The Zea shipsheds – new remarks on a tile deposit and other related finds

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Introduction

The Greek-Danish Zea Harbour Project is a cooperation between the Ephorate of Underwater Antiquities, The 26th Ephorate of Prehistoric and Classical Antiquities, and the Danish Institute at Athens. The project wish to express our thanks to the Archaeological Museum of the Piraeus and the Ephorate of Underwater Antiquities for providing working space for the author during research of the material presented.[1]

Context

Roof tiles were found during the land excavation of the upper ends of Shipsheds 16, 17 and 18 in the basement of Sirangiou 1 in 2002 (Fig. 3), and during the underwater excavation of Shipsheds 16, 17 and 18 in 2002 and 2003.[2] So far, only one undisturbed context has been found, while the remaining part of the material presented was excavated in disturbed contexts.

Fig. 28. Area 1, Shipshed 16, feature S17:U1 (Christensen 2002).

The pit (S17:U1)[3]

During the land excavation of Shipshed 17 a rock-cut pit (S17:U1) was found just north of ramp block (S17:R11)[4] in the southern part of Shipshed 17's frame-constructed ramp (Fig. 3). The feature is preserved well below the top surface of the ramp and is not structurally related to any identified shipshed remains. Inside the pit (Fig. 28) were found four large tile fragments (**1-3**, Fig. 29 (**1**)) intentionally stacked on top of each other, and some smaller tile fragments. In the top fill of the pit were found a rim fragment of a black-glazed kantharos (**14**, Fig. 30) and, at the bottom of the pit, an undiagnostic black-glazed kantharos fragment with incised graffito (**15**, Fig. 31). West of the pit in the fill of the north side of the foundation cutting of ramp block (S17:R11), and probably unrelated to the pit itself, was found a base fragment of a black-glazed fish-plate (**13**, Fig. 32)

Tile description

Complete tiles from the combined land and marine archaeological excavations at Zea remain to be discovered. A few tile fragments are large

[1] See Lovén *et al.*, p. 61, n. 1. Editor: D. Davis. Needless to say that remaining mistakes are the responsibility of the author.
[2] See Lovén *et al.*, p. 63-5, for a study on the phases of the area 1 shipsheds.
[3] Shipshed 17: Unidentified feature 1 = S17:U1
[4] Shipshed 17: Ramp feature 11 = S17:R11

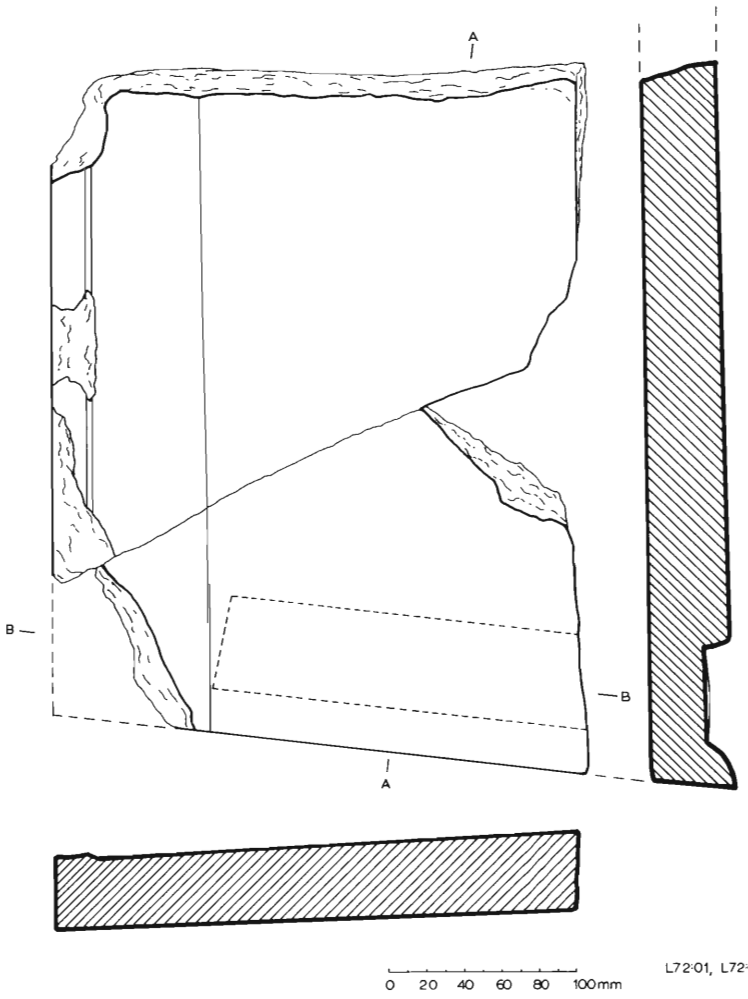

Fig. 29. No. **1**, corner fragment of Corinthian pan tile (Hooton 2002). 1:4.

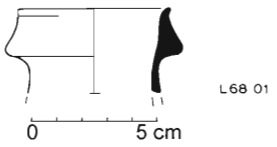

Fig. 30. No. **14**, rim fragment of a black-glazed kantharos (Hooton 2002). 1:3.

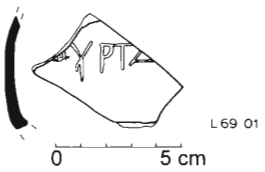

Fig. 31. No. **15**, undiagnostic black-glazed kantharos fragment with incised graffiti (Hooton 2002). 1:3.

