

Digital roofs

Guidelines for the documentation of undecorated roof tiles

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Foreword

Large quantities of undecorated roof tiles are found at many archaeological excavations and surveys. Due to the number and size of the objects and their considerable weight, this type of find poses a challenge for documentation.

For this reason, undecorated roof tiles cannot always be systematically recorded during excavations. Often, only their general form is published in idealized drawings. Individual items are not consistently documented or published, which makes analysis—for example, of the manufacturing technique—significantly more difficult. Traces of processing that occurred before or after firing in order to adapt the tiles to a specific roof construction are also usually not taken into account in idealized reconstructions. As a result, there is a lack of larger published comparative collections for many locations and regions.

It is therefore currently neither possible nor intended to present a handbook of all roof tile types in the Mediterranean region with these guidelines. The notes merely explain documentation and classification criteria that have been developed and tested as part of the *digital roofs* project, which was launched in 2020 at the German Archaeological Institute (Fless – Rheeder 2021; Fless – Rheeder 2023).

The aim of the project is to develop and establish digitally supported workflows and documentation procedures that enable efficient recording while remaining appropriate to the material. The following information is based on extensive documentation and analysis of roof tiles from various sites. One focus was on the roof-tile finds from the Greek excavations at the Gymnasium of Olympia, which were carried out between 2013–2015 and 2021–2023 (Kolia – Leventouri – Mourtzini 2020; Kolia 2024). The roof-tile finds are documented as part of the *digital roofs* project at the invitation of Dr. Erofili-Iris Kolia from the Ephorate of Antiquities of Iliia. A second focus is the documentation of the completely preserved roof tiles from the Kerameikos in Athens, which could be carried out thanks to the support of Dr. Jutta Stroszeck, DAI Athens.

In order to meet the challenges of documenting undecorated roof tiles, three approaches were combined in the project:

- the optimization of the equipment used for documentation,
- the creation of a database configuration in iDAI.field, and
- the inclusion of an image glossary for the visual explanation of the terminology used.

In addition, the aim is to gradually present well-documented roof tiles, that is, to build up a compendium.

The focus of this guideline is on simple, undecorated roof tiles, rather than on decorated architectural terracottas. Particular emphasis is placed on the so-called laconian roof tiles, which are numerous in the archaeological record but have been comparatively neglected in scholarly research (Hamari 2023). The notes are expressly aimed at individuals without specialized expert knowledge who wish to gain an initial, practice-oriented overview of this extensive and heuristically interesting group of materials (Lang – Pantelidis 2020).

The following references and quotations serve primarily as an introduction to further reading. Additional important information can be found in individual excavation reports, which could not be fully taken into account here.

The documentation guidelines presented here are one of the results of the *digital roofs* project, in which Dr. Annalize Rheeder, the participants of the Spring School 2023, and the staff involved in the individual documentation campaigns played a major role. In particular, the following individuals should be mentioned: Konstantinos Biliadis, Antonie Brenne, Fabian Gapp, Melissa Huntgeburth, Konstantina Kanellou, Arnulf Kimmig, Jana Laska, Catarina di Matteo, Anne Merten, Baylie Mountifield, Eirini Papageorgiou, Benedict Puff, Elianor Sket, Marius Stork, Magdalini Valsamidou, Jan Wagenführ, and Kristina Zielke.

1_A brief history

Clay roof tiles can already be attested in the Early Bronze Age (Early Helladic period). The early tiles were flat, rectangular slabs without distinguishable under- or cover tiles and recall modern slate or wooden shingle roof coverings (Jazwa 2024).

For the Late Helladic period, the existence of roof tiles has been assessed differently in scholarly research. More recent excavations, however, have brought to light large numbers of under- and cover tiles in clear architectural contexts and have thus provided evidence for tiled roofs in the Late Mycenaean period (14th century BC) (Aravantinos – Fappas – Galanakis 2020).

Between the Bronze Age and the renewed introduction of roof tiles in the Archaic period, no continuous production or use can so far be demonstrated.

From the 7th century BC onwards, roof covering with specially shaped clay tiles begins in the Greek cultural sphere, initially in sacred buildings (Hamari 2019; Sapirstein 2008, 2009, 2016; Winter 1993, 2022). In the Archaic period, different systems developed with numerous variations, for example the Laconian roof system with curved under tiles (*stroter*) and curved cover tiles (*kalypter*), or the Corinthian roof system with flat under tiles (*stroter*) and polygonal cover tiles (*kalypter*). In addition, there are numerous hybrid forms and regional manifestations.

