	-	Flat	5	7
16	5	5	10	8	4.5	-	-	-	-	-	-	-	-	-
16	6	1	13	9.5	6.5	-	1	1.5	-	-	-	-	-	-
16	6a	3	13	9.5	6.5	-	-	-	-	-	-	Circular	8.2	
16	7	5	8.5	7.5	4	-	-	-	-	-	-	-	-	-
16	8	5	12	8.5	6	-	-	-	-	-	-	-	-	-
17	1	1	10	9	4	-	3	1.6	1.2	Parallel	Perpendicular	-	-	-
17	2	3	10	8	5	-	-	-	-	-	-	Circular	5.2	-
17	3	4	11	5	8	-	-	-	-	-	-	Curvilinerar	10	-
17	4	1	8	7	3	-	1	1.3	-	Parallel	-	-	-	-
17	5	4	9	7	5	-	-	-	-	-	-	Flat	5	7
17	5a	4	9	7	5	-	-	-	-	-	-	Flat	5	5
17	5b	4	9	7	5	-	-	-	-	-	-	Flat	10	10
17	6	1	6	8	4	Y	2	1.5	1	Parallel	Perpendicular	-	-	-
17	7	1	7	11	4	-	1	1	-	-	Perpendicular	-	-	-
17	8	1	12	10	3	-	3	1.7	1.5	Parallel	Perpendicular	-	-	-
17	9	1	6	11	3	Y	3	1.2	1	Parallel	Perpendicular	-	-	-
17	10	1	6	10	3	-	1	1.5	-	-	Perpendicular	-	-	-
17	11	1	8	4	6	-	1	1.6	-	-	-	-	-	-
17	12	1	8	8	2	-	1	1.4	-	-	-	-	-	-
17	13	5	13	2	9	-	-	-	-	-	-	-	-	-
17	14	5	8	7	3	Y	-	-	-	-	-	-	-	-

Box	ID	CAT	L	H	Th	Plaster	Wattles	D	Spacing	Plane	Finished Edge	Impression Type	D/W	L
17	15	2	7	7	3	-	3	1.4	<1	Woven	Perpendicular	-	-	-
17	16	5	8	7	3	-	-	-	-	-	-	-	-	-
17	17	3	9	7	3	-	-	-	-	-	-	Circular	7	
17	18	1	6	8	4	-	1	1.7	-	-	-	-	-	-
17	19	5	7	6	4	-	-	-	-	-	-	-	-	-
17	20	5	5	2	5	-	-	-	-	-	-	-	-	-
17	21	5	4	5	2	-	-	-	-	-	-	-	-	-
17	22	5	5	2	2	-	-	-	-	-	-	-	-	-
17	23	5	8	6	2	-	-	-	-	-	-	-	-	-
17	24	3	3	9	6	-	-	-	-	-	-	Circular	3.5	-
18	1	6	14	16	10	Y	-	-	-	-	-	-	-	-
18	2	6	9.5	12	6	-	-	-	-	-	-	-	-	-
18	3	1	11	15	8	Y	2	1.5	2	Parallel	-	-	-	-
18	3a	3	11	15	8	Y	-	-	-	-	-	Circular	11	-
18	4	5	7	7..5	5	-	-	-	-	-	-	-	-	-
18	5	6	26	21	12	-	-	-	-	-	-	-	-	-
18	6	1	3.5	4	3.5	-	1	1	-	-	-	-	-	-
18	7	5	4	5	2.5	-	-		-	-	-	-	-	-
18	8	1	5.5	9	3.5	-	1	1.5	-	-	-	-	-	-
18	9	1	11	6	4	Y	1	1	-	-	-	-	-	-
18	10	1	7	10.5	6	-	2	1.7	1.3	Parallel	-	-	-	-
18	10a	1	-	-	-	-	3	1.3	1	Parallel	-	-	-	-
18	11	5	6	7.5	4	-	-	-	-	-	-	-	-	-
18	12	5	8	11	7	-	-	-	-	-	-	-	-	-

Box	ID	CAT	L	H	Th	Plaster	Wattles	D	Spacing	Plane	Finished Edge	Impression Type	D/W	L
18	13	5	2.5	3.5	2.5	-	-	-	-	-	-	-	-	-
18	14	1	3.5	5	2	-	1	1	-	-	-	-	-	-
18	15	1	5	9	6	-	1	1.5	-	-	-	-	-	-
18	16	5	5	5.5	3.5	-	-	-	-	-	-	-	-	-
19	1	1	17.2	12.8	8.2	Y	1	1.6	-	-	-	-	-	-
19	2	1	12	8	9	Y	1	1.5	-	-	-	-	-	-
19	3	5	9	8	4.5	Y	-	-	-	-	-	-	-	-
19	4	3	7	6	3	-	-	-	-	-	-	Circular	6	
19	5	1	9	11	3	Y	2	1.5	5.5	Parallel	-	-	-	-
19	6	1	11	11	7.7	Y	4	1	1.5	Parallel	-	-	-	-
19	7	1	7	11	5.5	Y	1	1.7	-	-	-	-	-	-
19	8	1	9	4	4	Y	1	1	-	-	-	-	-	-
19	9	1	10	12	11	Y	1	1.7	-	-	-	-	-	-
19	10	1	19	12	6	Y	1	1.5	-	-	-	-	-	-
20	1	5	17.8	11	8.5	Y	-	-	-	-	-	-	-	-
20	2	4	20.5	8	7	-	-	-	-	-	-	Flat	5.5	17
20	2a	4	20.5	8	7	-	-	-	-	-	-	Flat	8	20
20	3	5	14.5	13	3.5	-	-	-	-	-	-	-	-	-
20	4	5	6.5	5.5	3.5	-	-	-	-	-	-	-	-	-
20	5	5	9.5	11.5	3.5	-	-	-	-	-	-	-	-	-
20	6	5	11	8.5	9	-	-	-	-	-	-	-	-	-
20	7	5	19.5	14.5	7	-	-	-	-	-	-	-	-	-
20	8	5	15	11	8	-	-	-	-	-	-	-	-	-
20	9	5	15	13	7	-	-	-	-	-	-	-	-	-

Box	ID	CAT	L	H	Th	Plaster	Wattles	D	Spacing	Plane	Finished Edge	Impression Type	D/W	L
21	1	5	14	15	10	Y	-	-	-	-	-	-	-	-
21	2	1	6	7	5	-	2	1.4	1	Parallel	Parallel	-	-	-
21	3	5	11	6	3	Y	-	-	-	-	-	-	-	-
21	4	1	11.5	8	5	Y	3	1	1	Parallel	Parallel	-	-	-
21	5	1	9.5	10	4	-	2	2	<1	Parallel	-	-	-	-
21	6	1	8	7.5	2.5	Y	2	1.3	<1	Parallel	Perpendicular	-	-	-
21	7	1	10	5.5	4	-	2	1.5	<1	Parallel	-	-	-	-
21	8	5	6	4	3	-	-	-	-	-	-	-	-	-
21	9	6	21.5	14.5	9.5	-	-	-	-	-	-	-	-	-
21	10	4	24	11.5	15.5	-	-	-	-	-	-	Flat	10.5	20
22	1	1	16	13.5	13.5	-	2	1.5	5	-	-	-	-	-
22	1b	3	16	13.5	13.5		-	-	-	-	-	Circular	12.5	-
22	2	6	17.5	13.5	6.5	Y	-	-	-	-	-	-	-	-
22	3	4	11.5	9.5	7.5	-	-	-	-	-	-	Circular	8.2	10
22	4	1	13	13.5	5.5	-	2	3	1	Parallel	-	-	-	-
22	5	4	10.5	6	6.4	-	-	-	-	-	-	Curvilinear	6	-
22	6	5	4	7	5	-	-	-	-	-	-	-	-	-
22	7	6	17.5	20.5	11.5	Y	-	-	-	-	-	-	-	-
22	8	6	7	11	8	-	-	-	-	-	-	-	-	-
22	9	1	6	5.5	2	-	1	2	-	-	-	-	-	-
22	10	1	4	4.5	3	-	1	2.5	-	-	-	-	-	-
22	11	1	10	13.5	7.5	Y	1	2.5	-	-	-	-	-	-
22	12	5	7	7	4.5	-	-	-	-	-	-	-	-	-
22	13	1	10.5	8(3.8)	8.2 (2)	-	1	2	-	-	-	-	-	-

Box	ID	CAT	L	H	Th	Plaster	Wattles	D	Spacing	Plane	Finished Edge	Impression Type	D/W	L
22	14	3	10	8.5	5	-	-	-	-	-	-	Circular	9	-
22	15	1	8	5	4.5	-	2	1.5	-	-	-	-	-	-
22	16	5	7.5	9.5	5	Y	-	-	-	-	-	-	-	-
22	17	5	10	8.5	4.5	-	-	-	-	-	-	-	-	-
22	18	5	6	10.5	6.5	-	-	-	-	-	-	-	-	-
22	19	1	9	5	2.5	-	1	2.5		-	-	-	-	-
22	20	5	4	5.5	4	-	-	-	-	-	-	-	-	-
22	21	1	11	5.5	6	-	2	2	<1	Parallel	-	-	-	-
22	22	5	8	9	4.5	-	-	-	-	-	-	-	-	-
22	23	1	7	5	3.5	-	1	1.5	-	-	-	-	-	-
22	24	1	4	5	2	-	1	2.5	-	-	-	-	-	-
22	25	5	5	4	1	-	-	-	-	-	-	-	-	-
23	1	1	10	10.5	4	-	2	1.5	1.5	Parallel	-	-	-	-
23	2	1	15.5	7	4	-	2	1.5	<1	Parallel	-	-	-	-
23	3	5	9	6	4	-	-	-	-	-	-	-	-	-
23	4	5	21	16.5	4	-	-	-	-	-	-	-	-	-
23	5	5	12	11.5	6.5	-	-	-	-	-	-	-	-	-
23	6	6	13	12	6	-	-	-	-	-	-	-	-	-
23	7	5	8.5	8.5	6	Y	-	-	-	-	-	-	-	-
23	8	1	10.5	8.5	6	-	1	1.5	-	-	-	-	-	-
23	9	5	12	8	5	-	-	-	-	-	-	-	-	-
23	10	5	8.5	8	7	-	-	-	-	-	-	-	-	-
24	1	6	18	15	7.5	-	-	-	-	-	-	-	-	-
24	2	6	13	9	11.5	-	217	-	-	-	-	-	-	-

Box	ID	CAT	L	H	Th	Plaster	Wattles	D	Spacing	Plane	Finished Edge	Impression Type	D/W	L
24	3	5	10	6.5	6	-	-	-	-	-	-	-	-	-
24	4	5	14	11.5	11.5	-	-	-	-	-	-	-	-	-
24	5	1	15	17.5	7	Y	Y	2.2	3	Parallel	-	-	-	-
24	5a	3	15	17.5	7	Y	-	-	-	-	-	Circular	11	-
24	6	6	14.5	11	6	-	-	-	-	-	-	-	-	-
24	7	5	19	13	10.5	-	-	-	-	-	-	-	-	-
24	8	5	13	11	12	-	-	-	-	-	-	-	-	-

Appendix E:

Daub and mudbrick fragments from T-25

Box	ID	CAT	L	H	Th	Plaster	Wattles	D	Spacing	Plane	Finished Edge	Impression Type	D/W	L
1	1	1	16.2	12.5	5.9	-	3	2	2.5	Parallel	-	-	-	-
1	2	1	15.9	10.5	5.1	-	3	1.5	1.5	Parallel	-	-	-	-
1	3	5	5.1	5.2	4.2	-	-	-	-	-	-	-	-	-
1	4	1	8.2	9.9	4.1	-	3	2	1.5	Parallel	-	-	-	-
1	5	5	11.7	9.2	3.9	-	-	-	-	-	-	-	-	-
1	6	5	6.7	7.9	4.2	-	-	-	-	-	-	-	-	-
1	7	5	10.2	7.6	4.3	-	-	-	-	-	-	-	-	-
1	8	5	8.9	6.9	4.6	-	-	-	-	-	-	-	-	-
1	9	5	8.7	7.9	4.7	-	-	-	-	-	-	-	-	-
1	10	1	9.7	9.5	4.5	-	3	1.1	<1	Parallel	-	-	-	-
1	11	5	6.7	7.2	5.9	-	-	-	-	-	-	-	-	-
1	12	1	8.9	6	4.2	-	1	1.4	-	-	-	-	-	-
1	13	3	6.5	7.5	5.3	-	-	-	-	-	-	Circular	5.1	
1	14	5	8.5	6.5	4	-	-	-	-	-	-	-	-	-
1	15	5	5.1	7.5	2.9	Y	-	-	-	-	-	-	-	-
1	16	1	5.8	4.9	3.9	-	1	1.9	-	-	-	-	-	-
1	17	1	8	5.9	3.6	-	1	1	-	-	-	-	-	-
1	18	2	6	10.2	3	Y	5	1.5	<1	Woven	-	-	-	-
1	19	5	7.5	5.1	3.5	-	-	-	-	-	-	-	-	-
1	20	5	7.5	6.5	3.2	-	-	-	-	-	-	-	-	-
1	21	5	7.9	4.6	3.1	-	-	-	-	-	-	-	-	-
1	22	5	4	5.2	3	-	-	-	-	-	-	-	-	-
1	23	5	5.8	4.5	4.3	-	-	-	-	-	-	-	-	-