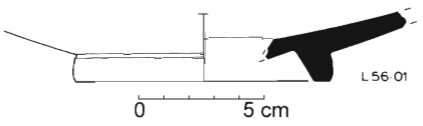

Fig. 32. No. **13**, base fragment of a black-glazed fish-plate (Hooton 2002). 1:3.

enough to reconstruct the shape of the pan tile, which will be presented in the following section. However, the majority of the tile finds are too fragmentary to provide any other information than the variety of fabric and colour, and will not be discussed here. Wikander's tile terminology is used (Fig. 33)[5] since Winter's terminology is less detailed.[6]

Pan tile

The majority of the excavated pan tile fragments are of Corinthian type. Two fragments with two sides preserved were found, and from them the first preliminary reconstruction of the shape is created.[7] However, it must be emphasized that the reconstruction is tentative and may have to be reconsidered if and when more material is found. Indeed, the form and shape of the two preserved sides under discussion may not, in fact, be applicable to all four sides.

No. **1** (Fig. 29) in the catalogue has a shallow raised border along one side of the top surface. The underside of the perpendicular side of the tile is divided into three parts: a shallow raised border,

[5] Wikander 1986, 15-17, fig. 1.
[6] Winter 1993, ii.
[7] Schaldemose 2003, 4-5, fig. 3.

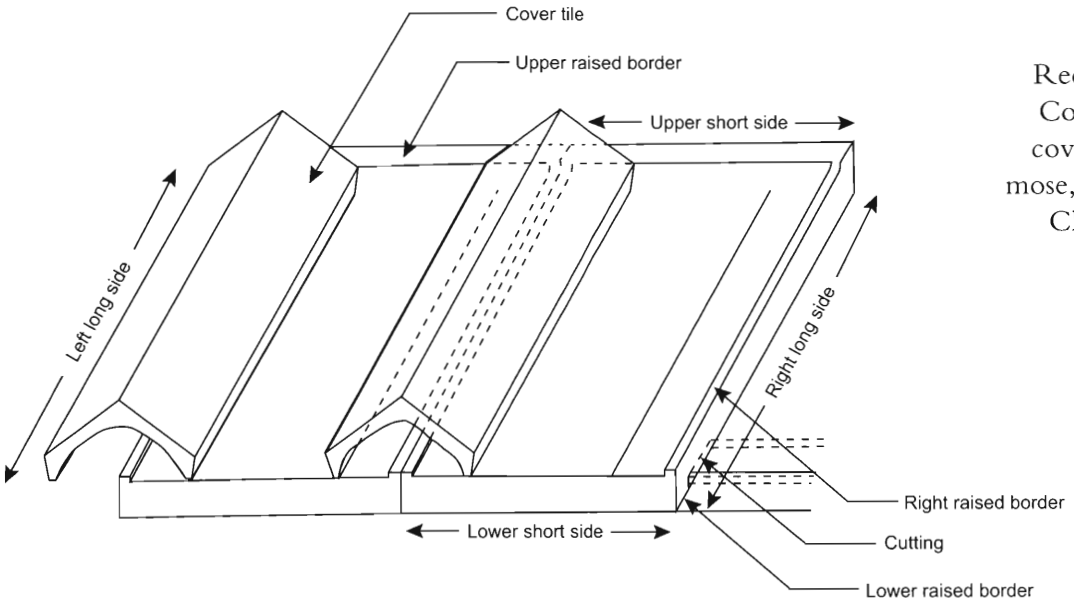

Fig. 33. Reconstruction of a Corinthian pan and cover tiles Schaldemose, Hooton, Klejn-Christensen 2007). 1:10.

a wide cutting and the surface of the tile. No. **5** (Fig. 34), a corner fragment, has a shallow raised border identical to no. **1**, while the other border is thicker. The shape of the fragments compares with the general shape of Corinthian pan tiles found in Attica,[8] and it is concluded that no. **1** is part of the left long side and the lower short side, while no. **5** is part of the right long side and the upper short side (Fig. 33).

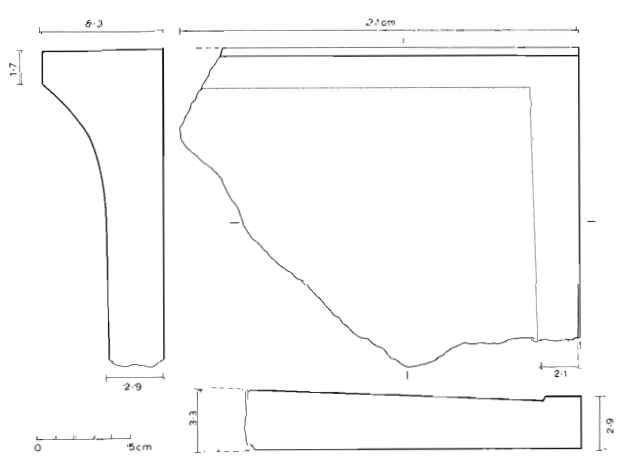

Fig. 34. No. 5, corner fragment of Corinthian pan tile (Hooton 2004). 1:4.