It is noteworthy that, in the Archaic period, the production of roof tiles begins with distinctly large and technically complex roof tiles. In the Classical and Hellenistic periods, by contrast, a stronger standardization can be observed.

The earliest terracotta roofs in Etruria and central Italy begin, for example, with finds such as those from Acquarossa in the Archaic period (7th century BC). These are hybrid systems with wide flat tiles and narrow, semicircular cover tiles (Wikander 2017, 2024). In addition, local innovations and experiments occurred at an early stage.

In many regions of the Roman Empire, Roman roofs continue the hybrid form in terracotta roofing, with flat under tiles (*tegulae*) and curved cover tiles (*imbrices*), while cover tiles made of marble, for example in Rome, tend to display a polygonal profile. (Hamari 2015, 2019; Shepherd 2006, 2007; Warry 2006a, 2006b). With reference to the Roman Empire as a whole, however, there are numerous divergent local traditions, such as the continuation of curved under tiles and hybrid cover-tile forms.

In Late Antiquity and the Middle Ages, a simple roof covering is added as a standard. This form of roof covering, known as the so-called monastery tile roof, with identically shaped, channel-shaped roof tiles (monk-and-nun), is still used for roofing today.

Depending on site and chronological context, roof tile forms are designated differently in scholarly research. For Roman sites, for example, the terms *tegula* for flat tiles and *imbrex* for cover tiles are used, while for Greek finds *stroter* is used for under tiles and *kalypter* for cover tiles of very different shapes. Traditional terms such as *stroter*, *kalypter*, *tegula*, and *imbrex* thus convey chronological or cultural interpretations that pose a problem for primary documentation and for the comparison of roof tile types. This results in the fundamental question of whether a Roman roof tile from Olympia in Greece should be designated with a Latin term on the basis of its chronological context or with a Greek term on the basis of its find location.

In the *digital roofs* project, the traditional terms are therefore replaced in the primary documentation by terms that describe the form. This facilitates recording, the comparability of database entries, and searching.

2_Glossary / Glossar

The following glossary provides an overview of the most important technical terms used in the *digital roofs* project. Since the project documentation is carried out in English, the English terms used in the database are juxtaposed with the German terms. The translations compiled here serve to standardize the vocabulary within the project. A more detailed explanation of the terms is provided at the relevant points in the text as well as through illustrations.

See Chapters 11 and 15.

Literature on ancient terminology: Hübner 1973; Gerding 2016.

Greek - Latin - digital roofs

singular	plural	Digital roof
<i>kalypter</i> (καλυπτήρ)	<i>kalypteres</i>	over tile
<i>strotēr</i> (στρωτήρ)	<i>strotēres</i>	under tile
<i>tegula</i>	<i>tegulae</i>	under tile
<i>imbrex</i>	<i>imbrices</i>	over tile

Englisch	German
combination tile	Kombinationsziegel
curved over tile (COT)	Gebogene Deckziegel
curved under tile (CUT)	Gebogene Unterziegel
drip edge	Wassernase
eave	Traufe
flat under tile (FUT)	Flache Unterziegel
gable	Giebel
groove	Nut, Rille
hip	Walm
hook	Haken
indentation	Ausschnitt bzw. Aussparung
insignificant multifind	Unbedeutender Sammelfund
interlocking components	Verbindungselemente
multifind	Multifund (Sammelfund)
notch	Einkerbung
polygonal over tile (POT)	Polygonale Deckziegel
pseudo interlocking components	Pseudo-Verbindungselemente
rabbet	Zurückgesetzte Fläche
raised border	Erhöhter Rand
raised strip	Schmale Leiste
recess	Zurückgesetzte Fläche
significant multifind	Bedeutender Sammelfund
single find	Einzelfund
slope	Dachfläche
under tiles	Unterziegel
valley	Kehle
monk-and-nun tiles	Mönch-und-Nonne-Ziegel