Box	ID	CAT	L	H	Th	Plaster	Wattles	D	Spacing	Plane	Finished Edge	Impression Type	D/W	L
1	24	1	7.1	6.2	5	-	2	1.6	1	Parallel	-	-	-	-
1	25	5	6.9	5.7	3	-	-		-	-	-	-	-	-
1	26	1	5.3	3.9	4	-	1	1.4	-	-	-	-	-	-
1	27	5	5.6	3.5	4.9	-	-	-	-	-	-	-	-	-
2	1	3	12.4	9.5	3.9	N	N	-	-	-	-	Circular	5.2	-
2	2	5	9.5	5.6	3.9	-	-	-	-	-	-	-	-	-
2	3	1	12.5	10.2	4.2	-	1	1.4	-	-	-	-	-	-
2	4	1	8.7	5.6	2.9	-	1	1.3	-	-	-	-	-	-
2	5	6	9.4	8.2	5.4	-	-	-	-	-	-	-	-	-
2	6	1	6.9	10	4.3	Y	3	1.8	<1	Parallel	-	-	-	-
2	7	5	8.3	8.2	4.1	-	-	-	-	-	-	-	-	-
2	8	5	11.2	6.9	3.6	-	-	-	-	-	-	-	-	-
2	9	5	5	9.8	7.4	-	-	-	-	-	-	-	-	-
2	10	1	10.1	12.4	5	-	2	2	1	Parallel	-	-	-	-
2	11	1	9	9.1	5.5	-	1	1.9	-	-	-	-	-	-
2	12	6	6.9	5.6	3.5	-	-		-	-	-	-	-	-
2	3	1	9.9	4.7	5	-	1	1.9	2	Parallel	Parallel			
2	4	4	14.5	10.7	6	Y	-	-	-	-	-	Curvilinear	5	
2	14	4	-	-	-	-	-	-	-	-	-	Flat	1.5	10
2	14	4	-	-	-	-	-	-	-	-	-	Flat	1	7
2	5	1	5.7	7	3.8	-	1	1.6	-	-	-	-	-	-
2	6	5	12.4	7.2	3.9	Y	-	-	-	-	-	-	-	-
2	7	1	7.5	8.2	3.9	-	1	1.7	-	-	-	-	-	-
2	8	1	5.5	7	3.5	-	1	1.4	-	-	-	-	-	-

Box	ID	CAT	L	H	Th	Plaster	Wattles	D	Spacing	Plane	Finished Edge	Impression Type	D/W	L
2	9	1	7.3	11.2	4.6	Y	1	1.7	-	-	-	-	-	-
2	10	1	4.2	4.5	2.4	-	1	1.8	-	-	-	-	-	-
2	11	1	11	6.2	6.3	-	2	2.8	1	Parallel	-	-	-	-
2	12	5	6.2	6.9	4.3	-	-	-	-	-	-	-	-	-
2	13	5	11.1	16.9	3.1	-	-	-	-	-	-	-	-	-
2	14	1	8.2	5.2	4.8	-	1	1	-	-	-	-	-	-
2	15	5	8.4	6.6	3.5	-	-	-	-	-	-	-	-	-
2	16	1	7	7.2	3.5	-	1	1.3	-	-	-	-	-	-
2	17	5	9.8	6.7	3.1	-	-	-	-	-	-	-	-	-
2	18	5	8.2	6.2	3	Y	-	-	-	-	-	-	-	-
2	19	1	7.7	7.7	4.2	Y	1	2	-	-	-	-	-	-
2	20	5	7.2	5.5	5	-	-	-	-	-	-	-	-	-
2	21	5	9.8	6.5	3.3	-	-	-	-	-	-	-	-	-
2	22	1	7.8	5.5	4.2	-	1	1	-	-	-	-	-	-
2	33	1	7.8	6.5	4	-	1	1.6	-	-	-	-	-	-

Appendix F:

Daub and mudbrick fragments from T-18 and T-19

Box	ID	CAT	L	H	Th	Plaster	Wattles	D	Spacing	Plane	Finished Edge	Impression Type	D/W	L
1	1	1	15	9.8	7	Y	2	1.5	<1	Parallel	-	-	-	-
1	2	5	1.5	8.5	6.5	Y	-	-	-	-	-	-	-	-
1	3	2	16	12.5	5	Y	2	1.8	1.5	Woven	-	-	-	-
1	4	5	9.5	7	5	Y	-	-	-	-	-	-	-	-
1	5	5	8	9	4	Y	-	-	-	-	-	-	-	-
1	6	5	8.5	8	3	Y	-	-	-	-	-	-	-	-
1	7	5	13	6.5	4	Y	-	-	-	-	-	-	-	-
1	8	5	1	6	2.5	Y	-	-	-	-	-	-	-	-
1	9	5	12	5	6.5	Y	-	-	-	-	-	-	-	-
1	10	5	9.5	8	1.5	Y	-	-	-	-	-	-	-	-
1	11	5	6.5	4	4.5	Y	-	-	-	-	-	-	-	-
1	12	1	5.5	6	4.5	Y	1	1.5	-	-	-	-	-	-
1	13	5	10	5	6	N	-	-	-	-	-	-	-	-
1	14	1	8.5	3	7	Y	1	1.5	-	-	-	-	-	-
2	1	6	22	30	7	N	-	-	-	-	-	-	-	-
2	2	6	5.5	6	4	N	-	-	-	-	-	-	-	-
2	3	6	4.5	5	2.5	N	-	-	-	-	-	-	-	-
2	4	6	4.5	9	6	N	-	-	-	-	-	-	-	-
2	5	1	7	7	3	N	1	2	-		-	-	-	-
2	6	6	5	9	2.5	N	-	-	-	-	-	-	-	-
2	7	6	4.5	5	4	N	-	-	-	-	-	-	-	-
2	8	1	6.5	8	4.5	N	1	1	-	-	-	-	-	-
2	9	3	8	11	2	N	-	-	-	-	-	Circular	5	-
2	10	6	6	9	4.5	N	-	-	-	-	-	-	-	-
2	11	1	7.5	8	3.5	Y	3	1.5	2	-	-	-	-	-

Box	ID	CAT	L	H	Th	Plaster	Wattles	D	Spacing	Plane	Finished Edge	Impression Type	D/W	L
2	12	5	4	4.5	2	N	-	-	-	-	-	-	-	-
2	13	5	5	6	4	N	-	-	-	-	-	-	-	-
2	14	1	6	5.5	1.5	N	3	1.5	2	-	-	-	-	-
2	15	6	6.5	10	2.5	-	-	-	-	-	-	-	-	-
3	1	5	6.5	9	3.5	Y	-	-	-	-	-	-	-	-
3	2	1	3	3.5	2.5	N	1	1.5	-	-	-	-	-	-
3	3	1	6.5	4.5	2	N	3	1	1	Parallel	-	-	-	-
3	4	1	8.5	6.5	4.5	N	1	1.5	-	-	-	-	-	-
3	5	5	6.5	3.5	1.5	N	-	-	-	-	-	-	-	-
3	6	1	6	5.5	2.5	N	1	1.5	-	-	-	-	-	-
3	7	1	2.5	2.5	2.5	Y	1	1.5	-	-	-	-	-	-
3	8	5	3.5	2.5	2.5	N	-	-	-	-	-	-	-	-
3	9	1	3	3	2	N	1	1	-	-	-	-	-	-
4	1	5	6	4.5	2.5	Y	-	-	-	-	-	-	-	-
4	2	3	5.5	3	3	N	-	-	-	-	-	Circular	4	-
4	3	5	6	2.5	3	N	-	-	-	-	-			-
4	4	3	6	2.5	4	N	-	-	-	-	-	Circular	4	-
4	5	5	7	6	3.5	N	-	-	-	-	-	-	-	-
4	6	1	6.5	5	4	Y	1	1.5	-	-	-	-	-	-
4	7	1	5.5	4	3	N	1	1.5	-	-	-	-	-	-
4	8	1	6	4	1.5	N	3	1	1	Parallel	-	-	-	-
4	9	5	4	2.5	2	N	-	-	-	-	-	-	-	-
5	1	1	4	4.5	4.5	N	1	3	-	-	-	-	-	-
5	2	5	9	5	3.5	N	-	-	-	-	-	-	-	-
5	3	1	6.5	5	4	N	3	1.5	1	Parallel	-	-	-	-
5	4	5	6	5	5	N	-	-	-	-	-	-	-	-

Appendix G:

Daub and mudbrick fragments from R-5 and R-13

Box	ID	CAT	L	H	Th	Plaster	Wattles	D	Spacing	Plane	Finished Edge	Impression Type	D/W	L
1	1	1	7.5	8.5	5.5	Y	2	1.5	2.5	Parallel	-	-	-	-
1	2	5	11.5	16	2.5	Y	-	-	-	-	-	-	-	-
1	3	1	8.5	10.5	4.5	-	1	1.5	-	-	-	-	-	-
1	4	1	8.5	9.5	4	Y	2	1	1	Parallel	-	-	-	-
1	5	1	7	8.5	3.5	Y	3	1.5	1	Parallel	-	-	-	-
1	6	1	4	6	4	Y	2	1	<1	Parallel	-	-	-	-
1	7	5	10	11	4.5	Y	-	-	-	-	-	-	-	-
1	8	5	6.5	6.5	4	Y	-	-	-	-	-	-	-	-
1	9	1	7.5	12.5	5	Y	2	2	<1	Parallel	-	-	-	-
1	10	5	7.5	9.5	3	Y	-	-	-	-	-	-	-	-
1	11	5	7	7.5	4.5	Y	-	-	-	-	-	-	-	-
1	12	1	7.5	10	4	Y	3	2	<1	Parallel	-	-	-	-
1	13	1	5.5	8.5	4	Y	1	2	-	-	-	-	-	-
1	14	1	6	8	4	Y	1	1	-	-	-	-	-	-
1	15	1	8	10.5	5.5	Y	1	1.2	-	-	-	-	-	-
1	16	5	5.5	9	3	Y	-	-	-	-	-	-	-	-
1	17	5	7	9.5	4	Y	-	-	-	-	-	-	-	-
1	18	5	3.5	6	3	Y	-	-	-	-	-	-	-	-
1	19	5	7	10.5	4	Y	-	-	-	-	-	-	-	-
1	20	5	6	7	6	Y	-	-	-	-	-	-	-	-
1	21	1	9	17.5	8	Y	2	2.5	<1	Parallel	-	-	-	-
1	22	6	7	13	6	Y	-	-	-	-	-	-	-	-
1	23	6	10	13.5	5	Y	-	-	-	-	-	-	-	-
1	24	5	5	6.5	5	-	-	-	-	-	-	-	-	-
1	25	6	7	11	6	Y	-	-	-	-	-	-	-	-
1	26	5	7	8	6	-	-	-	-	-	-	-	-	-
1	27	3	8	29	5	Y	-	-	-	-	-	Circular	5	
1	28	6	17	21	9	Y	-	-	-	-	-	-	-	-
2	1	6	23.5	20.1	10	-	-	-	-	-	-	-	-	-

Box	ID	CAT	L	H	Th	Plaster	Wattles	D	Spacing	Plane	Finished Edge	Impression Type	D/W	L
3	1	1	8.5	12	5	-	6	1.5	<1	Parallel	-	-	-	-
3	2	1	10.5	14	4.5	-	4	1.5	<1	Parallel	-	-	-	-
3	3	2	15.5	18	9.5	Y	7	2	<1	Woven	Perpendicular	-	-	-
3	4	1	9.5	13.5	6.5	-	1	1.5	-	-	-	-	-	-
		4	9.5	13.5	6.5	-	-	-	-	-	-	Flat	4	12
3	5	2	17	25	7.5	Y	13	2.5	1	Woven	Perpendicular			
3	6	1	9.5	14	8.5	Y	1	1.5	-	Parallel	-	-	-	-
3	7	1	14	23	4	Y	10	1.2	1	Parallel	-	-	-	-
4	1	2	15	14	4	Y	3	1	<1	Woven	-	-	-	-
4	2	1	6	4	3.5	Y	1	0.7	-		-	-	-	-
4	3	1	4	4.5	3	-	3	1	<1	Parallel	-	-	-	-
4	4	1	10	8	4.5	Y	4	1.1	<1	Parallel	-	-	-	-
4	5	1	8	10.5	7	Y	3	1.4	1	Parallel	-	-	-	-
4	6	1	19.5	15	5.5	-	5	1.2	<1	Parallel	-	-	-	-
4	7	1	13.5	10.5	4	Y	3	0.9	<1	Parallel	-	-	-	-
4	8	5	10	9.5	5	Y	-	-	-	-	-	-	-	-
4	9	1	8	6.5	4	-	1	1.5	-	-	-	-	-	-
4	10	1	14.5	22	5.5	Y	5	2	1	Parallel	Perpendicular	-	-	-
4	11	1	22	11	6	Y	1	1	-	-	-	-	-	-
4	12	1	6	5.5	3	Y	1	0.7	-	-	-	-	-	-
R13-1	1	6	8.5	6	5.2	N	-	-	-	-	-	-	-	-
R13-2	2	6	24.9	11.5	7	N	-	-	-	-	-	-	-	-
R13-3	3	6	19.2	9.3	7	N	-	-	-	-	-	-	-	-

BIBLIOGRAPHY

Abruzzese, D. and G. Cinque, G. Lo Gatto. 2005. "Analysis of Roman masonry flat-slab in Hadrian's Villa, Tivoli," in *Proc. Int. Conf. Structural analysis of historical constructions 2004, Padua,* C. Modena, P. Lourenço and P. Roca (eds.), London: 183-90.