Description of the borders

The raised border of the upper short side is represented in nos. **4**-**6**.The width of the border is between 2.2 cm (**4**) and 2.5 cm (**6**) and it is between 2.3 cm (**4**) and 3.0 cm (**5**, Fig. 34) thicker than the surface of the tile. The lower short side is preserved only in no. **1** (Fig. 29), the underside of which is divided into three parts: a raised border along the lower short side, a transverse cutting and the surface of the tile. The border is 2.7 cm wide and curves with two radii towards the 5.1 cm wide cutting. The long sides are partially preserved in nos. **1**–**3** and **5**, all of which have a shallow raised border. The width of the border varies from 2.1 cm (**1**) to 3.0 cm (**2**), and their thickness varies from 0.2 cm (**3** and **5**) to 0.3-0.4 cm (**2**). The differences in width and thickness of the upper borders and the long borders respectively are too small to be anything other than small variations resulting from the skill of the tile-maker.

In general, Corinthian pan tiles have a higher raised border along the long sides than in the present reconstruction (Fig. 33).[9] It may be argued that the upper short side in the reconstruction is more probably part of the long sides, but until more

[8] Wikander 1988, 208, fig. 3, C2a, 2b; Winter 1993, 209-10.
[9] Winter 1993, ii, 82; Wikander 1988, 208.

diagnostic fragments are uncovered the present reconstruction stands.[10]

Eaves tile(?)

The lower left corner of no. **1** (Fig. 29) is not preserved, but enough of the two sides are preserved to establish that the angle of the corner was greater than 90° (in fact it measures 96.8°), and that the left long side of the pan tile tapers towards the lower side. The parallelogram shape suggests that this pan tile may have had a special position on the roof, along the eaves/valley or in the area next to the gables. No. **1** has remains of slip on both edges, demonstrating that it was moulded in this shape and not cut on site to fit an unexpected angle of the roof. Thus, in place of a common pan tile, we may have an eaves tile. However, it is likely that the upper short side and the two long sides of both tiles are similar to one another not only because the upper short side of the eaves tile would have to fit with the lower short side of the pan tile above it, but also because the long sides on both tiles would be covered by the same kind of cover tile.

At present, no. **1** is the only one of its kind from the Zea shipsheds, and it would be presumptuous to expect that the design of the underside of the lower short side of no. **1** applies to all regular pan tiles. But assuming that regular pan tiles would have a similar cutting along the underside, two pan tiles would be joined by the raised border of the upper short side locking into the corresponding slot on the underside of the lower short side of the next tile. This would prevent the tiles from sliding apart.

The width of the slot in no. **1** is wider than the raised borders of the upper short sides in nos. **4–6**. Similar features on regular pan tiles provided some flexibility when the roof was tiled, thus permitting the tiles to be slid back and forth to adjust to the total length of the sloping roof. This would leave room to compensate for irregularities in the individual tiles. The overlap between nos. **1** and **5** is about 5.0 cm. Assuming that the cutting along the underside of no. **1** is unique, its function could perhaps be related to fitting the tile to the battens of the wooden roof construction or fitting to the gutter.

The total length and width of the Zea pan tiles are unknown.[11] The preserved length of no. **1** is 37.6 cm and the preserved width of no. **3** is 35.3 cm. According to Wikander,[12] the most common length of Corinthian tiles varies between: 36.0 and 117.0 cm, and the width between 20.0 and 85.0 cm. Tiles from Rhamnous and the Kerameikos are between 60.0 and 73.0 cm long and 48.5 to 55.0 cm wide.[13] In Assos, a standard measurement of 40.0 × 45.3 cm was found for Corinthian tiles.[14] It is likely that the tiles from Zea fall within the above pan and eaves tile groups.

Cover tiles

The six cover tiles found at Zea are of the Corinthian gable-shaped type. The tops of the gable are preserved in nos. **7–12**, and the undersides of nos. **8–12** are curved. The base edge of the cover tile is partially preserved in no. **12**, whose estimated width is 18.2 cm (Fig. 35). The width of the cover tiles is also indicated by the slip along the long side of the top surface of no. **1**, which has a different colour than on the rest of the preserved top surface. This area was overlapped by a cover tile, while the rest of the tile was exposed to sun and precipitation. The width of the covered area measures ca. 8.0 cm: this dimension demonstrates that the cover tiles were at least 16.0 cm wide, thus fitting well with the width of no. **12**. The general width of Corinthian cover tiles varies from ca. 15.0 to 30.0 cm, with most falling between ca. 15.0 and 20.0 cm.[15] The tile width based on nos.

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[10] The staff at the American School Excavations at the Athenian Agora kindly allowed me to study their collection of roof tiles; type A tiles found at the tholos have a similar low raised edge, while the perpendicular underside has a wide cutting: see also Thompson 1940, 67, fig. 52. The tholos tiles are obviously of a very special design, yet they do indicate that the reconstruction of the Zea tiles, with their low raised border along the long sides, is not entirely unlikely. Special buildings, such as the shipsheds with their multiple roofs sloping in three directions, required tiles suited to their peculiar designs.

[11] The reconstruction Fig. 33 is thus not made to scale.

[12] Wikander 1988, 208.

[13] Winter 1993, 221.

[14] Bacon, Clark & Koldewey 1902, 71.

[15] Wikander 1988, 210; Winter 1993, 212.

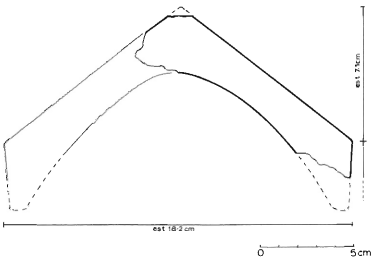

Fig. 35. No. **12**, fragment of Corinthian cover tile (Hooton 2004). 1:4.