German	Englisch
Ausschnitt bzw. Aussparung	indentation
Dachfläche	slope
Einkerbung	notch
Einzelfund	single find
Erhöhter Rand	raised border
Flache Unterziegel	flat under tile (FUT)
Gebogene Deckziegel	curved over tile (COT)
Gebogene Unterziegel	curved under tile (CUT)
Giebel	gable
Haken	hook
Interlocking Components	interlocking components
Kehle	valley
Kombinationsziegel	combination tile
Mönch-und-Nonne-Ziegel	monk-and-nun tiles
Multifund (Sammelfund)	multifind
Nut, Rille	groove
Polygonale Deckziegel	polygonal over tile (POT)
Pseudo-Verbindungselemente	pseudo interlocking components
Schmale Leiste	raised strip
Bedeutender Sammelfund	significant multifind
Unbedeutender Sammelfund	insignificant multifind
Traufe	eave
Unterziegel	under tiles
Verbindungselemente	interlocking components
Walm	hip
Wassernase	drip edge
Zurückgesetzte Fläche	rabbet - recess

3_Workflow within the digital roofs project

As part of the digital roofs project, field campaigns were carried out at different sites. In addition to extensive work at the Kerameikos in Athens and in Olympia, shorter campaigns or Spring Schools took place in Pergamon, Pompeii, and Vulci.

The different find locations involved different challenges. At the Kerameikos, the task was to document completely preserved roof tiles measuring more than one metre in length. At the other end of the spectrum are the finds from the Greek excavation at the Gymnasium of Olympia, where the focus lies on the recording and classification of thousands of fragments. In the first four campaigns, approximately 40,000 fragments were documented in Olympia during four campaigns, each lasting three weeks.

The find contexts from the Greek excavation at the Gymnasium of Olympia (2013–2015, 2021–2023) offer a unique opportunity for documentation (Kolia – Leventouri – Mourtzini 2020; Kolia 2024). The roof-tile fragments, building bricks, and stones were largely deposited in the manner in which they had been removed as find complexes during the excavation. No prior selection between diagnostic (significant) and non-diagnostic fragments had been carried out. In this respect, the initial situation essentially corresponded to a real excavation context – with one decisive difference: there was no time pressure for processing comparable to that of an active excavation.

Given the large quantity of material, it was decided for the roof tiles from the Gymnasium excavation to carry out most of the processing directly next to the find-context piles. For reasons of space and time, most of the finds were sorted on site and only brushed. This method proved sufficient to reliably identify paint, stamps, or markings.



Fig. 3_1: Deposited find contexts from the Greek excavation at the Gymnasium of Olympia

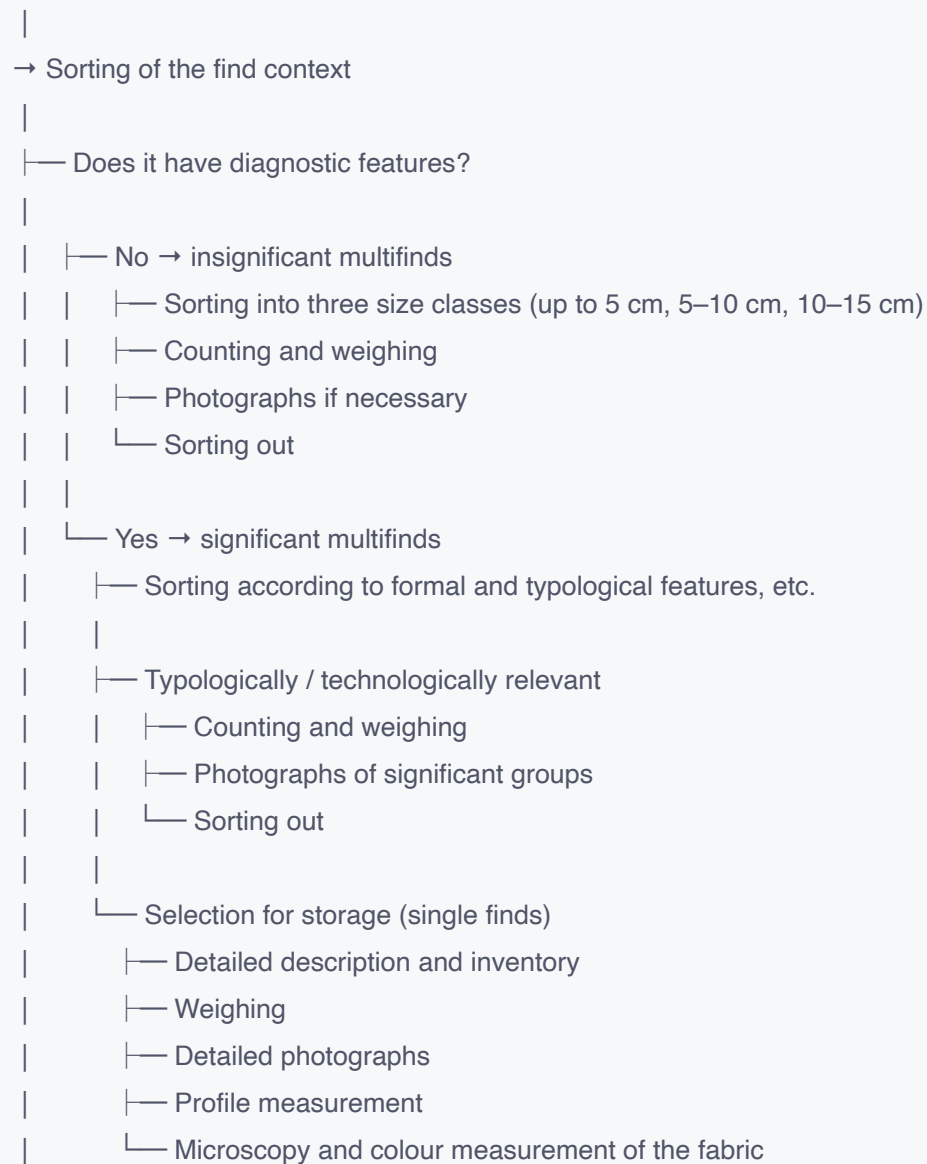
Find categories and documentation procedures