Acanfora, M. 1952. "Avanzi di abitato capannicolo a Francavilla Fontana." *Riv. Sc. Preist.* 7: 212-34.

Achilli, A. and A. Oliveiri, M. Pala. 2007. "Mitochondrial DNA variation of modern Tuscans supports the Near Eastern origin of Etruscans." *Am. J. Hum. Genet.* 80: 759-68.

Acquafredda, P. and A. Cinquepalmi, R. Laviano, I. Muntoni. 2006a. "Analisi comparativa di ceramiche e piastre dell'età del Bronzo provenienti da Monopoli - Piazza Palmieri (BA) e da Masseria Chiancudda (Cisternino – BR)," in *La ceramica in Italia quando l'Italia non c'era", Atti della 8th Giornata di Archeometria della Ceramica (Vietri sul Mare - SA, 27-28 aprile 2004),* Edipugli: 23-34.

2006b. "Indagine archeometrica su ceramiche e intonaci di capanna dell'età del Bronzo recente da Torre Santa Sabina (Carovigno – BR)," in *Innovazioni tecnologiche per i beni culturali in Italia, Atti del Convegno A.I.Ar. (Reggia di Caserta – CE, 16-18 febbraio 2005),* Bologna: 155-172.

Aitchison, J, and C. Barcelo-Vidal, V. Pawlowsky-Glahn. 2002. "Some comments on compositional data analysis in archaeometry, in particular the fallacies in Tangri and Wright's dismissal of log-ratio analysis." *Archaeometry* 44(2): 295-304.

Albenda, P. 2005. "The 'Queen of the Night' Plaque: A Revisit." *Journal of the American Oriental Society* 125 (2): 171-190.

Albore Livadie, C. 2002. "A First Pompeii: the Early Bronze Age village of Nola–Croce del Papa." *Antiquity* 294: 941-2.

Albright, W. 1965. "The Role of the Canaanites in the History of Civilization," in *The Bible and the Ancient Near East,* G. Wright (ed.), Garden City: 438-487.

Ambrose, J. and D. Vergun. 1987. *Design for Lateral Forces*. New York.

American Forest and Paper Association. 1986. *Wood Structural Design Data*. Washington D.C.

American Institute of Timber Construction. 1994. *Timber Construction Manual*. New York.

American Society of Civil Engineers. 2010. *Minimum design loads for buildings and other structures (ASCE/SEI 7-10)*. Reston, VA.

Ammerman, A. 1990. "On the Origins of the Forum Romanum." *AJA* 94(4): 627-45.

Ammerman, A., and G. Shaffer, N. Hartman. 1988. "A Neolithic Household at Piana di Curinga, Italy." *JFA* 15(2): 121-40.

Arcelin, P. and O. Buchsenschutz. 1985. "Les données de la Protohistoire," in *Architectures de terre et de bois: L'habitat privé des provinces occidentales du monde romain*, J. Lasfargues (ed.), Lyon: 15-28.

Armstrong, E. A. 1958. *The folklore of birds*. London.

Arribas Palau, A. and E. Pareja Lopez, F. Molina Gonzalez, O. Arteaga Matute, F. Molina Fajardo. 1974. *Excavaciones en el poblado de la Edad del Bronce Cerro de la Encina Monachil (Granada). El corte estratigráfico nº 3´*. Madrid.

Arthur, W. B. 2007. "The structure of Invention." *Research Policy* 36: 274–287.

Aubet, M. E. 1993. *The Phoenicians and the West*. Cambridge.

2006. "On the Organization of the Phoenician Colonial System in Iberia," in *Debating Orientalization: Multidisciplinary Approaches to Change in the Ancient Mediterranean*, C. Riva and N. Vella (eds.), Cambridge: 94-109.

Bagolini, B. 1992. "Il Neolitico nell'Italia settentrionale," in *Italia preistorica*, A. Guidi and M. Piperno (eds.), Rome: 274-305.

Baldacci, O.1958. "L'ambiente geografico della casa in terra cruda in Italia." *Rivista Geografica Italiana Firenze* 65: 13-43.

Balfet, H., and N. Lafuma, P. Longuet, P. Terrier. 1969. "Une invention néolithique sans lendemain." *BPSF* 66: 188-192

Bammer, A. 2004. "Zu den Schichten und Bauabfolgen im Artemision von Ephesos," in *Anadoluda Dogdu Festschrift fur F. Isık*, T. Korkut (ed.), Istanbul: 69–88.

Bandelt, H. 2004. "Etruscan artifacts." *Am. J. Hum. Genet.* 75: 919–920.

Bankoff, H. and F. Winter. 1979. "A House-Burning in Serbia." *Archaeology* 32 (5): 8-14.

Barbujani, G. and C. Vernesi, D. Caramelli, L. Castrì, C. Lalueza-Fox, G. Bertorelle. 2004. "Etruscan artifacts: Much ado about nothing." *Am. J. Hum. Genet.* 75: 923-927.

Barbujani, G. 2007. "DNA and Etruscan Origins. G. Barbujani's Response to J. Turfa." *Etruscan News* 8: 4.

Barfield, L. 1966. *Excavations on the Rocca di Rivoli (Verona).* Museo Civico di Storia Naturale di Verona.

Barker, G. 1995. *A Mediterranean Valley. Landscape Archeology and Annales History in the Biferno Valley*. Leicester.

Bartlett Wells, H. 1974. "The position of the large bronze saws of Minoan Crete in the history of tool making." *Expedition* 16 (4): 2-8.

Bartoloni, G. 1987. *Le Urne a capanna rinvenute in Italia*. Rome.

2009. "The earliest Etruscan toast. Considerations on the earliest phases of Populonia," in *Votives, Places and Rituals in Etruscan Religion,* M.Gleba, and H. Becker (eds.), Leiden: 159-70.

2010. "The King's hut and the deposit of cups." *Etruscan News* 12: 14.

Basalla, G. 1988. *The Evolution of Technology*. Cambridge.

Baxter, M. and I. Freestone.2006. "Log-ratio compositional data analysis in archaeometry." *Archaeometry* 48(3): 511–531.

Berkin, J. 2003. *The Orientalizing Bucchero from the Lower Building at Poggio Civitate (Murlo).* Boston.

Bernabo Brea, M. 1984, "L'insediamento neolitico di Tirlecchia (Matera)." *Riv. Sc. Preist.* 39: 23-84.

Bieber, A., and D. Brooks, G. Harbottle, and E. V. Sayre. 1976. "Application of Multivariate Techniques to Analytical Data on Aegean Ceramics." *Archaeometry* 18:59-74.

Bietti Sestieri, A.M., and J. De Grossi Mazzorin, A. De Santis. 1990. "Fidene: la struttura dell'Età del Ferro." *Quaderni di Archeologia Etrusco-Italica* 19: 115–120.

Bietti Sestieri, A.M. 1992. *The Iron Age community of Osteria dell'Osa. A study of socio-political development in central Tyrrhenian Italy*. Cambridge.

Bietti Sestieri, A.M. and A. De Santis. 2001. "L'edificio della I età del Ferro di Fidene (Roma): posizione nell'abitato, tecnica costruttiva, funzionalità in base alla distribuzione spaziale dei materiali e degli arredi," in *From huts to houses. Transformations of ancient societies. Proceedings of an international seminar organized by the Norwegian and Swedish Institutes in Rome, 21 - 24 September 1997,* J. R. Brandt and L. Karlsson (eds.), Stockholm: 594-604.

Binford, L. 1981. "Behavioral archaeology and the Pompeii premise." *Journal of Anthropological Research* 37: 195-208.

1987. "Data, Relativism and Archaeological Science." *Man* 22: 391-404.

Bintliff, J. 1991. "The contribution of an Annaliste/structural approach to archaeology," in *The Annales School and Archaeology*, J. Bintliff (ed.), Leicester: 1-33.

Bittarello, M. 2009. "The construction of Etruscan 'Otherness' in Latin Literature." *Greece & Rome* 56(2): 211-233.

Blackman, D. 2008. "Sea Transport: Harbors," in *The Oxford Handbook of Engineering and Technology in the Classical World,* J. Oleson (ed.), Oxford: 638-72.

Blake, M. 1959. *Roman construction in Italy from Tiberius through the Flavians*. Washington, D.C.

Bloch, M. 1967 (1935). "The Advent and Triumph of the Water Mill," in *Land and Work in Medieval Europe. Selected Papers* (trans. J.E. Anderson), New York: 136-68.

Bloch, R. 1963 "Première campagne de fouilles franco-italiennes à Casalecchio di Reno," in *Preistoria dell'Emilia e Romagna 2*, Bologna: 69-74.

Blome, B. 1986. "Tecnica di costruzione," in *Architettura etrusca nel Viterbese. Catalogo della mostra. Rome,* Ö. Wikander and P. Roos (eds.), Rome: 56-58.

Boardman, J. 2001. "Aspects of 'Colonization'." *BASOR* 322: 33-42.

Boethius, A. 1978. *Etruscan and Early Roman Architecture*. Harmondsworth.

Bonamici, M. 1974. *I buccheri con figurazioni graffite*. Florence.

Bonghi Jovino, M. 1991. "Osservazioni sui sistemi di costruzione a Tarquinia: tecniche locali e impiego del 'muro a pilastri' fenicio." *ArchClass* 43: 171–191.

Brandt, J. R. 1996. *Scavi di Ficana II,1. Il periodo protostorico e arcaico*. Roma.

Braudel, F. 1972. *The Mediterranean and the Mediterranean World in the Age of Philip II.* 2 Vols. London.

Braun, D. 1987. "Coevolution of Sedentism, Pottery Technology, and Horticulture in the Central Midwest, 200 B.C.-A.D. 600," in *Emergent Horticultural Economies of the Eastern Woodlands* . (ed.) W.F. Keegan. Carbondale: 153-181.

Broughton, J. and J. O'Connell. 1999. "On evolutionary ecology, selectionist archaeology, and behavioral archaeology." *American Antiquity* 64: 153–65.

Brown, B. 2001. "Thing Theory," *Critical Inquiry* 28(1): 1-22.

Brown, F. E. 1974-75. "La Protostoria della Regia." *RendPontAcc* 47: 15-36.

Brown, N. 1919. *The lumber market in Italy and reconstruction requirements.* Dept. of Commerce. Bureau of Foreign and Domestic Commerce. Special agents series, no.182. Washington, D.C.

Brown, W.L. 1960. *The Etruscan Lion.* Oxford.

Bruner, J. 1986. *Actual Minds, Possible Worlds.* Harvard Unipress.

Bulliet, R. 1992. "Annales and archaeology," in *Archaeology, Annales, and Ethnohistory*, A. B. Knapp (ed.), Cambridge: 131-4.

Bultrini, G., and A. Mezzolani, A. Morigi, 1996. "L'approvvigionamento idrico a Tharros: le cistern." *Rivista Studi Fenici* 24: 103–127.

Burkert, W. 1992. *The Orientalizing Revolution: Near Eastern Influence on Greek Culture in the Early Archaic Age* (trans. M. E. Pindar and W. Burkert), Cambridge.

Burnham, R. and D. Tarling. 1975. "Magnetization of Shards as an Assistance to the Reconstruction of Pottery Vessels." *Studies in Conversation* 20: 152-157.

Butler, R. 2002. *Architectural engineering design*. New York.

Calvi Rezia, G. 1972 "I resti dell'insediamento neolitico di Pienza," in *Atti XIV Riunione Scientifica IIPP, Puglia, 1970.* Firenze: 285-299.

Calzoni, U. 1954. "Le abitazioni preistoriche." *Quaderni di Studi Etruschi* I: 32-57.

Capponi, F. 1981. "Avifauna e magia." *Latomus* 40(1): 292–304.

Carollo, G. 2009. "La residenza ad abside: la struttura, l'organizzazione degli spazi, le fasi," in *Lo spazio del potere : la residenza ad abside, l'anaktoron, l'episcopio a*

Torre di Satriano : atti del secondo Convegno di studi su Torre di Satriano (Tito, 27-28 settembre 2008), M. Osanna, L. Colangelo, and G. Carollo (eds.), Venosa: 19-33.