1 and **12** compares well with the most common measurement for Corinthian cover tiles. Unfortunately, the cover tiles are too fragmentary to determine how any two were connected.[16]

Tile fabric

The fabric terminology employed in this study is based on Sanders 1999[17] and the Munsell® Colour Charts. The clay composition of the tiles from Zea has some similarities. The tiles are divided into two groups according to the colour of the clay. Group 1 (nos. **1-2**, **4-5**, **9-10**) is characterized by shades of beige colour ranging from very pale brown to light yellowish brown and pale yellow. Group 2 (nos. **3**, **6-7**, **11-12**) is characterized by a reddish beige colour ranging from reddish yellow to reddish brown and light reddish brown.

The fabric of the majority of the tiles is hard (nos. **1-4**, **6-9**, **12**); no. **11** is medium hard, while nos. **5** and **10** are soft. The difference in hardness may well be due to the different find circumstances: all tile fragments found on land excavation are hard, while all the softer fragments (desalinated) are from the sea, perhaps because they have been saltwater-logged.

The clay is coarse levigated with a general composition of lime, chamotte and black particles in different amounts and sizes. In addition, no. **8** has brown particles, no. **9** pebbles and no. **10** red particles. The fabric of groups 1 and 2 is similar to tiles found in the South Stoa I in the Agora.[18]

The majority of the tile fragments (nos. **1-10**, **12**) have a yellowish to beige slip on the top surface. The slip is well preserved on no. **1**, where the colour difference between the surface protected by the cover tile and the surface exposed to the sun and precipitation is considerable. No. **5** has a similar colour difference on the upper raised border, which was covered by the lower side of the next pan tile; this part has a darker colour than the rest of the tile. Tile fragments nos. **7**, **10** and **12** also have remains of a beige slip on the underside.

The undersides of tiles are, in general, of coarser composition than the top surface, a phenomenon probably caused in the manufacturing process. The tiles were made in a wooden frame, and the shaping took place on a worktable.[19] The table was covered with grit in order to prevent the clay from sticking to the table. Some of the grit is embedded in the tiles, leaving impressions, as seen on the underside of the tile, e.g. no. **3**.

Other finds

The rim fragment of a kantharos (**14**, Fig. 30) and the undiagnostic fragment from a kantharos with incised letters on the exterior side (**15**, Fig. 31) are briefly mentioned here because of their importance for understanding the chronology of the pit and the tiles. S.I. Rotroff has kindly helped with the dating of no. **14**.[20]

Kantharoi with moulded rims were produced from the 4th century BC.[21] The shape continues in the 3rd century BC, though it becomes rarer as the century wore on. The shape of the rim on no. **14** (Fig. 30) should probably be dated after ca. 380 BC. It compares with a kantharos of the second quarter of the 4th century BC found in the

[16] New information on the Zea cover tiles will be available when the 2006 finds have been studied.

[17] Sanders 1999, 477-78.

[18] I have studied several cover tiles found in room 6 in the South Stoa I. The tiles are mentioned in Thompson & Wycherley 1972, 76, n. 217. Thompson (1968, figs. 2-3) shows a reconstruction of the roof. They neither discuss the cover tiles in detail nor include any photos. The South Stoa is dated to 430-420 BC (Camp 1986, 122).

[19] Wikander 1993, 104.

[20] Correspondance of 02-12-2002 and 03-09-2006.

[21] Sparkes & Talcott 1970, 113, 118.

Athenian Agora (no. 705).[22] The shape of the kantharos fragment with incised letters (**15**, Fig. 31) is too small to provide any typological date. The shape of the upsilon and to a lesser degree the rho suggests a date in the sixth century BC.[23] Fragments incised with a similar upsilon were found in 5th century BC contexts in the Agora.[24] Obviously, dating by epigraphical evidence alone is a very unreliable method. The graffiti are too fragmentary to be interpreted. The base fragment of the fish-plate (**13**, Fig. 32) will be further discussed in the forthcoming publication.

A preliminary reconstruction of the roof arrangement[25]

Owing to the limited material, full reconstruction of the roofs of the Zea shipsheds is not yet achievable. However, the following conclusions may be drawn.

The shipshed complex at Zea harbour was one of the largest roofed building complexes of the Classical Period. A roof of Corinthian tiles covered one or more building phases of the shipsheds. A superstructure covered by tiles is more durable and offers better protection from fire caused either by natural, hostile or accidental means. Compared to a thatched roof or one made with wooden shingles, a tiled roof was an expensive solution.

Superstructures covered by Corinthian pan and cover tiles always sloped in at least one direction. The alternating shorter/longer interaxial spacing of the colonnades in the upper half of the Sirangiou shipsheds (Phase 3) suggests a saddle-roof design, i.e. sloping on two sides, and indicates that a saddle roof covered two ramps: the columns with the narrow interaxial spacing (2.16 m) carried the eaves, while the columns with the larger interaxial spacing (3.38-3.39 m) carried the ridge.[26] The longer intercolumniation provided more light, space and easier passage inside the shipsheds.

The shipsheds were also built on a slope inclined towards the sea. Thus, the complex of slopes (lateral and longitudinal) may have demanded a special placing and shaping of the tiles.[27] The shipsheds were built directly adjacent to one another, with one colonnade carrying the eaves of two adjoining roofs. This arrangement, known also as a butterfly roof, created valleys between the roofs that required some kind of solution for draining the water they collected.