In order to process the large quantity of roof tile fragments efficiently, all finds are divided into three main categories:

- insignificant multifinds
- significant multifinds
- single finds

The following diagram reflects the practical procedure during processing: first, the find material is roughly sorted; it is then classified according to diagnostic features; and finally, particularly informative pieces are selected for detailed individual documentation.

Workflow



Insignificant multifinds

Very small fragments without edges, inscriptions, stamps, or other special features are recorded as insignificant multifinds. Although they have no individual significance for the classification of the finds, they are important for characterizing the degree of fragmentation and the composition of a find context.

Sorting is carried out according to three size classes:

- 0–5 cm
- 5–10 cm
- 10–15 cm

Measurements are taken pragmatically, for example using finger or hand widths, rather than with centimetre precision. The fragments are then counted and weighed by size class and, for exemplary contexts, photographed from both sides. This allows the degree of fragmentation and the very different states of surface preservation to be documented. These vary depending on whether the fragments derive from a collapsed roof (better surface preservation) or whether the fragments were reused several times for construction purposes (e.g. mortar adhering on all sides, heavily abraded surfaces). The data are recorded in the database in a general manner. Further information on colour, form, or state of preservation is only described in summary form where this appears meaningful.

Significant multifinds

All fragments that do not belong to the insignificant multifinds but are not stored individually are classified as significant multifinds. They display characteristics that are typologically or technologically relevant, without requiring more detailed documentation.

First, the roof tiles are divided into two main groups:

1. Large body fragments and lateral edges

For curved under tiles (CUT), curved over tiles (COT), and flat under tiles (FUT), large fragments without edges were only counted and

weighed. In the case of CUT and COT, the right and left lateral edges were also only counted and weighed.

2. Corners and typologically significant features

For corners, the typologically significant back of the CUT, and the front of the COT, additional photographs were taken. In the case of FUT, corners, lateral edges, and interlocking components were likewise documented photographically.

Subgroups are subsequently formed according to typological characteristics. See Chapters 16 and 17.

This differentiation allows large quantities of material to be processed efficiently without dispensing with the documentation of important typological features. At the same time, a sufficient number of fragments are documented photographically in order to record whether they are fragments of a collapsed roof (e.g. better surface preservation) or whether the fragments were reused several times for construction purposes (e.g. mortar adhering on all sides, heavily abraded surfaces).