Castellana, G. 1988-89. "L'insediamento di Montagnoli nei pressi di Selinunte." *Sicilia Archaoelogica* 15: 325-33.

Cazzella, A. and M. Moscoloni. 1984. "Testimonianze del paleolitico superiore e del neolitico iniziale a Tor Vergata," in *Preistoria e protostoria del territorio di Roma*, A.M. Bietti Sestieri (ed.), Roma: 105-16.

1988. "Eta del Bronzo," in *Coppa Nevigata e il suo territorio. Testimonianze archeologiche dal VII al II millennio a.C.,* S. Cassano, A. Cazzella, A. Manfredini, and M. Moscoloni (eds.), Rome: 109-89.

Celli, A. 1995. "Analisi mineralogica dei concotti," in *L'insediamento terramaricolo di Pilastri (Bondeno-Ferrara): prime fasi di una ricerca*, P. Desantis and G. Stuffè (eds.), Giugno: 62-3.

Chazelles-Gazzal, C. 1995. "Les origines de la construction en adobe en Extrême Occident," in *Sur les pas des Grecs en Occident. Hommages à André Nickels*, P. Arcelin, M. Bats, D. Garcia, G. Marchand, and M. Schwaller (eds.), Paris: 49-58.

1997. *Les maisons en terre de la Gaule méridionale*. Montagnac.

Cherubini, L. 2009. "The Virgin, the Bear, the Upside-Down Strix: An Interpretation of Antoninus Liberalis 21." *Arethusa* 42 (1): 77-97.

Chiotis, E. and E. Dimou, G. Papadimitriou, S. Tzoutzopoulos. 2001. "The Study of Some Ancient and Prehistoric Plasters and Watertight Coatings from Greece," in *Archaeometry Issues in Greek Prehistory and Antiquity*, E. Aloupi, Y. Bassiakos, and Y. Facorellis (eds.), Athens: 327-342.

Cogswell, J. and H. Neff, M. Glascock. 1996. "The Effect of Firing Temperature on the Elemental Characterization of Pottery." *Journal of Archaeological Science* 23, 283–287.

Coles, J. 1967. "Experimental archaeology." *Proceedings of the Society of Antiquaries of Scotland* 99: 1-20.

Collepardi, M. 1990. "Degradation and restoration of masonry walls of historical buildings." *Materials and Structures* 23:81-102.

Collon, D. 2007. "The Queen Under Attack – A rejoinder." *Iraq* 69: 43–51.

Colonna, G. 1986. “Urbanistica e Architettura,” in *Rasenna: Storia e civiltà degli Etruschi*, M. Pallottino (ed.), Milan.

Cook, J. and R. V. Nichols. 1998. *Old Smyrna Excavations: The Temples of Athena*. London.

Costantini, L. and L. Costantini-Biasini, L. Loredana. 2003. “Paléoenvironnement et activités de l'homme préhistorique - Indagini archeobotaniche sugli intonaci neolitici di Torre Sabea,” in *Torre Sabea: un établissement du néolitique ancien en Salent*o, J. Guilaine and G. Cremonesi (eds.), Rome: 234-67.

Cuomo, S. 2007. *Technology and Culture in Greek and Roman Antiquity*. New York.

Damgaard Andersen, H.. 1992/3. “The origin of Potnia Theron in Central Italy.” *HBA* 19-20: 73-107.

1997. “The Archaeological Evidence for the Origin and Development of the Etruscan City in the 7th to 6th Centuries B.C.,” in *Urbanization in the Mediterranean in the 9th to 6th centuries BC,* Stockholm: 342-83.

1998. *Etruscan Architecture from the Late Orientalizing to the Archaic Period (c. 640-480 B.C.).* Ph.D dissertation. Copenhagen.

Damgaard Andersen, H. and J. Toms. 2001. “The earliest tiles in Italy?,” in *From huts to houses. Transformations of ancient societies. Proceedings of an international seminar organized by the Norwegian and Swedish Institutes in Rome, 21 - 24 September 1997,* J. R. Brandt and L. Karlsson (eds.), Stockholm: 264-8.

Dal Ri, L. 1992. “Note sull'insediamento e sulla necropoli di Vadena (Alto. Adige),” in *Die Räter / I Reti,* I. Metzer and P. Gleirscher (eds.), Bozen: 475-522.

Dandrau, A., and S. Dubernet. 2006. “Plasters from Kommos: A Scientific Analysis of Fabrics and Pigments,” in *Kommos 5: The Monumental Minoan Buildings at Kommos*, J. Shaw (Ed.), Princeton: 236-241.

Davico, A. 1951. “Ricostruzione probabile dell’abitazione laziale del primo periodo del ferro secondo le testimonianze dello scavo sul Germalo.” *MontAnt* 41: 127-34.

1950-51. “Nota sulla recostruzione probabile di una abitazione della 1a fase laziale scoperta sul Palatino.” *Rivista di Antropologia* 38:29-36.

Davis, L. 1981. “A Note on Some Cistern Mortars Found at Carthage,” in *Excavations at Carthage 1977 conducted by the University of Michigan, Vol. 6,* J. H. Humphrey (ed.). Ann Arbor: 43-9.

DeGrummond, N. 1997. “Poggio Civitate. A turning point.” *Etruscan Studies* 4: 23-40.

DeMarinis, R. 2009. “Continuity and discontinuity in northern Italy from the recent to the final Bronze Age. A view from north-western Italy.” *Scienze dell'antichita: storia, archeologia, antropologia* 15: 535-545.

DePuma, R. 1981. “Etruscan Gold and Silver Jewelry from Poggio Civitate (Murlo).” *ArchCl* 23: 78-93.

1985. “Metalli preziosi e pietre semi-preziose,” in *Case e palazzi d'Etruria,* S. Stopponi (ed.), Milan: 93.

De Santis, A. and R. Merlo, J. De Grossi Mazorin. 1998. *Fidene: una casa dell’Eta del Ferro.* Milan.

DeVries, K. 2003.“Eighth century Corinthian pottery: evidence for the dates of Greek settlement in the west,” in *Corinth, the centenary, 1896-1996,* C.K. Williams II and N. Bookidis (eds.), Princeton: 141-56.

Dies Cusi, E. 1995. *La arquitectura fenicia de la peninsula iberica y su influencia de la arquitectura indigenas*. Valencia.

2001. “La influencia de la arquitectura fenicia en las arquitecturas indígenas de la Península Ibérica (siglos VIII-VII),” in *Arquitectura oriental y orientalizante en la Península Ibérica,* D. Ruiz Mata and S. Celestino Pérez (eds.), Madrid: 69-122.

Dobres, M.A. 1995. “Gender and prehistoric technology: on the social agency of technical strategies.” *World Archaeology* 27 (1): 25-49.

2000. *Technology and Social Agency: Outlining a Practice Framework for Archaeology*. Oxford.

2009. “Technologies,” in *The Oxford Handbook of Archaeology,* B. Cunliffe, C. Gosden, and R. Joyce (eds.), Oxford: 115-41.

Dontas, G. 1976. “Ein kerkyräisches Heiligtum,” in *Neue Forschungen in griechischen Heiligtümern,* U. Jantzen (ed.), Tubingen: 121-33.

Duke, P. 1992. “Braudel and North American Archaeology: An Example from the Northern Plains,” in *Archaeology, Annales and Ethnohistory,* A.B. Knapp (ed.), Cambridge: 99-111.

Dunnell, R. 1978. “Style and Function: A Fundamental Dichotomy.” *American Antiquity* 43(2): 192-202.

1989. “Aspects of the Application of Evolutionary Theory in Archaeology,” in *Archaeological Thought in America*, C. C. Lamberg-Karlovsky (ed.), New York: 35-99.

1992. “Archaeology and Evolutionary Science,” in *Quandaries and Quests. Visions of Archaeology's Future*, L. Wandsnider (ed.), Carbondale: 209-224.

Elsen, J., and K. Van Balen, G. Mertens. 2010. “Hydraulicity in Historic Lime Mortars: a Review,” in *2nd Historic Mortars Conference*, J. Valek, C. Groot, and J. Hughes (eds.), Prague: 127-45.

Evely, R. 1993. *Minoan crafts: tools and techniques, an introduction, Vol. 1.* Göteborg.

Fabbri, B., and S. Gualtieri, M. Rottili, G. Tasca, S. Vitri, P. Visentini. 2007. “Materiali concotti dell'abitato tardoneolitico di Palù di Livenza (Pn),” in *Materiali argillosi non vascolari: un'occasione in più per l'archeologia. Atti della IX Giornata di Archeometria della Ceramica (Pordenone 18-19 Aprile 2005),* B. Fabbri, S. Gualtieri, and A. Rigoni (eds.), Faenza: 67-80.

Falchi, I. 1895. “Vetulonia: scavi dell'anno 1894.” *NSA*: 272–317.

Fantar, M. 1984. *Kerkouane, cite punique du cap Bon, Tunisie*. Tunis.

Farneti, F. 1997. “The Italian peninsula,” in *Encyclopedia of vernacular architecture of the world, Vol. 2,* P. Oliver (ed.), Cambridge: 1564-1568.

Feeney, D. 2007. *Caesar's Calendar: Ancient Time and the Beginnings of History*. Berkeley.

Fenelli, M. 1984. “Lavinium.” *Archeologia Laziale* 6: 325-344.

Finley, M. 1965. “Technological innovation and economic progress in the ancient world.” *Econ. His. Rev.* 18(1): 29-45.

1973. *The Ancient Economy*. London.

Fiorentino, G. and I. Muntoni. 2002. “Le capanne di Balsignano: materiali e tecniche costruttive,” in *La preistoria della Puglia. Paesaggi, uomini e tradizioni di 8000 anni fa,* F. Radina (ed.), Bari: 167-175.

Fiori, A. 1923-25. *Nuova flora analticia d’Italia*. *Vol. I.* Firenze.

Firpo, G. 1997. “Posidonio, Diodoro e gli Etruschi.” *Aevum* 71: 103–11.

Fletcher, L. 1992. “Time perspectivism, Annales, and the Potential of Archaeology,” in *Archaeology, Annales, and Ethnohistory,* A.B. Knapp (ed.), Cambridge: 35-49.

Fletcher, R. 2007. *Patterns of imports in Iron Age Italy*. Oxford.

Fol, A. and J. Lichardus. 1988. "Archaeologie und Geschichte," in *Macht, Herrschaft, und Gold*, A. Fol and J. Lichardus (eds.), Saarbrucken: 19-26.

Forbes, R. J. 1964. *Studies in ancient technology*. 9 vols. Leiden.

Francalacci, P. and J. Bertranpetit, F. Calafell, and P. Underhill. 1996. "Sequence diversity of the control region of mitochondrial DNA in Tuscany and its implications for the peopling of Europe." *Am. J. Phys. Anthropol*. 100: 443-60.

Frankfort, H. 1996. *The Art and Architecture of the Ancient Orient*. 5th ed. New Haven.

Fusco,V. 1970. "L'insediamento di Vidolasco nel quadro delle stazioni preistoriche coeve." *Insula Fulcheria* 8: 1-10.

Garraty, C. and T. Murakami, A. Simon, M. McKelvy. 2007. "Thermogravimetric Analysis (TGA) of Archaeological Materials, Part II: Ceramics." *SAS Bulletin* 30(1): 17-20.

Gell, A. 1998. *Art and Agency: An Anthropological Theory*. Oxford.

Genestar, C. and C. Pons, A. Mas. 2006. "Analytical characterization of ancient mortars from the archaeological Roman city of Pollentia (Balearic Islands, Spain)." *Analytica Chimica Acta* 557: 373–379.

Genovesi, E. 2000. "Labratorio di architettura etrusca presso il museo civico di Allumiere," in *From huts to houses. Transformations of ancient societies. Proceedings of an international seminar organized by the Norwegian and Swedish Institutes in Rome, 21 - 24 September 1997,* J. R. Brandt and L. Karlsson (eds.), Stockholm: 311-19.

Giammateo, T. 2009. "I risultati preliminary delle analisi archaeometriche," in *Lo spazio del potere: la residenza ad abside, l'anaktoron, l'episcopio a Torre di Satriano: atti del secondo Convegno di studi su Torre di Satriano (Tito, 27-28 settembre 2008)*, M. Osanna, L. Colangelo, and G. Carollo (eds.), Venosa: 205-15.

Gibson, A. and A. Woods. 1997. *Prehistoric pottery for the archaeologist*. London.

Gierow, P.1966. *The iron age culture of Latium, I: classification and analysis*. Lund.

Gilstrap, W. 2009. "The Conundrum of the Workshop OR Etruscan Utilitarian Ceramics: A Compositional Analysis." *Rasenna* 2(1): 2.

Gimbutas, M., 1965. *Bronze Age cultures in central and eastern Europe*. The Hague.

Gjerstad, E. 1953. *Early Rome. Vol 1*. Lund.

1960. *Early Rome. Vol 3*. Lund.

1963. *Early Rome. Vol 4*. Lund.