In investigating the arrangement of the roof of the Zea shipsheds, comparative material from other shipsheds and other similar ancient buildings such as stoas has been taken into consideration.

Sloping

The inclination of the slanting roof is unknown.[28] In general, pan tiles were not fastened to the wooden roof construction (as suggested in Thuc. 3.22.4) and none of the 401 tile fragments found at Zea had signs of attachment holes.[29] The rough underside of the tiles increased the friction coefficients between the tiles and the woodwork, and between overlapping tiles, thus reducing the risk of the tiles falling off the roof.

The lack of fastenings in pan tiles limits the degree of the roof's inclination, since the higher gradient would apply more lateral force to the tiles and cause them to slide apart more easily. Scholars have calculated the maximum inclination of a tile roof. Brodribb[30] considers 30° as a maximum angle, and Rook[31] 35-40°. The angle of the roof

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[22] Sparkes & Talcott 1970, pl. 29.

[23] Jeffery 1998, 67.

[24] Sparkes & Talcott 1970, fig. 23 no. 1906.

[25] I am indebted to Mr. Richard C. Anderson, Architect of the Athenian Agora, and Drs. Jari Pakkanen and Henrik Gerding, respectively a co-director and a former staff member of the project "Ship-Sheds in the Ancient Mediterranean" at Royal Holloway, University of London, for discussing the roof construction with me. Any mistakes, however, are entirely my own.

[26] Dörpfeld's section drawing in Dragátsis 1885, pl. 2, shows the saddle roof construction.

[27] I am indebted to Dr. Jari Pakkanen for pointing out that unless the roof was build of horizontal sections, complex tile shapes would have been necessary.

[28] I have earlier (Schaldemose 2003, 7) proposed that no. **12** could be part of a ridge tile. It was, however, shown to be a cover tile, and consequently we have no indication of the inclination of the saddle roof.

[29] The majority of these tile fragments are not included in this article.

[30] Brodribb 1987, 10.

[31] Rook 1979, 295.

inclination in Greek Archaic temples is, according to Gàbrici,[32] on average 17°. According to Wikander,[33] roofs from the Archaic and Classical periods rarely exceed 15 to 25°. The relatively high raised border along the upper sides of pan tiles may suggest a steeper angle of the roof slope, and could in that case reduce the risk of tiles sliding apart. On the other hand, the lower limit of a tiled roof is at least 15° to prevent water from backing up under the tiles in heavy rain and wind.[34]

The longitudinal slope of the roof towards the sea is also unknown in absolute terms, but we can safely assume that the roof slope followed, at least approximately, the gradient of the wall dividing shipshed 16 and shipshed 26 to the north of 16, towards the sea. Owing to the need for further survey in Area 1 during the autumn 2006 campaign, the final calculations of the gradient and the roof will be presented in a forthcoming publication. However, it is most likely that the roof was constructed in one continuous slope to the sea, as reconstructed by Dörpfeld.[35]

Capitals

Capitals have not been discovered to date. If we assume that the roof maintained a continuous slope, then certain architectural elements would have been required between the top of the capital and the architrave to accommodate it to either a sloping abacus or an additional wedge-shaped block.[36]

Gutters

At present we have found no indications of how gutters were constructed in the valleys between two adjoining roofs, but some sort of arrangement was clearly required to prevent water from running into the shipsheds and drenching the wooden elements of the roof construction.

Several solutions are possible. One includes the use of Laconian pan tiles to serve as a gutter –a less-then-likely scenario at Zea, however, since we have found very few Laconian tiles.[37] At Oiniadai, by contrast, Laconian as well as Corinthian tiles were discovered.[38]

A second solution is that the gutter was made of terracotta and rested on the wooden valley beam beneath. A terracotta gutter, however, would have been constructed from several parts, and thus unless the gradient of the gutter towards the sea was rather considerable some water could penetrate the joins and damage the wooden construction beneath.[39]

A third solution is that the gutter may have been cut from wood and made waterproof with sheets of metal - this however would have been a very costly method of construction.[40]

A fourth solution is that the gutter was cut into a stone architrave, which at the same time could have replaced the valley beam as a support for the wooden rafters. A stone gutter is an expensive solution, but has the merit of being less likely to have had water penetration in the joins. An argument for a stone architrave design is the support offered by the narrower intercolumniation in the columns carrying the eaves and thus the ability of the columns here to carry heavier weight than those with higher intercolumniation. In fact, during investigations of the shipsheds in Mounychia, a stone block with a carved channel was found. Milchhöfer interpreted it as a gutter, but did not mention any slots for the wooden rafters along the exterior side of the block.[41]

An alternative scenario has rainwater being diverted into the interior of the shipsheds via drain

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[32] Gàbrici 1933, 181-2.

[33] Wikander 1988, 207-8.

[34] Wikander 1988, 207-8.

[35] Dörpfeld's plan drawing in Dragatzes 1885, plan 2; personal communication with B. Lovén.

[36] Capitals have been found in Oiniadai, but are not described in detail. See Kolonas 1989-90, 156.

[37] Laconian tiles amount to less than 10 per cent of the complete tile corpus.

[38] Kolonas 1991, 165.

[39] Compare that the minimum slope on a tile roof is at least 15°. See Wikander 1988, 207-8.