Single finds

Individual fragments are treated as single finds if they are particularly informative for analysis or typology. These include:

1. fragments with inscriptions, stamps, or marks
2. types not previously documented
3. particularly well-preserved examples of known types
4. fragments with remarkable or well-preserved painting, a slip or coating, or special surface treatment

These fragments are documented individually. Documentation includes detailed photography, profile measurements using the Laser Aided Profiler, microscopic images of the clay/fabric obtained with a USB microscope, colour measurements, and a detailed description in the database. After processing, these pieces are stored individually and serve as reference material for subsequent analyses.

Classification of significant multifinds and single finds

The classification of significant multifinds and single finds is carried out consistently in a bottom-up manner during the processing of the finds, beginning with the individual object. The starting point is always the fragment's own characteristics—form, function, and technological details—from which typological and, ultimately, cultural-historical classifications are derived step by step.

Classification of significant multifinds and single finds



This procedure differs fundamentally from the structure of controlled vocabularies such as the DAI Thesaurus, which are organized top-down and arrange terms according to conceptual super- and subordinate categories. While the thesaurus provides the general object type roof tile, it does not offer tools for the identification of individual fragments or for deriving their functional and typological properties. Analytical classification therefore takes place below the object class defined by the thesaurus and in the opposite direction, but is nevertheless compatible with it.



Data entry

Data entry is carried out using a version of iDAI.field that has been specifically configured for the documentation of roof tiles. iDAI.field is available free of charge as open-source software and is a largely freely configurable image and context database that was developed for archaeological documentation processes during excavations (<https://fiel.d.idai.world/download>). It is, however, also suitable for use as an object database. The structure of the input forms and selection fields reflects the workflow described above and enforces a level of data depth adapted to the respective category.

For insignificant multifinds, for example, only the number of fragments and their total weight are recorded.

The screenshot shows a web-based data entry form. On the left is a vertical sidebar with the following items: 'Core', 'Insignificant amount' (highlighted in blue), 'Significant description', 'Significant amount', 'Storage', 'Unused fields', and 'Dimensions'. The main content area is divided into sections with labels and corresponding input fields:

- Core:** 'AMOUNT of SMALL fragments < 5 cm' with an empty input field.
- Insignificant amount:** An empty input field.
- Significant description:** 'AMOUNT of MEDIUM fragments >= 5 cm and < 10 cm' with an empty input field.
- Significant amount:** An empty input field.
- Storage:** 'AMOUNT of BIG fragments >= 10 cm and <= 15 cm' with an empty input field.
- Unused fields:** An empty input field.
- Dimensions:** Three sections:
 - 'WEIGHT [g] of SMALL fragments < 5 cm' with an empty input field.
 - 'WEIGHT [g] of MEDIUM fragments >= 5 cm and < 10 cm' with an empty input field.
 - 'WEIGHT [g] of BIG fragments >= 10 cm and <= 15 cm' with an empty input field.

Fig. 3_2: Screenshot: iDAI.field – recording of insignificant multifinds

For significant multifinds, this means that an initial, coarse classification is carried out according to function and according to the profile between the right and left side, for example under tile > flat or under tile > curved.

The screenshot shows a web-based data entry form for function and profile classification. It is divided into two main sections:

- Function main:** A group of radio buttons for selecting the function. 'Under tile' is selected (checked). Other options include 'Over tile', 'Combination tile', 'Sima', 'Revetment', 'Akroterion', 'Monk and Nun tile', 'Single form tile', 'Chimney', and 'Unknown'.
- by Profile:** A group of radio buttons for selecting the profile. 'Flat' is selected (checked). Other options include 'Curved', 'Pentagonal', 'Triangular', 'Hybrid (pentagonal and curved)', 'Other', and 'Unknown'.

Fig. 3_3: Screenshot: iDAI.field – recording of function

Within the significant multifinds, it is advisable to form groups of similar roof tile forms and types. How these groups are formed depends on the composition of the find contexts. Thus, for example, in the case of curved under tiles, all rear right and left corners with a comparable form of the interlocking or pseudo-interlocking components can be recorded, weighed, and photographed together. However, they are counted

separately for the right and left corners.

The screenshot displays a software interface with a sidebar on the left and a main form area on the right. The sidebar contains several menu items: 'Core', 'Insignificant amount', 'Significant description', 'Significant amount' (highlighted in blue), 'Storage', 'Unused fields', and 'Dimensions'. The main form area is titled 'Weight [g]' and contains several input fields. At the top, there is a 'Weight [g]' label and an 'Add...' button with a green circular icon. Below this is a 'Thickness' label and another 'Add...' button with a green circular icon. The form then lists four corner types, each with an associated input field: '01 CornerBackRight', '02 CornerBackLeft', '03 CornerFrontRight', and '04 CornerFrontLeft'.