Gonzalez-Longo, C. and D. Theodossopoulos. 2005. “The vaulting structure of the Temple of Venus and Rome at the Roman Forum,” in *Proc. Int. Conf. Structural analysis of historical constructions 2004, Padua*, C. Modena, P. Lourenço and P. Roca (eds.), London: 1383-94.

Goodman, M. 1998. *The effects of wood ash on lime plaster*. M.S. thesis, University of Pennsylvania.

Goodman, W. L. 1964. *The history of woodworking tools*. London.

Goren, Y. and P. Goldberg.1991.“Petrographic Thin Sections and the Development of Neolithic Plaster Production in Northern Israel.” *JFA* 18:134.

Gosden, C. 2005. “What Do Objects Want?” *Journal of Archaeological Method and Theory* 12 (3): 193-211.

Gourdin, W. and W. Kingery. 1975. “The Beginnings of Pyrotechnology: Neolithic and Egyptian Lime Plaster.” *JFA* 2: 133-50.

Greene, K . 1994. "Technology and innovation in context: The Roman background to medieval and later developments," *JRA* 7: 22–32.

2000. “Technological Innovation and Economic Progress in the Ancient World: M. I. Finley Re- Considered.” *Econ. His. Rev*. 53 (1): 29-59.

2008. “Historiography and Theoretical Approaches,” in *Handbook of Engineering and Technology in the Classical World*, in J. Oleson (ed.), New York: 62-90.

Grenier, A. 1912. *Bologne villanovienne et etrusque*. Paris.

Hansen, H. O. 1962. “Ungdommelige Oldtidshuse - Mudhouses,” *Kulm 1961:*128 - 145.

Harding, A. 2000. *European societies in the Bronze Age*. Cambridge.

Haynes, S. 2000. *Etruscan civilization: a cultural history*. Los Angeles.

Heal, G. 2002. “Thermogravimetry and Derivative Thermogravimetry,” in *Principles of thermal analysis and calorimetry*. P.J. Haines (ed.), Cambridge: 10-54.

Hellström, P. 1975. *Luni sul Mignone - The zone of the large Iron Age building*. Stockholm.

Hocker, F. M. 2004. “Tools,” in *Serçe Limanı An Eleventh-Century Shipwreck Vol. 1, The Ship and Its Anchorage, Crew and Passengers*, G. F. Bass, S. D. Matthews, J. R. Steffy, and F. H. Van Doorninck Jr. (eds.), College Station: 297–326.

Hodder, I. 2002. *Archaeological theory today*. Cambridge.

2011. “Human-thing entanglement: towards an integrated archaeological perspective.” *Journal of the Royal Anthropological Institute* 17: 154-177.

Hodges, R. 1986. “Rewriting History. Archaeology and the Annales Paradigm,” in *Alltag und Fortschriftt im Mittelalter,* H. Kuhnel (ed.), Krems: 137-49.

Holloway, R. et al. 1975. “The early Bronze Age village of Tufariello.” *JFA* 2(1/2): 11-81.

Holloway, R. and S. Lukesh. 1995. *Ustica: the results of the excavations of the Regione Siciliana, Soprintendenza ai Beni Culturali ed Ambientali Provincia di Palermo in collaboration with Brown University in 1990 and 1991*. Providence.

Horden, P. and N. Purcell. 2000. *The Corrupting Sea: A Study of Mediterranean History*. Oxford.

Humphreys, J. 1998. *Greek and Roman technology : a sourcebook : annotated translations of Greek and Latin texts and documents*. London.

Iannone, G. 2002. “Annales History and the Ancient Maya State: Some Observations on the "Dynamic Model."” *American Anthropologist* 104 (1): 68-78.

Ingo, G. and I. Fragala, G. Bultrini, T. de Caro, C. Riccucci, G. Chiozzini. 2004. “Thermal and microchemical investigation of Phoenician–Punic mortars used for lining cisterns at Tharros (western Sardinia, Italy).” *Thermochimica Acta* 418: 53-60.

Jacobsen, T. 1987. “Pictures and pictorial language (the Burney Relief),” in *Figurative Language in the Ancient Near East,* M. Mindlin, M. Geller, and J. Wansbrough (eds.), London: 1–11.

Jameson, R. 2002. “The Beaker Phenomenon,” in *A dictionary of archaeology*, I. Shaw and R. Jameson (eds.), Oxford: 111-12.

Jannot, J-R. 2005. *Religion in ancient Etruria* (trans. by J. K. Whitehead). Madison.

Johnson, M. 1999. *Archaeological Theory: An Introduction*. Oxford.

Karlsson, L. 2006. *San Giovenale. Results of excavations conducted by the Swedish institute of classical studies at Rome and the Soprintendenza alle antichità dell'Etruria meridionale. 4, 1. Area F East, huts and houses on the acropolis*. Stockholm.

Kingery, D. and P. Vandiver, M. Pickett. 1988. "The beginnings of pyrotechnology, part II: production and use of lime and gypsum plaster in the Pre-Pottery Neolithic Near East." *JFA* 15: 219-44.

Knapp, A. B. 1992. "Archaeology and Annales: time, space, and change," in *Archaeology, Annales, and Ethnohistory,* A.B. Knapp (ed.), Cambridge: 1-22.

1993. *Society and polity at Bronze Age Pella: an Annales perspective*. Sheffield.

Knappett, C. 2005. *Thinking Through Material Culture: An Interdisciplinary Perspective*. Philadelphia.

2007. "Materials with materiality?" *Archaeological Dialogues* 14: 20-23.

Kraeling, E. 1937. "A Unique Babylonian Relief." *BASOR* 67: 16–18.

Kristiansen, K. 2005. "Innovation and invention - independent event or historical process?," in *Archaeology: The Key Concepts,* C. Renfrew and P. Bahn (eds.), Routledge: 113-6.

Kuusela, K . 1994. *Forest resources in Europe, 1950-1990*. Cambridge.

Lambrugo, C. 2003. "Archeologia degli spazi domestici: analisi degli elementi strutturali e discussione delle aree funzionali nel saggio E," in *Ricerche archeologiche all'Incoronata di Metaponto: Scavi dell'Università degli Studi di Milano 6 - L'oikos greco del saggio E. Lo scavo e i reperti,* C. Lambrugo and M. Castoldi (eds.), Milan: 29-50.

2005. "Un nuovo paradigma interpretativo per l'Incoronata di Metaponto: analisi della cultura abitativa ed interpretazione di taluni indicatori archeologici," in *Papers in Italian Archaeology VI:Communities and Settlements from the Neolithic to the Early Medieval Period, Proceedings of the 6th Conference of Italian Archaeology (Groningen aprile 2003)*, P. Attema, A. Nijboer, and A. Zifferero (eds.), Groningen: 773-781.

Lanas, J. and J. Perez Bernal, M. Bello, J. Alvarez Galindo. 2004. "Mechanical properties of natural hydraulic lime-based mortars." *Cement and Concrete Research* 34: 2191–2201.

Lancaster, L. 2008. “Roman engineering and construction,” in *The Oxford Handbook of Engineering and Technology in the Classical World*, J. P. Oleson (eds.), Oxford: 256-84.

Landels, J. 1978. *Engineering in the ancient world*. London.

Last, J. 1995. “The Nature of History,” in *Interpreting Archaeology: Finding Meaning in the Past.* I. Hodder, M. Shanks, A. Alexandri, V. Buchli, J. Carman, J. Last and G. Lucas (eds.), New York: 141-157.

Latour, B. 1993. *We Have Never Been Modern* (trans. C. Porter). Cambridge.

2005. *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford.

Lauffer, S. 1971. *Diokletians Preisedikt*. Berlin.

Laviano, R., I. Muntoni and F. Radina. 1995. “Studio archaeometrico di manufatti in argilla dall’insediamento di Punta la Terrare.” *Taras* 15(2): 455-77.

1999. “Materie prime e tecnologia degli intonaci nel Neolitico Antico: la capanna 1 di Balsignano (Modugno - Bari),” in *Le Scienze della Terra e l'Archeometria (Bari). 19-20/Febbraio/1998*, C. D'Amico and C. Tampellini (eds.), Bologna: 129-136.

Laviosa, C. 1960. “Rusellae, relazione preliminare della seconda campagna.” *StEtr* 28: 289-337.

1961. “Rusellae, relazione preliminare della terza campagne di scavi.” *StEtr* 29: 31-46.

1965. “Rusellae, relazione preliminare della quinta e della sesta campagne di scavi.” *StEtr* 33: 49-108.

1966. “L'Urbanistica della città arcaiche e le strutture in mattoni crudi di Roselle,” *Studi della città antica 1, Atti del convegno di studi sulla città etrusca e italica preromana*, Imola: 209- 216.

1969. “Rusellae, relazione preliminare della settima e della ottava campagne di scavi.” *StEtr* 37: 577-609.

1971. “Rusellae, relazione preliminare della nona e della decima campagne di scavi.” *StEtr* 39: 534-538.

Lawrence, R. 2006. *A Study of Carbonation in non-hydraulic mortars*. Ph.D dissertation, University of Bath.

Lawrence-Zuniga, D. 2001. “From bourgeois to modern: transforming houses and family life in rural Portugal,” in *Architectural Anthropology*, M. Amerlinck (ed.),Westport: 171-200.

Lechtman, H. 1993. “Technologies of Power - the Andean Case,” in *Configurations of Power in Complex Society*, J.S. Henderson and P.J. Netherly (eds.), Ithaca: 244-80.

Leighton, R. 1993. *The protohistoric settlement on the Cittadella. Vol.4*. Princeton.

2005. “Later Prehistoric Settlement Patterns in Sicily: Old Paradigms and New Surveys.” *European Journal of Archaeology* Vol. 8(3): 261–287

Lemonnier, P. 1992. *Elements for an Anthropology of Technology*. Ann Arbor.

1993. “Introduction,”in *Technological choices. Transformation in Material Cultures since the Neolithic,* P. Lemonnier (ed.), London: 1-35.

Leonard, R. and G. Jones 1987. “Elements of an inclusive evolutionary model for archaeology.” *Journal of Anthropological Archaeology* 6: 199–219.

Leonard, R. 2001. “Evolutionary Archaeology,” in *Archaeological Theory Today*, I. Hodder (ed.), Cambridge: 65-97.

Leonardi, G. 1997. “I sette album di Castellazo di FontanellatoL primi spunti critici sulla documentazione originale degli scavi pigoriani,” in *Le terramare: La piu antica civilta padana,* M. Bernabo Brea, A. Cardarelli, M. Cremaschi (eds.), Milan: 70-81.

Lewthwaite, J. 1987. “The Braudelian beaker: a Chalcolithic conjoncture in western Mediterranean prehistory,” in *Bell beakers of the western Mediterranean*, W.H. Waldren and R.C. Kennard (eds.), Oxford: 31-60.

Liebhart, R. 1988. *Timber roofing spans in Greek and Near Eastern monumental architecture during the early Iron Age.* Ph.D. dissertation, University of North Carolina at Chapel Hill.

Linington, R. 1976. “Tarquinia (Viterbo).” *StEtr* 45: 453-454.

Linington, R., and F. Delpino, M. Pallottino. 1976. “Alla origine di Tarquinia: scoperta di un abitato villanoviano su Monterozzi.” *StEtr* 46: 3-23.

Liseno, A. 2008. *Dalla capanna alla casa: dinamiche di trasformazione nell'Italia sud-orientale, VIII-V sec. a.C.* Bari.

Lollini, D. and R. Peroni, M. Pallottino. 1969. ‘Terza Discussione,” in *Atti del primo simposio internazionale di protostoria italiana: Orvieto, 21-24 settembre 1967*, Fondazione per il Museo Claudio Faina (eds.), Roma: 177-83.

Loney, H. 2000. “Society and Technological Control: A Critical Review of Models of Technological Change in Ceramic Studies.” *American Antiquity* 65 (4): 646-668.

LoPorto, F. 1998. *I villaggi preistorici di Murgia Timone e Murgecchia nel Materano*. Rome.

Lorenzi, R. and M. Serradimigni. 2009. “Il sito neolitico di le Grotteline (Spinazzola, Bari).” *Origini* 31: 41-74.

Loten, H. S. 1970. “Architecture and Engineering: A Reply to Marshall.” *American Antiquity* 35(2): 201-202.

Lulof, P. 2000. “Archaic terracotta acroteria representing Athena and Heracles: manifestations of power in central Italy.” *JRA* 13: 207-219.

Lyman, R. and M. O’Brien. 1998. “The goals of evolutionary archaeology: History and explanation.” *Current Anthropology* 39: 615–652.

2000. *Applying Evolutionary Archaeology: A Systematic Approach.* New York.

Maaskaant-Kliebrinkt, M. 1991. “Early Latin settlement-plans at Borgo Le Ferriere (Satricum).” *BABesch* 66: 51-114.

1992. *Settlement excavations at Borgo le Ferriere. Satricum II, the campaigns 1983, 1985 and 1987.* Groningen.

Macfarlane, R. “*Tyrrhena Regum Progenies:* Etruscan Literary Figures from Horace to Ovid,” in *Etruscan Italy,* J. F. Hall (ed.), Provo: 241-265.