[40] It has been suggested by Dr. Jari Pakkanen that terracotta gutters also could have been made waterproof with lead lining: this theory was presented at the John Morrison Memorial Conference in Oxford in 2005.

[41] Milchhöfer 1881, 62, no. 69. Von Alten (1881,15) interprets the block as belonging to a ramp/keel runner.

pipes placed at some interval, then collected in large vessels to be used for drinking or ship maintenance.

Wooden roof construction

Stone blocks with slots for wooden roof elements have not been found at Zea, and so we base our reconstruction on other buildings with similar spans to cover, mainly stoas.[42] In the Zea shipsheds the roof was supported by columns at the ridge and at the eaves. If the columns were of the same height, it is possible that a post-and-lintel construction was used. The span of the roof on each side of the central colonnade averages 6.5 m. Such spans in temples were easily covered with a post-and-lintel system, and without the use of internal columns.[43]

In Philo's Arsenal, the purlins were supported directly on internal colonnades, with the crossbeams laid at the same level and with only a block between them and the ridge beam, instead of a post.[44] In the Zea shipsheds, with their central colonnade, it is possible that the columns carrying the ridge were higher than the eaves columns, and that the ridge beam was placed directly on them. This arrangement could make the crossbeam redundant. Similar constructions with a saddle roof carried by columns of different height are known from stoas.[45] However, the span of these stoas is smaller than the span of the Zea shipsheds. In the Stoa of Attalos in the Agora,[46] the roof of which was of post-and-lintel construction, a false ceiling was inserted above the inner aisle of the upper colonnade.[47] The ceiling of the aisle has a span of 6.60 m (interaxial).[48] However, in the interval in time between the construction of the shipsheds and that of the Stoa of Attalos, the spanning of ever larger spaces had apparently developed.

If the crossbeams were omitted in the Zea shipsheds, further roof support could have been applied by adding a beam at an angle from the upper part of the columns in the ridge colonnade towards the rafters, in a similar way to that in which the ceiling was supported in the Erechtheion, with struts inserted between the wall and purlins,[49] or to the hypothetical reconstruction of the roof in the Megaron of Demeter in Gaggera, but without the use of a truss.[50]

On the colonnade carrying the eaves either a stone architrave or a valley beam would have been placed. If the roof was of post-and-lintel construction, the ends of the cross beam could also have rested on the colonnades, but possibly placed further down the columns.[51]

The wooden rafters would have created a slope between the top of the ridge and the architrave or valley beam. Atop these would have been placed battens laid at right angles to the rafters. The tiles would have been positioned either directly on the battens, as in the Erechtheion and the Pinakotheke,[52] or with sheathing placed in between.[53]

The tiles in Philo's Arsenal rested on a clay bedding (IG II^2 1054, 58-9).[54] The same seems to have been the case for the gallery of the walls of Athens (IG II^2 167, 67-9),[55] but may not have been the case for other buildings. Hodge points out that the weight of the roof would be doubled, if not trebled, by a bed of clay spread all over the roof, and believes that clay was mainly used as a coating around awkward joins, such as those along the ridge and under the cover tiles.[56] This is supported by several ancient writers who mention the use of tiles as weapons.[57]

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[42] Coulton 1976, 211-94.
[43] Hodge 1960, 39.
[44] Lorenzen 1964, fig. 11; Marstrand 1922, figs. 61-2.
[45] Coulton 1976. figs. 11-12.
[46] The Stoa of Attalos was built during Attalos II's reign 159-138 BC. See Camp 1986, 172.
[47] Camp 1986, fig. 145.
[48] Travlos 1971, fig. 638.
[49] Paton *et al.* 1927, 76-7, fig. 49.
[50] Hodge 1960, fig. 8(b)3.
[51] Hodge 1960, 10b.
[52] Paton 1927, 368-69.
[53] Hodge (1960, Fig. 15) gives a description of the secondary timbers of the roof.
[54] Jeppesen 1958, 73. Hodge (1960, 65-6) questions the interpretation of the extensive use of clay.
[55] Caskey 1910, 305, pl. VI.
[56] Hodge 1960, 68, 75.
[57] For example, Thuc. 2.4.2, Xen. Hell. 6.5.9, Dion. Hal. 6.92.6.

Drainage and the placement of angled tiles

It has been proposed by Henrik Gerding[58] that special tiles were required since the shipshed roof sloped in three directions. Thus, instead of pan tiles laid in vertical lines, these special tiles would have been laid at slight angles in proportion to the gradient of the roof slope in the direction of the sea. Such placement would prevent rain water from spilling over the edges of the tiles as it runs down the roof. This theory requires the placement of specially cut tiles along the ridge and the eaves. No. 1 (Fig. 29), with its apparent parallelogram shape, does support this theory.[59] But it now seems that the angle at the lower side of no. 1 does not fit with the currently assumed downhill gradient of the roof slope. Consequently, further research in this aspect of the roof construction must wait until the gradient of the colonnade is finally calculated, and the angled arrangement of the tiles determined.

Opaion tiles?

The Zea shipsheds were open to the sea and to some extent along the sides. Interior longitudinal walls did, however, replace at least one colonnade (wall dividing Shipsheds 26 and 16), and, in the direction of the city of Piraeus, the shipsheds were bounded by a wall.