Fig. 3_4: Screenshot: iDAI.field – recording of number and fragments of significant multifinds

For single finds intended for storage, detailed descriptions of traces of production, the fabric, and the colour of the clay and surface are additionally recorded. These objects receive their own data records with complete individual object documentation and serve as reference material for further typological and technological analyses.

Equipment and working environment

For efficient processing carried out directly next to the find contexts, the following equipment has proven effective:

1. Coolant scales

These scales are capable of recording large weights of up to 50 or 100 kg as well as individual smaller fragments with a high degree of accuracy. They tolerate substantial temperature differences and are robustly constructed for industrial use.

2. Photo station

Folding buffet tables with white surfaces have proven to be the most

robust and cost-effective option for a photographic background. On top of these, a frame constructed from aluminium profiles with dimensions of 100 cm × 90 cm × 80 cm (width × height × depth) was placed. A diffuser fabric forms a photo tent that allows photographs to be taken even under changing light and shadow conditions. Over the course of the campaigns, several options for mounting the camera were tested, each with its own advantages and disadvantages.

3. Notebook tent

The computers connected to the camera (tethering) were placed in a notebook tent, which allows them to be used without difficulty even in direct sunlight.



Fig. 3_5: Photo station

Literature on the project: Fless – Rheeder 2021; Fless – Rheeder 2023.

Recommendations for the documentation of roof tiles: Hamari 2019, 137–144.

4_Functions of ancient roof tiles

One of the greatest challenges in the construction of ancient roof structures was the production of a permanently watertight roof covering. A roof covered with roof tiles therefore had to fulfil several functions simultaneously:

- The roof tiles had to form a continuous, water-repellent surface on which rainwater could run off quickly.
- At the same time, they had to securely cover the joints between the individual roof tiles in order to prevent the penetration of water.
- In addition, it had to be taken into account that wind can force rainwater underneath the roof tiles. The form and laying of the roof tiles therefore also had to create an effective barrier against this.
- At the highest point of the roof, the ridge, or also at a hip, additional protection was required in order to prevent the ingress of water and damage caused by wind even at these exposed locations.
- Finally, specific technical solutions had to ensure that rainwater was drained in a controlled manner at the eaves without damaging the underlying wall structures.
- And, of course, effort, colour, and decoration could also convey aesthetic and semantic meaning.

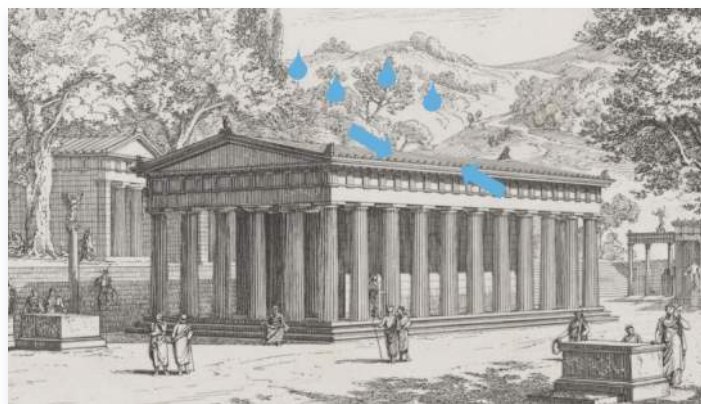


Fig. 4_1: Modified representation of the Temple of Zeus at Olympia (drawing: Olympia II, 1896)

5_Roofing systems

Most ancient buildings have only a limited number of basic forms of roof construction, determined by the geometry of the building. The most common are monopitch roofs (sloping on one side) and gable roofs (two sloping roof planes that meet at the ridge).



Fig. 5_1: Front of the Temple of Hera in Olympia with a gable roof (drawing: Olympia II, 1896)

In addition, roof forms over circular or polygonal ground plans are found, which require specific constructional solutions. At the Philippeion in Olympia, the rows of cover tiles run radially towards the centre of the circular building. While the cover tiles generally did not have to be specially shaped for this purpose, the under tiles had to be adapted towards the centre and taper towards the roof centre.