Magagnini, A. and A. Rathje. 1985. “Ficana,” in *Case e palazzi d'Etruria*, S. Stopponi (ed.), Milan: 164-77.

Magi, F. 1939. “Buccheri e ceramica d’impasto,” in *La raccolta Benedetto Guglielmi nel Museo Gregoriano Etrusco*, J. Beazley and F. Magi, Vatican City: 107-54.

Magness, J. 2001. “A Near Eastern Ethnic Element among the Etruscan Elite?” *Etruscan Studies* 8: 79-117.

Malainey, M. 2002. *A consumer's guide to archaeological science : analytical techniques. Manuals in archaeological method, theory and technique*. New York.

Malinowski, R. and Y. Garfinkel. 1990, "Prehistory of Concrete." *Concrete International* 13/3: 62–68.

Malyarchuk, B. and I. Rogozin. 2004. "On the Etruscan mitochondrial DNA contribution to modern humans." *Am. J. Hum. Genet.* 75: 920–923.

Maravelaki-Kalaitzakia, P. and A. Bakolas, A. Moropoulou. 2003. "Physico-chemical study of Cretan ancient mortars." *Cement and Concrete Research* 33: 651–661.

Maravelaki-Kalaitzakia, P. and A. Galanos, I. Doganis, N. Kallithrakas-Kontos. 2011. "Physico-chemical characterization of mortars as a tool in studying specific hydraulic components: application to the study of ancient Naxos aqueduct." *Applied Physics A: Materials Science Processing* 104:335–348.

Marruggi, G. 1996. "Crispiano (Taranto), L'Amastuola," in *Ricerche sulla casa in Magna Grecia e in Sicilia. Atti del colloquio, Lecce, 23 – 24 giugno 1992*, K. Mannino and F. D'Andria (eds.), Galatina: 197-218.

Marshall, J. A. 1969. "Engineering Principles and the Study of Prehistoric Structures: A Substantive Example." *American Antiquity* 34(2): 166-171.

Martelli, M. and F. Gilotta. 2000. "The Minor Arts," in *The Etruscans*, M. Torelli (ed.), London: 455-75.

Marzatico, F. 1997. "L'architettura del legno negli abitati palafitticoli del Trentino," in *Le Terramare. La più antica civiltà padana*, Milano: 263-71.

2004. "150 Years of Lake-Dwelling Research in Northern Italy," in *Living on the Lake in Prehistoric Europe: 150 years of lake-dwelling research*, F. Menotti (ed.), London: 83-97.

Maschner, H. and S. Mithen. 1996. "Darwinian Archaeologies: An Introductory Essay," in *Darwinian Archaeologies*, H. Maschner (ed.), New York: 3-14.

McDonnell. B. 1992a. *La Muculufa II: Excavation and survey 1988-1991. The Castelluccian village and other areas.* Providence.

1992b. "The early Bronze age village of La Muculufa and prehistoric hut architecture in Sicily." *AJA* 96: 23-44.

McDonough, C.M. 1997. "Carna, Proca, and the Strix on the Kalends of June." *TAPA* 127: 315-44.

McGlade, J. 1999. "The times of history: archaeology, narrative and non-linear causality," in *Time and Archaeology*, T. Murray (ed.), London: 139-63.

McIntosh, R. 1974. “Archaeology and Mud Wall Decay in a West African Village.” *World Archaeology* 6(2): 154-171

McPherron, D. and A. Srejovic. 1988. *Divostin and the Neolithic of Central Serbia*. Pittsburgh.

Meiggs, R. 1982. *Trees and Timber in the Ancient Mediterranean World*. Oxford.

Meirion-Jones, G. 1976. “Some early and primitive building forms in Brittany.” *Folk Life* 14: 46-64.

Mellart, J. 1967 *Catal Huyuk: A Neolithic Town in Anatolia*. London.

Merlo, R, and G. Frigerio.1986. “L’abitato tecnologie edilizie,” in *Como fra Etruschi e Celti*, A. Cavalli (ed.), Caripio: 41-61.

Mertens-Horn, M. and Viola, L. 1990. “Archaische Tondacher westgriechischer Typologie in Delphi und Olympia.” *Hesperia* 59: 235-50.

Mesado Oliver, N. 1974. *Vinarragell (Burriana, Castellon).* Valencia.

Meteorological Office of Great Britain, Her Majesty’s Stationery Office. 1972. *Tables of temperature, relative humidity, precipitation and sunshine for the world. Part III. Europe and the Azores.* London.

Michelaki, K. and R. Hancock. 2011. “Chemistry versus data dispersion: Is there a better way to assess and interpret archaeometric data?” *Archaeometry*: Published online, 4 APR 2011.

Milanese, M. 1983. “Reperti concotti dell'abitato protostorico di Camogli,” in *Atti [del] XII Convegno internazionale della ceramica : Albisola, 31 maggio - 3 giugno 1979*, Albisola: 213-221.

Milisauskas, S. and J. Kruk. 2002. *European Prehistory: A Survey.* New York.

Minke, G. 2006. *Building with Earth*. Basel.

Mirabella Roberti, M. 1962. “Un insediamento protovillanoviano a Vidolasco.” *Insula Fulcheria* 1: 11-17.

Mitchell, T. 1991. “Israel and Judah until the Revolt of Jehu (931–841 B.C.),” in *Cambridge Ancient History 3, Part 1*, J. Boardman et al. (ed.), Cambridge: 442-487.

Moffa, C. 2002. "L'intonaco di capanna," in *L'organizzazione dello spazio sull'Acropoli di Broglio di Trebisacce: dallo studio delle strutture e dei manufatti in impasto di fango all'analisi della distribuzione dei reperti*, C. Moffa (ed.), Firenze: 21-45.

2005. "L'architettura in malta di fango nella penisola italiana tra media età del Bronzo e la prima età del Ferro," in *Papers in Italian Archaeology VI:Communities and Settlements from the Neolithic to the Early Medieval Period, Proceedings of the 6th Conference of Italian Archaeology (Groningen aprile 2003),* P. Attema, A. Nijboer, and A Zifferero (eds.), Groningen: 652-655.

Moggi-Cecchi, J. and B. Chiarelli, E. Pacciani. 1997. "The anthropological study of Etruscan populations." *Etruscan Studies* 4: 73-86.

Moreland, J. 1992. "Restoring the Dialectic: Settlement patterns and documents in medieval cental Italy," in *Archaeology, Annales, and Ethnohistory,* A.B. Knapp (ed.), Cambridge: 112-29.

2001. *Archaeology and Text.* London.

Moropoulou, A., and A. Bakolas, K. Bisbikou. 1995. "Characterization of ancient, byzantine, and later historic mortars by thermal and X-ray diffraction techniques." *Thermochimica Acta* 269/270: 779-795.

2000. "Investigation of the technology of historic mortars." *Journal of Cultural Heritage* 1:45–58.

Moropoulou, A. and A. Bakolas, S. Anagnostopoulou. 2005. "Composite materials in ancient structures." *Cement & Concrete Composites* 27: 295–300.

Moropoulou, A., and K.Polikreti, A. Bakolas, P. Michailidis. 2003. "Correlation of physicochemical and mechanical properties of historical mortars and classification by multivariate statistics." *Cement and Concrete Research* 33: 891–898.

Moscati S. 1999. *Storia degli italiani: dalle origini all'età di Augusto*. Rome.

Mosso, A. 1910. "La Necropoli Neolitica del Pulo di Molfetta." *MonAnt* 20: 237-52.

Mulkay, M. 1978. *Science and the Sociology of Knowledge*. London.

Muscarella, O. 2008. "The Veracity of 'Scientific Testing' by Conservators," in *Original - Copy - Fake, Proceedings of an International Symposium, Stiftung Situation Kunst/Ruhr-Universität, Bochum, 2007,* E. Pernicka (ed.), Mainz: 9-18.

Naumann, R and E. Hiller. 1959. "Rusellae. Bericht über die Untersuchungen der Jahre 1957 und 1958." *RM* 66: 1-30.

Neff, H. 1992. “Ceramics and Evolution,” in *Archaeological Method and Theory, Vol. 4,* M. B. Schiffer (ed.), Tucson: 141-193.

2001. “We Have Met the Selectionist and It Is Us: Some Comments on Loney's Critical Review of Models of Technological Change in Ceramic Studies." *American Antiquity* 66 (4): 726-728.

Neff, H., and J. Blomster, M. Glascock, R. Bishop, M. Blackman, M. Coe, G. Cowgill, R. Diehl, S. Houston, A. Joyce, C. Lipo, B. Stark, M. Winter. 2006. “Methodological issues in the provenance investigation of Early Formative Mesoamerican ceramics.” *Latin American Antiquity* 17(1):54-57

Negroni Catacchio, N. 1983. *Sorgenti della Nova. Una communità protostorica e il suo territorio nell'Etruria Meridionale: guida alla mostra*. Arezzo.

Negroni Catacchio, N. and L. Domanico. 2001. “L'abitato protourbano di Sorgenti della Nova: dagli spazi dell'abitare all'organizzazione sociale,” in *From huts to houses. Transformations of ancient societies. Proceedings of an international seminar organized by the Norwegian and Swedish Institutes in Rome, 21 - 24 September 1997,* J. R. Brandt and L. Karlsson (eds.), Stockholm: 337-59.

Nielsen, E. O. 1983. “Speculations on an ivory workshop of the Orientalizing Period,” in *Crossroads of the Mediterranean*, T. Hackens (ed.), Leuven: 333-49.

1984. “Lotus Chain Plaques from Poggio Civitate,” in *Studi di antichita in onore di Guglielmo Maetzke*, G. Maetzke, M. Costagli, and L. Perna (eds.), Rome: 397-99.

1985. “Poggio Civitate (Murlo),” in *Case e palazzi d'Etruria*, S. Stopponi (ed.), Milan: 64-154.

1987. “Some preliminary thoughts on new and old terracottas.” *OpRom* 16: 91-119.

1991. “Excavations at Poggio Civitate.” *Studi e Materiali* 6: 245-59.

1994. “Interpreting the Lateral Sima at Poggio Civitate,” in *Murlo and the Etruscans: Art and Society in Ancient Etruria*, R. DePuma and J. P. Small (eds.),Wisconsin: 64-71.

1996. “Poggio Civitate.” *EAA 2º supplement, vol. 4*: 394-5.

1998. “Bronze production at Poggio Civitate (Murlo).” *EtrSt* 5: 95-107.

Nielsen, E. O. and K.M. Phillips. 1983. “Poggio Civitate (Siena). The excavations at Murlo in 1976-1978.” *NSc* 37: 5-24.

Nielsen, E. O. and A.Tuck. 2001. “An Orientalizing Period Complex at Poggio Civitate.” *Etruscan Studies* 8: 35-63.

Nielsen, M. and A. Rathje. 2009. “Artumes in Etruria: the Borrowed Goddess.” *Acta Hyperborea* 12: 261–301.

Nijboer, A. J. 2008. “Italy and the Levant during the Late Bronze and Iron Age (1200-750/700 BC),” in *Beyond the Homeland: Markers in Phoenician Chronology*, A. Sagona (ed.), Leuven-Paris-Dudley: 357–394.

O’Brien, M. J. and R. Bentley. 2011. “Stimulated Variation and Cascades: Two Processes in the Evolution of Complex Technological Systems.” *Journal of Archaeological Method and Theory.* Published online 23 JUN 2011.

O’Brien, M. J. and D. Glover, R. Lyman, and J. Darwent. 2003. “Trees and Clades,” in *Cladistics and archaeology*, M.J. O’Brien (ed.), Salt Lake City: 167-97.

O'Brien, M.J. and R.L. Lyman. 2000. "Evolutionary Archaeology. Reconstructing and Explaining Historical Lineages," in *Social Theory in Archaeology*. M. Schiffer (ed.), Salt Lake City: 126-42.

2004. “History and explanation in archaeology.” *Anthropological Theory*, 4(2): 173-97.

O’Brien, M.J., and R.L. Lyman, R.D. Leonard. 1998. “Basic Incompatibilities between Evolutionary and Behavioral Archaeology.” *American Antiquity* 63 (3): 485-498.

Oleson, J. P. 1986. *Bronze Age, Greek, and Roman technology : a select, annotated bibliography*. New York.

ed., 2008. *The Oxford handbook of engineering and technology in the Classical world*. Oxford.

Olsen, B. 2003. “Material Culture after Text: Re-membering Things.” *Norwegian Archaeological Review* 36 (2): 87-104.

Orlandini, P. 1986. “Incoronata: Scavi dell’universita statale del’Milano (1974-84),” in *I Greci sul Basento: mostra degli Scavi archeologici all’incoronata di Metapont*o, *1971-1984*, Como: 29-39.

Ostenberg, C. 1967. *Luni sul Mignone e problemi della preistoria d'Italia*. Lund.

1975. *Case etrusche di Acquarossa*. Rome.

Papadopoulou, D. and M. Lalia-Kantouri, N. Kantiranis, J. A. Stratis. 2006. “ Thermal and mineralogical contribution to the ancient ceramics and natural clays characterization.” *Journal of Thermal Analysis and Calorimetry* 84(1):39–45.