In Phase 3 the Area 1 shipshed complex consisted of at least ten shipsheds positioned adjacent to each other, with a reconstructed length up to about 70-80 meters,[60] thus leaving a large area of the interior poorly lit. It is possible that the "pediment" at the upper end of the slipways was open to allow light into the interior, and thus the height of the city wall would be placed at the level of the architrave and valley beam. Such a solution, however, raises the question of unguarded entry and overall security in the shipshed complex.[61] Pan tiles with skylight holes, or opaion tiles, have not been found at Zea, but are known from several sites in mainland Greece[62] and seem to have been used in stoas (such as at Corinth),[63] temples (Tegea, Bassai and Olympia),[64] secondary buildings (Nemea),[65] in private houses (Olynthos)[66] and in the tholos in the Athenian Agora.[67] Although opaion tiles typically have a raised edge around the opening to prevent rain water from dripping into the building (and at Acquarossa opaion tiles with a lid have been found),[68] their hypothetical usage at Zea, while letting in more light, would also have let in at least some rainwater, thus negating the primary purpose of the building – to protect triremes from rain. On the other hand, opaion tiles would have brought in more light for maintenance workers and more ventilation for drying out ships. If the roof had opaion tiles, the use of sheathing and clay bedding would probably be omitted as the two would minimize or completely annul the concept of opaion tiles.[69]

Closing remarks

There are still many open questions regarding the reconstruction of the roof of the Zea shipsheds. Some will hopefully be answered during the autumn 2006 campaign, others may never be answered, and indeed certain aspects of the roof construction will definitely remain hypothetical. The computerised reconstruction of the roof will be presented in the publication of the Area 1 shipsheds.

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[58] Dr. Henrik Gerding presented this theory at the John Morrison Memorial Conference in Oxford 2005. Further discussion on this topic regarding the Zea shipsheds has taken place between Henrik Gerding and this author.

[59] Schaldemose 2006, 49.

[60] The length calculation is preliminary (Lovén: 15.12.2006)

[61] In the Oeniadae shipsheds a drain was cut close to the back wall, suggesting that there was an opening between the back wall and the roof, since drainage was necessary in this part of the shipsheds. See Sears 1904, 232, n. 1.

[62] Dinsmoor 1950, 151, n. 3; Wikander 1983, 84-5.

[63] Broneer 1954, 87, fig. 61.

[64] Dörpfeld 1892, 17, fig. 10a.

[65] Miller 1976, 184-5.

[66] Robinson 1946, 49-50.

[67] Thompson 1940, 78 fig. 61. The tiles are ascribed to the second period of the kitchen building of the Tholos. Tsakirgis (2001, 174) noticed that the tiles bear no evidence of smoke and states that their function could have been building ventilation rather than fire and smoke ventilation.

[68] Wikander 1986, 38-41; Wikander 1983, 92.

[69] Hodge 1960, 72.

Dating the tile material

Did the tiles presented here cover the Zea shipsheds? The Corinthian tiles of Groups 1 and 2 are the only common types found during the excavations of Shipsheds 16, 17 and 18. They were found both on land and in the sea, and their distribution pattern strongly suggests that the tiles belong to these or nearby shipsheds. The tile fragments found in the pit in Shipshed 17 (S17:U1) probably belong to a building phase in the 5th or 4th century BC, whilst the pit was closed in the 4th century BC. In the top of the fill above the tiles a black glaze kantharos rim fragment was found, dated 375-350 BC.

The tiles in the pit had been used. The slip on the top surface of no. **1** shows which part of the tile was covered by the cover tile and which part was exposed to the elements. Perhaps the tile fragments lay scattered around the area of Shipsheds 16, 17 and 18 after the probable demolition of the shipshed complexes in 404/3 BC, or were destroyed and deposited during the building phases of the first half of the 4th century BC. On practical grounds, it is highly probable that the ramp of Shipshed 17 was constructed before the superstructure. The tiles were placed intentionally in the pit (Fig. 28), and it is reasonable to assume that tiles nos. **1** and **2** either lay broken nearby or were broken and placed inside. At the bottom of the pit and beneath the tile fragments was found an undiagnostic black glaze fragment with incised letters. The epigraphical evidence suggests a date in the 6th-5th centuries BC.

The preliminary conclusion is that the tiles found in the pit probably belong to the 5th-or less probably to the 4th century BC shipsheds. Similar tiles found in disturbed contexts both on land and in the sea could belong to the same phase, but it is not possible to ascribe them to a precise building phase either in the 5th or in the 4th century BC.

Bibliography

Alten, G. von, 1881
'Die Befestigungen der Hafenstadt Athens', in *Karten von Attika*, E. Curtius & J.A. Kaupert (eds.), Berlin, 10-22.

Bacon, F.H., J.T. Clarke & R. Koldewey (eds.), 1902
Investigations at Assos: drawings and photographs of the buildings and objects discovered during the excavations of 1881-1882-1883, Cambridge, MA.

Brodribb, G. 1987
Roman brick and tile, Gloucester.

Broneer, O. 1954
The South Stoa and its Roman successors, Corinth 4.

Camp, J.McK., II, 1986.
The Athenian Agora: Excavations in the Heart of Classical Athens, New York & London.

Caskey, L.D. 1910
'The roofed gallery of the walls of Athens', *AJA* 14, 298-309.

Coulton, J.J. 1976
The architectural development of the Greek stoa (Oxford Monographs on Classical Archaeology), Oxford.