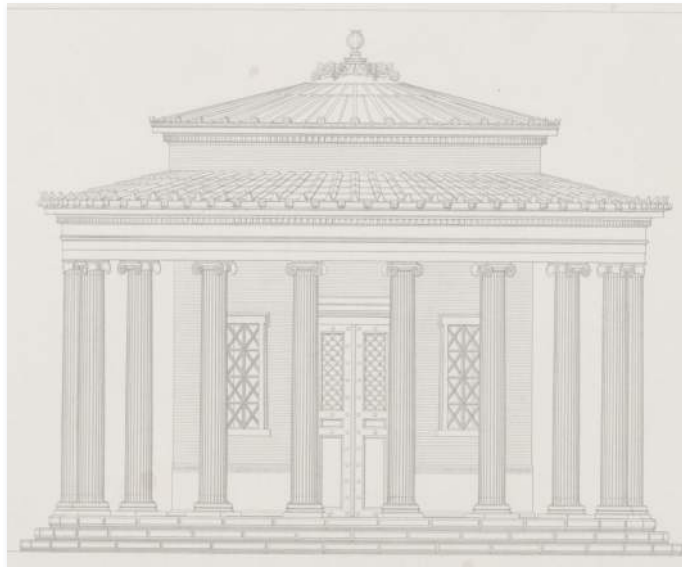


Fig. 5_2: Philippeion in Olympia (drawing: Olympia II, 1896)

In addition, roof forms with internal or external angles occur, for example in hipped and valley roofs. Here, ridge and valley lines require special tile shapes in order to ensure a closed, water-conducting roof covering. See Chapter 17.4.

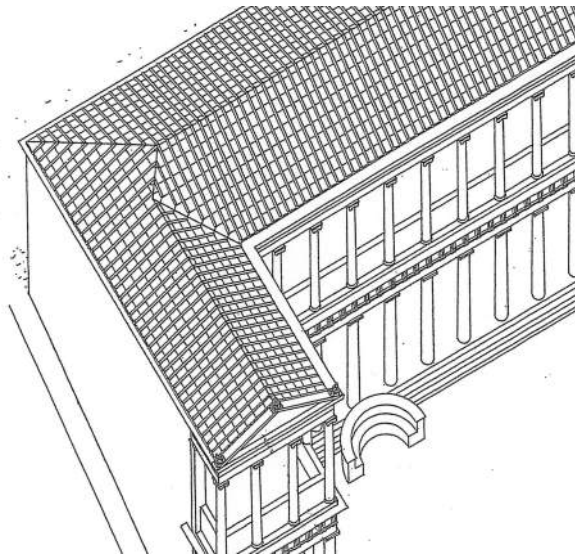


Fig. 5_3: Stoa of the Agora in Solunt with hip and valley (drawing: M. Wolf)

Selected further reading: Centola 2018, Hodge 1960, Klein 1998, Ulrich 2007.

6_Water drainage

The devices on roofs for the drainage of rainwater in ancient cities were always only part of more complex systems for the drainage and collection of water. Here, only three basic solutions for the drainage of rainwater at the roof edge are listed:

1. Direct runoff over the eaves tiles

Rainwater runs largely unhindered over the eaves edge of the roof tiles. Channeling can be achieved by the roof tiles becoming narrower towards the eaves or, for example, by the lateral edges being drawn in towards the eaves edge.