Patzek, B. 1988. “Die mesopotamische Dämonin Lamaštu im orientalisierenden griechisch- kolonialen Kulturkreis: ein Amulett aus Poggio Civitate und Ilias 21, 479 ff.” *Oriens Antiquus* 27: 221-30.

Paulik, J. 1962 “Mazanica s plastickom uzyzdobou y dobe bronzovej na Slovenku.” *Studijne Zvesti Ausav* 10: 31-57.

Pedrotti, A. 2000. “Il Neolitico,” in *Storia del Trentino*, M. Lanzinger, F. Marzatico, and A. Pedrotti (eds.), Bologna: 119-83.

Peebles, C. 1991. “Annalistes, Hermeneutics and Positivists: Squaring Circles or Dissolving Problems,” in *The Annales School and Archaeology,* J. Bintliff (ed.), Leicester: 108-24.

Pellecchia, M. and R. Negrini, L. Colli, M. Patrini, E. Milanesi, A. Achilli, G. Bertorelle, L. Cavalli-Sforza, A. Piazza, A. Torroni, P. Ajmone-Marsan. 2007. “The mystery of Etruscan origins: novel clues from Bostaurus mitochondrial DNA.” *Proc. Biol. Sci. 274: 1175–1179.*

Perini, R. 1987. *Scavi archeologici nella Zona palafitticola di Fiave-Carera, vol.2*. Trentino.

Perkins, P. 2009. “DNA and Etruscan Identity,” in *Etruscan by Definition: Papers in Honour of Sybille Haynes,* P. Perkins and J. Swaddling (eds.), London: 95–111.

Pernier, L. 1920. “Arezzo - ricerche per la scoperta delle antiche mura urbane laterizie nei terreni di ‘Fonte Pozzolo’ e ‘Catona.” *Not.Sc*. 17: 167-215.

Peroni, R. 1988. “Comunita e insediamento in Italia fra Eta del bronzo e prima Eta di ferro,” in *La Storia di Roma,* A. Schiavone (ed.), Torino: 7-38.

1994. *Introduzione alla protostoria italiana*. Rome.

Persson, C. 1986. “Acquarossa,” *Architettura etrusca nel Viterbese*. *Catalogo della mostra. Rome,* Ö. Wikander and P. Roos (eds.), Rome: 40-47.

Pfaffenberger, B. 1992. “Social Anthropology of Technology.” *Annual Review of Anthropology* 21: 491-516.

Phillips Jr., K.M. 1966. “Poggio Civitate (Siena). Campagna di scavo 1966 del Bryn Mawr College in Toscana.” *NSc* 20: 5-17.

1967. “Bryn Mawr College excavations in Tuscany, 1966.” *AJA* 71: 133-39.

1968. “Bryn Mawr College excavations in Tuscany, 1967.” *AJA* 72: 121-124.

1969. “Bryn Mawr College excavations in Tuscany, 1968.” *AJA* 73: 333-39.

1970. “Bryn Mawr College excavations in Tuscany, 1969.” *AJA* 74: 241-244.

1971. “Bryn Mawr College excavations in Tuscany, 1970.” *AJA* 75: 257-261.

1972. “Bryn Mawr College excavations in Tuscany, 1971.” *AJA* 76: 249-55.

1978. “Orientalizing Gem Stones from Poggio Civitate (Murlo, Siena),” *PP* 33: 355-69.

1984. “Protective masks from Poggio Civitate and Chiusi,” in *Studi di antichita in onore di Guglielmo Maetzke*, G. Maetzke, M. Costagli, and L. Perna (eds.), Rome: 413-17.

1985. “Italic house models and Etruscan architectural terracottas of the 7th c. B.C. from Acquarossa and Poggio Civitate, Murlo.” *ARID* 14: 7-16.

1986. “Masks on a canopic urn and an Etrusco-Corinthian perfume pot,”in *Italian Iron Age Artefacts in the British Museum*, in J. Swaddling (ed.), London: *153-55.*

1993. *In the hills of Tuscany. Recent excavations at the site of Poggio Civitate (Murlo, Siena)*. Philadelphia: University of Pennsylvania.

Pohl, I. 1977. *The Iron Age Habitation in Area E, San Giovenale. III:2*. Stockholm.

Poole, C. 2005. “The Daub and Fired Clay and Briquetage,” in *Segsbury Camp. Excavations in 1996 and 1997 at an Iron Age hillfort on the Oxfordshire Ridgeway*. G. Lock, C. Gosden and P. Daly (eds.), Oxford: 1-5.

Porada, E. 1980. “The Iconography of Death in Mesopotamia in the early Second Millennium B.C.,” in *Death in Mesopotamia. Papers read at the XXVIe Rencontre assyriologique internationale*, B. Alster (ed.), Copenhagen: 259–270.

Porath, Y. 2002. “Hydraulic plaster in aqueducts as a chronological indicator,” in *The Aqueducts of Israel*, D. Amit, J. Patrich and Y. Hirschfeld (eds.), Portsmouth: 25-36.

Prayon, F. 1975. *Frühetruskische Grab- und Hausarchitektur*, Heidelberg.

2004. "Überlegungen zur Monumentalität frühetruskischer Plastik und Architektur," in *Die Außenwirkung des späthethitischen Kulturraums*, M. Novák, F. Prayon, and A.-M. Wittke (eds.), Tubingen: 85-105

Preucel, R. and A. Bauer. 2001. "Archaeological Pragmatics." *Norwegian Archaeological Review,* Vol. 34, No. 2: 85-96.

Preucel, R. and S. Mrozowski (eds.) 2010. *Contemporary Archaeology in Theory: The New Pragmatism.* Malden, MA.

Puglisi, S. 1951. "Gli abitatori primitivi del Palatino attraverso le testimonianze archeologiche e le nuove indagini stratigrafiche sul Germalo." *MontAnt* 41: 3-98.

1959. *La civilta appeninnica. Origine delle comunita pastorali in Italia.* Firenze.

Rageth, J. 1974. "Der Lago di Ledro im Trentino und seine Beziehungen zu den alpinen und mitteleuropäischen Kulturen." *BerRGK* 55: 73-259.

Rapoport, A. 1969. *House Form and Culture*. Englewood Cliffs.

Reeves, G., and I. Sims, J. Cripps. 2006. *Clay materials used in construction*. London.

Regev, L., and A. Zukerman, L. Hitchcock, A. Maeir, S. Weiner, E. Boaretto. 2010. "Iron Age hydraulic plaster from Tell es-Safi/Gath, Israel." *Journal of Archaeological Science* 37: 3000-3009.

Renfrew, C. 1969. "Trade and Culture Process in European Prehistory." *Current Anthropology* 10 (2/3): 151-169.

1978. "The anatomy of innovation," in *Social Organization and Settlement*, D. Green, C. Haselgrove, and M. Spriggs (eds.), Oxford: 89-117.

Rhodes, R. 2003. "The earliest Greek temple architecture in Corinth and the 7th century temple on Temple Hill," in *Corinth, the Centenary 1896-1996*, C.K. Williams II and N. Bookidis (eds.), Princeton: 85-94.

Ridgway, D., and F. Ridgway. 1994 "Demaratus and the archaeologists," in *Murlo and the Etruscans. Art and society in ancient Etruria*, R. De Puma and J. Small (eds.), Madison: 6-15.

Rindos, D. 1985. "Darwinian selection, symbolic variation, and the evolution of culture." *Current Anthropology* 26: 65–88.

Riva, C. and N. Vella (eds.) 2006. *Debating Orientalization: Multidisciplinary Approaches to Change in the Ancient Mediterranean.* Cambridge.

Rizzo, G. and B. Megna. 2008. "Characterization of hydraulic mortars by means of simultaneous thermal analysis." *Journal of Thermal Analysis and Calorimetry* 92(1): 173–178.

Robb, J. 2007. *The Early Mediterranean Village. Agency, Material Culture, and Social Change in Neolithic Italy.* Cambridge.

Rowe, J. H. 1966. "Diffusionism and Archaeology." *American Antiquity* 31 (3): 334-337.

Russo Tagliente, A. 1992. *Edilizia domestica in Apulia e Lucania, Ellenizzazione e società nella tipologia abitativa indigena tra VIII e III secolo a.C.* Galatina.

Rystedt, E. 1983. *Acquarossa IV: Early Etruscan Akroteria from Acquarossa and Poggio. Civitate (Murlo)*. Stockholm.

2000. "Huts vis-à-vis houses: a note on Acquarossa," in *From Huts to Houses. Transformations of ancient societies. Proceedings of an international seminar organized by the Norwegian and Swedish Institutes in Rome, 21-24 September 1997,* J. R. Brandt and L. Karlsson (eds.), Stockholm: 245-262.

Salmon, J. 1984. *Wealthy Corinth: A History of the city to 338 B.C.*. Oxford.

Sapirstein, P. 2008. *The Emergence of Ceramic Roof Tiles in Archaic Greek Architecture*, Ph.D dissertation, Cornell University.

2009. "How the Corinthians Manufactured Their First Roof Tiles." *Hesperia* 78: 195-229.

SAS Institute, Inc. 1985. *SAS user's guide: statistics, Version 5 Edition*. Cary, NC.

Schädler, U., and P. Schneider. 2004. *Einfrühes Tondach aus dem Artemision von Ephesos*. Wien.

Schiffer, M.B. and J.M. Skibo. 1987. "Theory and Experiment in the Study of Technological Change." *Current Anthropology* 28:595-622.

Schiffer, M. B. 1993. "Cultural Imperatives and Product Development: The Case of the Shirt-Pocket Radio." *Technology and Culture* 34: 98-113.

2004. "Studying Technological Change: A Behavioral Perspective." *World Archaeology* 36 (4): 579- 585.

2005. "The Devil Is in the Details: The Cascade Model of Invention." *American Antiquity* 70 (3): 485-502.

2010. "Can archaeologists study processes of invention?," in *Innovation in cultural systems: Contributions from evolutionary anthropology,* M. J. O'Brien and S. J. Shennan (eds.), Cambridge: 235–249.

Schlanger, N. 2005. "The Chaine Operatoire," in *Archaeology: The Key Concepts,* C. Renfrew and P. Bahn (eds.), Routledge: 18-23.

Schleif, H. and K. Rhomaios, G. Klaffenbach. 1940. *Korkyra. Archaische Bauten und Bildwerke, Band I: Der Artemistempel. Architektur, Dachterrakotten, Inschriften,* Berlin.

Schubart, M. 1985. "Morro de Mezquitilla. Informe preliminar sobre la campana de excavaciones de 1982." *NAHisp* 23: 141-72.

Schumpeter, J. 1939. *Business Cycles*. New York.

Serio, B. 2009. "Lo scavo: struttura, articolazione, degli spazi e fasi dell'edificio in proprieta Greco," in *Lo spazio del potere: la residenza ad abside, l'anaktoron, l'episcopio a Torre di Satriano: atti del secondo Convegno di studi su Torre di Satriano (Tito, 27-28 settembre 2008),* M. Osanna, L. Colangelo, and G. Carollo (eds.),Venosa: 117-126.

Shaffer, G. 1983. *Neolithic building technology in Calabria, Italy*. Ph.D. dissertation, State University of New York at Binghamton.

1993. "An Archaeomagnetic Study of a Wattle and Daub Building Collapse." *JFA* 20(1) 59-75.

Shanks, M. 2007. "Symmetrical Archaeology." *World Archaeology* 39(4): 589–596

Shanks, M. and C. Tilley 1987. *Social theory and archaeology*. Cambridge.

Shaw, I. 2002. "Annales," in *A dictionary of archaeology*, I. Shaw and R. Jameson (eds.), Oxford: 63-4.

Sherratt, A. 1992. "What can archaeologists learn from Annalistes?," in *Archaeology, Annales and Ethnohistory,* A. B. Knapp (ed.), Cambridge: 135-42.

Sherratt, S. and Sherratt, A. 1993. "The Growth of the Mediterranean Economy in the Early First Millennium BC." *World Archaeology* 24 (3): 361-378.

Sheffer, C. 1990. "Domus Regiae - A Greek Tradition." *OpRom* 18: 185-191.

Signorini, R. 1963. "La formazione di Murlo a sud di Siena." *Boll. Serv. Geol. d'It*. 84: 65-81.

Sillar, B. 2002. "Rev. of *Technology and Social Agency: Outlining a Practice Framework for Archaeology* by M.A. Dobres." *Antiquity* 76 (292): 593-594

Sillar, B. and M. Tite. 2000. "The challenge of 'technological choices' for material science approaches in archaeology." *Archaeometry* 42(1), 2-20.

Silva, D., and H. Wenk, P. Monteiro. 2005. "Comparative investigation of mortars from Roman Colosseum and cistern." *Thermochimica Acta* 438: 35–40.

Skibo, J. and M. B. Schiffer. 2008. *People and Things: A Behavioral Approach*. Springer, New York

Smith, M.E. 1992. "Braudel's temporal rhythms and chronology theory in archaeology," in *Archaeology, Annales, and Ethnohistory,* A. Knapp (ed.), Cambridge: 25-36.