Dinsmoor, W.B. 1950
The Architecture of Ancient Greece. An account of its historic development, 3rd ed. Revised. London, Toronto, Sydney & New York.

Dörpfeld, W. 1892
'Der Zeustempel' in *Olympia, die Ergebnisse der von dem Deutschen Reich veranstalteten Ausgrabung*, 2: *Die Baudenkmäler*, E. Curtius & F. Adler (eds.), Berlin, 4-27.

Dragátzes, I. 1885
"Εκθεσις περί τών εν Πειραιεϊ ανασκαφών', *Praktika tis en Athenais archaiologikis etairias*, 63-71, pls. 2-3.

Gàbrici, E. 1933
'Per la storia dell'architettura dorica in Sicilia', *MonAnt* 35, 137-262.

Hodge, A.T. 1960
The woodwork of Greek roofs, Cambridge.

Jeffery L.H. 1998
The local scripts of Archaic Greece. A study of the origin of the Greek alphabet and its development from the eight to the fifth centuries B.C. (Oxford Monographs on Classical Archaeology), Oxford. (2nd edit. by A.W. Johnston)

Jeppesen, K. 1958
Paradeigmata. Three mid-fourth century main works of Hellenic architecture (Jytland Archaeological Society Publications 4), Aarhus.

Kolonas, L. 1989-90
'Ανασκαφή Οινάδών τα νεώρια', *Archaiognosia* 6, 153-9.

Kolonas, L. 1991
'Οινάδες' *ArchDelt* 46, Chron. B' 1, 164-6.

Lorenzen, E. 1964
The arsenal at Piraeus designed by Philo and reconstructed after his description, Copenhagen.

Lovén, B., G. Steinhauer, D. Kourkoumelis & M.M. Nielsen 2007
'The Zea Habour Project: The first six years' *PoDIA* V, 1-13.

Marstrand, V. 1922
Arsenalet i Piræus og oldtidens byggeregler. En teknisk, matematisk, arkitektonisk, skibsbygningsteknisk, topografisk, filosofisk, historisk og æstetisk undersøgelse, Copenhagen.

Milchhöfer, A. 1881
'Der Peiraieus', in *Karten von Attika*, E. Curtius & J.A. Kaupert (eds.), Berlin, 23-72.

Miller, S.G. 1976
'Excavations at Nemea, 1975', *Hesperia* 45, 174-202.

Paton, J.M., L.D. Caskey, H.N. Fowler & G.P. Stevens, 1927
The Erechtheum, Cambridge, MA.

Robinson, D.M. 1946
Domestic and public architecture, Olynthos 12.

Rook, T. 1979
'Tiled roof' in Roman brick and

tile. Studies in manufacture, distribution and use in the western Empire, studies in manufacture, distribution and use in the Western Empire, A. McWhirr (ed.), (BAR-IS 68), Oxford, 295-301.

Rotroff, S.I. 1997
Hellenistic pottery: Athenian and imported wheelmade table ware and related material, Athenian Agora 29.

Sanders, G.D.R. 1999
'A Late Roman bath at Corinth, excavation in the Panayia Field, 1995-1996, Appendix 2: Fabrics', *Hesperia* 68, 477-8.

Sears, J.M., Jr. 1904
'Oeniadae VI: the ship-sheds', *AJA* 8, 227-37.

Schaldemose, M. 2003, 6 October. The Zea shipsheds – a tile deposit and other related finds, *www.zeaharbourproject.dk/publications.*

Schaldemose, M. 2006
'Zea Harbour Project' in *Videnskab & Kunst. Det Danske Institut i Athen*, E. Hallager *et al.* (eds.), Athens, 48-50.

Sparkes, B. & Talcott, L. 1970
Black and plain pottery of the 6th, 5th, and 4th centuries B.C., Athenian Agora 12.

Thompson, H. 1940
'The tholos of Athens and its predecessors' (*Hesperia* Suppl. 4).

Thompson, H.A. 1968
'Activity in the Athenian Agora: 1966-1967', *Hesperia* 37, 36-72.

Thompson, H.A. & R.E. Wycherley, 1972
The history, shape and uses of an Ancient city center, Athenian Agora 14.

Travlos, J. 1971
Bildlexicon zur Topographie des Antiken Athen, Tübingen.

Tsakirgis, B. 2001
'A chimney pot from the north slope of the Acropolis', *Hesperia* 70, 173-5.

Wikander, Ö. 1974
'Etruscan roofing-tiles from Acquarossa', *OpRom* 8, 17-28.

Wikander, Ö. 1983
'**ΟΠΑΙΑ ΚΕΡΑΜΙΣ** skylight-tiles in the ancient world', *OpRom* 14, 81-99.

Wikander, Ö. 1986
Aquarossa. Vol. VI, part 1, *The roof-tiles. Catalogue and architectural context* (Skrifter Utgivna av Svenska Institutet i Rom 38:6, 1), Stockholm.

Wikander, Ö. 1988
'Ancient Roof-tiles –use and function', *OpAth* 17, 203-16.

Wikander, Ö. 1993
Aquarossa. Vol. VI, part 2, *The roof-tiles. Typology and technical features* (Skrifter Utgivna av Svenska Institutet i Rom 38:6, 1), Stockholm.

Winter, N.A. 1993
Greek architectural terracottas: from the Prehistoric to the end of the Archaic period (Oxford Monographs on Classical Archaeology), Oxford.