Sordini, G. 1894. *Vetulonia: Studi e ricerche*. Spoleto.

Spatafora, F. 1997. "Tipilogie abitative arcaiche nei centri indigeni occidental: il caso di Maranfusa," in *Wohnbauforschung in Central- und Westsizilien*, H. Isler, D. Kaech, and O. Stefani (eds.), Zurich: 151-64.

Speakman, R. J. and H. Neff 2005. *Laser ablation ICP-MS in archaeological research.* Albuquerque.

Spivey, N. and S. Stoddart. 1990. *Etruscan Italy. An Archaeological History*. London.

Staniforth, M., 2003. "Annales-Informed Approaches to the Archaeology of Colonial Australia." *Historical Archaeology* 37(1), 102-113.

Startin, W. 1978. "Linear Pottery Culture Houses: Reconstruction and Manpower." *Proceedings of the Prehistoric Society* 44: 143-159.

Stefani, E. 1922. "Veio. Esplorazione dentro l'area dell'antica città," *NSc* 19: 379-404.

1953. "Veio, tempio detto del Apollo." *NSc* 8(7): 29-112.

Steponaitis, S. and M. J. Blackman, H. Neff. 1996. "Large-Scale patterns in the chemical composition of. Mississippian pottery." *American Antiquity* 61(3): 555-72.

Stoltman, J. B., and R. Mainfort. 2002. "Minerals and elements: using petrography to reconsider the findings of neutron activation in the findings of Neutron Activation in the compositional analysis of ceramics from Pinson Mounds, Tennessee." *Midcontinental Journal of Archaeology* 27 (1): 1-33.

Strøm, I. 1971. *Problems concerning the origin and early development of the Etruscan Orientalizing style*, Odense.

Sturgeon, M. C. 1987. *Isthmia IV. Sculpture I*: *1952-1967*. Princeton.

Tangri, D. and R. Wright. 1993. "Multivariate analysis of compositional data: applied comparisons favour standard principal components analysis over Aitchison's loglinear contrast method." *Archaeometry* 35(1): 103-12.

Tasca, G. 1998a. "I reperti concotti," in *Pozzuolo del Friuli - II, 2*, P. Cassola Guida, S. Pettarin, G. Petrucci, and A. Giumili-Mari (eds.), Roma: 235-254.

1998b. "Intonaci e concotti nella preistoria." *Archaeologia della Italia Settentrionale* 7: 77-87.

Taylor, J. 2001. "Rural society in Roman Britain," in *Britons and Romans: Advancing an Archaeological Agenda*, S. James and M. Millett (eds.), London: 46–59.

Tine, S. 1983. *Passo di Corvo e la civiltà neolitica del Tavoliere.* Genova.

Tine, V. 2009. *Favella. Un villaggio neolitico nella Sibaritide*. Rome.

Tobey, M., and E. Nielsen, M. Rowe. 1986. "Elemental analysis of Etruscan ceramics from Murlo, Italy," *in Proceedings of the 24th International Archaeometry Symposium*, J. Olin and M. J. Blackman (eds.), Washington D.C.: 115-27.

Torelli, M. 2000. "Le Regiae etrusche e laziali tra orientalizzante e arcaismo," in *Principi etruschi, tra Mediterraneo ed Europa*, G. Bartoloni (ed.), Venice: 67-78.

Treuil, R. 1983. *Le Neolithique et le Bronze ancien egeiens: les problemes stratigraphiques et chronologiques, les techniques, les hommes*. Paris.

Trigger, B. 2006. *A History of Archaeological Thought*. Cambridge.

Tsolakidou, A. and V. Kilikoglou. 2002. "Comparative analysis of ancient ceramics by neutron activation analysis, inductively coupled plasma–optical-emission spectrometry, inductively coupled plasma–mass spectrometry, and X-ray fluorescence." *Anal. Bioanal. Chem.* 374: 566–572.

Tuck, A. 2006. "The Social and Political Context of the 7th Century Architectural Terracottas and Poggio Civitate," in *Deliciae Fictiles III, Architectural Terracottas in Ancient Italy: New Discoveries and Interpretations, Proceedings of the international conference held at the American Academy in Rome, November 7-8, 2002*, I. Edlund-Berry (ed.), Oxford: 130-35.

2010. "Mistress and Master: The Politics of Iconography in Pre-Roman Central Italy," in *The Master of Animals in Old World Iconography*, D. Counts and B. Arnold (ed.), Budapest: 211-221.

Turfa, J.M. and A. Steinmayer. 1996. “The Comparative Structure of Greek and Etruscan Monumental Buildings.” *PBSR* 64: 1-39.

2002. “Interpreting early Etruscan structures: the question of Murlo.” *PBSR* 70: 1-28.

Turfa, J.M. 2006. “Staring down Herodotus: mitochondrial DNA studies and claims about Etruscan origins.” *Etruscan News* 7: 4-5.

Uino, P. and E. Linturi. 1986. *Iron Age studies in Salo I and II*. Helsinki.

Ulrich, R.B. 2007. *Roman Woodworking.* New Haven: Yale University Press.

Underwood, J. and M. Chiuini. 1998. *Structural design : a practical guide for architects*. New York.

Urban, R. and E. Wells, M. Ausec. 1997. “The Fires without and the Fires within: Evidence for Ceramic Production Facilities at the Late Classic Site of La Sierra, Naco Valley, Northwestern Honduras, and in its Environs,” in *The Prehistory & History of Ceramic Kilns*, P. Rice (ed.), Westerville, OH: 173-94.

Valentini, A. 1969. “Il motivo della Potnia Theron sui vasi di bucchero.” *StEtr* 37: 414-42.

Van Beek, G. 2008. *Glorious mud: ancient and contemporary earthen design and construction in North Africa, Western Europe, the Near East, and Southwest Asia*. Washington, D.C.

Van Buren, E. 1936-7.”A further note on the terra-cotta relief,” *Archiv für Orientforschung* 11: 354–357.

Vencl, S. 1971. “Some remarks on the study of prehistoric structures.” *American Antiquity* 36(4): 451-455.

1991. “Fragments of clay daub as a source of information on prehistoric architecture.” *Pam. arch*. 82: 406-411.

Vernesi, C. and D. Caramelli, I. Dupanloup, G. Bertorelle, M. Lari, E. Cappellini, J. Moggi, B. Chiarelli, L. Castrì, A. Casoli, F. Mallegni, C. Lalueza-Fox, G. Barbujani. 2004. “The Etruscans: A Population-Genetic Study.” *American Journal of Human Genetics* 74: 694-704.

Viden, A. 1986. “Acquarossa,” in *Architettura etrusca nel Viterbese. Catalogo della mostra. Rome.* Ö. Wikander and P. Roos (eds.), Rome: 50-55.

Vitali, D. 1988. "Monte Bibele: criteri distributivi nell'abitato ed aspetti del territorio bolognese dal IV al II secolo a.C.," in *La formazione della città preromana in Emilia*, G.A. Mansuelli (ed.), Imola: 105-29.

Von der Osten-Sacken, E.2002. "Zur Göttin auf dem Burneyrelief," in *Sex and Gender in the Ancient Near East. Proceedings of the XLVII Rencontre Assyriologique Internationale,* S. Parpola and R. Whiting (eds.), Helsinki: 479–487.

Walsh, V. 1980. *A computer simulation of the house construction activity system at Nichoria in SW Greece.*. Ph.D. dissertation, University of Minnesota.

Ward-Perkins, J. 1959. "Excavations beside the northwest gate at Veii, 1957-58." *PBSR* 27: 38-79.

Warden, G. and R. Maddin, T. Stech, J. D. Muhly. 1982. "Copper and iron production at Poggio Civitate (Murlo): Analysis of Metalworking By-products from an Archaic Etruscan Site." *Expedition* 25 (1): 26-35.

Warden, P. 1984. "The Colline Metallifere," in *Crossroads of the Mediterranean,* T. Hackens (ed.), Providence: 349-364.

1985. *The Metal Finds from Poggio Civitate (Murlo) 1966-1978.* Rome.

Warner, H. 1979. "Megaron and Apsidal House in Early Bronze Age Western Anatolia: New Evidence from Karataş." *AJA* 83 (2): 133-147.

Warnier, P. 2007. "Material Culture Meaning or Handling? Rev. of *Thinking through Material Culture: An Interdisciplinary Perspective* by Carl Knappett." *Current Anthropology,* Vol. 48, No. 5: 770-771.

Webmoor, T. and C. Witmore. 2008. "Things Are Us! A Commentary on Human/Things Relations under the Banner of a 'Social' Archaeology." *Norwegian Archaeological Review* 41 (1): 53-70.

Webmoor, T. 2007. "What about 'one more turn after the social' in archaeological reasoning? Taking things seriously." *World Archaeology* 39 (4): 563-578.

Wendt, L. 1986. "Tecnica di costruzione," in *Architettura etrusca nel Viterbese. Catalogo della mostra. Rome,* Ö. Wikander and P. Roos (eds.), Rome: 58-60.

Whittlemore, H., and A. Stang, E. Hubbel, R. Dill. 1941. *Building Materials and Structures: Structural, Heat-Transfer, and Water Permeability Properties of Five Earth-Wall Constructions.* Washington, D.C.

Wikander, C. 1982. “Architectural elements in terracotta,” in *Acquarossa: results of excavations conducted by the Swedish Institute of Classical Studies at Rome and the Soprintendenza alle antichità dell'Etruria meridionale. Vol. 3. Zone A.* L. Wendt and M. Lundgren (eds.). Stockholm: 26-8.

1986. *Sicilian Architectural Terracottas*. Stockholm.

2001. “From huts to houses; the problem of architectural decoration,” in *From huts to houses. Transformations of ancient societies. Proceedings of an international seminar organized by the Norwegian and Swedish Institutes in Rome, 21 - 24 September 1997,* J. R. Brandt and L. Karlsson (eds.), Stockholm: 269-72.

Wikander, Ö. 1974. “Etruscan roof tiles from Acquarossa. A preliminary report.” *OpRom* 8: 17-28.

1986. *Acquarossa. Vol VI, Part 1. The Roof Tiles 1. Catalogue and architectural context.* Stockholm.

1988. “Ancient Roof Tiles - Use and Function.” *OpAth* 12: 203-216.

1990. “Archaic Roof Tiles. The First Generations.” *Hesperia* 59: 285-290.

1992. “Archaic roof tiles: the first (?) generation.” *OPAth* 19, 151-61.

1993. *Acquarossa: results of excavations conducted by the Swedish Institute of Classical Studies at Rome and the Soprintendenza alle antichità dell'Etruria meridionale. Vol. VI: The roof tiles, part 2: Typology and technical features*. Stockholm.

Wikander, Ö. and P. Roos. 1986. *Architettura etrusca nel Viterbese. Catalogo della mostra. Rome.* De Luca: Rome.

Williams II, C. K. 1978. “Demaratus and Early Corinthian roofs.” In *Στήλη. Τόμος εις μνήμην Νικολάου Κοντολέοντος,* Athens: 345-50.

Winter, N. 1993a. “The Greek background for archaic architectural terracottas of central Italy,” in *Deliciae fictiles : proceedings of the first International Conference on Central Italic Architectural Terracottas at the Swedish Institute in Rome, 10-12 December 1990*, E. Rystedt, C. Wikander, and Ö. Wikander (eds.), Stockholm: 17-20.

1993b. *Greek architectural terracottas from the prehistoric to the end of the Archaic period*. Oxford.

1999. “New information concerning the early terracotta roofs of Etruria,” in *Classical archaeology towards the third millennium. Reflexions and perspectives. Proceedings of the XVth International Congress of Classical Archaeology, Amsterdam, July 12 - 17, 1998,* Amsterdam: 460-463.

2000. “The early roofs of Etruria and Greece,” in *Die Ägäis und das westliche Mittelmeer: Beziehungen und Wechselwirkungen 8. bis 5. Jh. v. Chr.: Akten des Symposions , Wien 24. bis 27. März 1999,* F. Krinzinger (ed.), Vienna: 251-56.

2002/3. “Commerce in Exile: Terracotta roofing in Etruria, Corfu, and Sicily, a Bacchiad Family Enterprise.” *Etruscan Studies* 9: 227-36.

2009. *Symbols of Wealth and Power. Architectural Terracotta Decoration in Etruria and Central Italy, 640-510 B.C.* Ann Arbor.

Winters, R.K. 1974. *The forest and man.* New York.

Winthrop, R. 1991. *Dictionary of concepts in cultural anthropology.* New York.

Witmore, C. 2007. “Symmetrical archaeology: excerpts of a manifesto.” *World Archaeology* 39(4): 547–562.

Wright, G.R.W. 2000. *Ancient Building Technology, Vol. 1: Historical Background.* Leiden.

Zink, J. P. 2009. *Form and function: Interpreting the Woodland architecture at the McCammon Circle in central Ohio*. M.A. Thesis, Ohio State University.