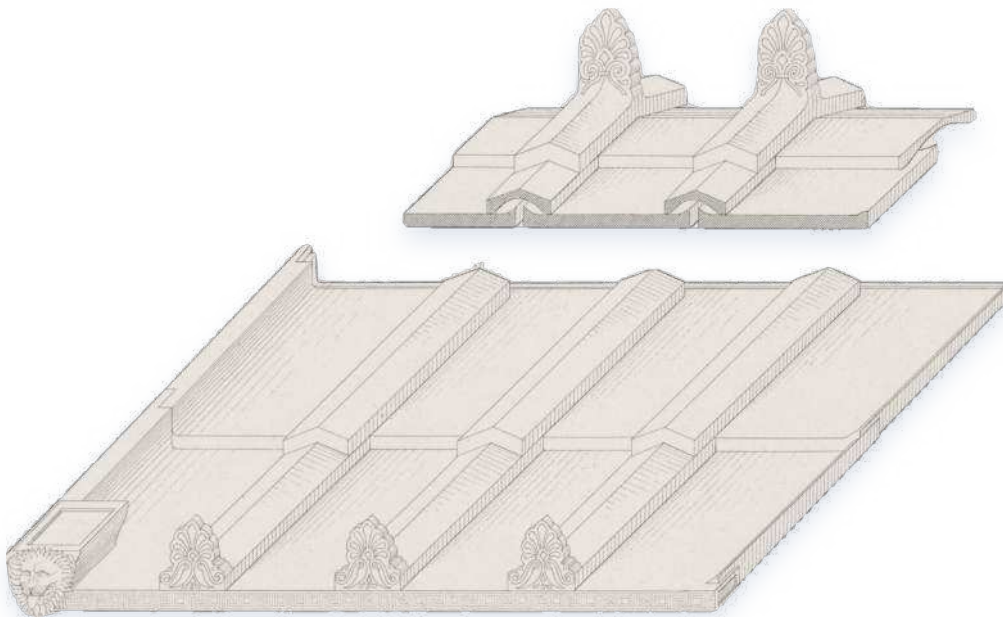


Fig. 6_1: Eaves tiles without further channeling of water at the roof edge (drawing: Olympia II, 1896)

2. Drainage via a sima with waterspouts

A sima forms a raised edge at the eaves, which retains the rainwater and directs it in a targeted manner to regularly arranged waterspouts, through which it flows off in a more controlled way.

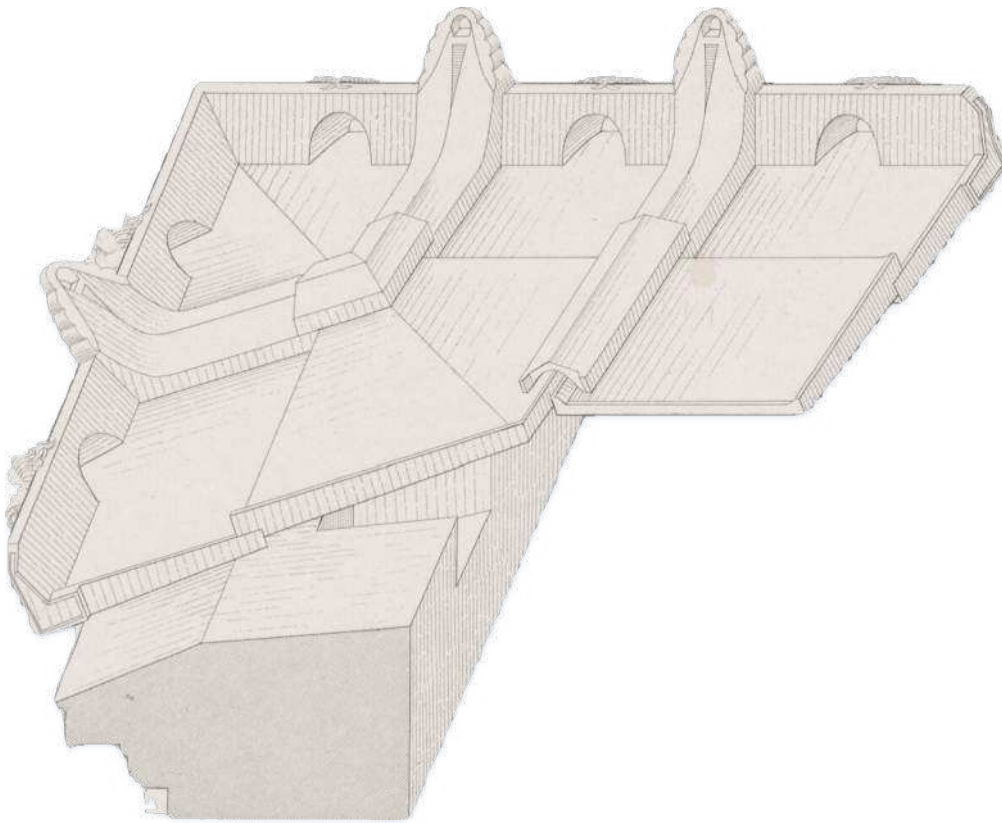


Fig. 6_2: Eaves tiles with a sima and lion-head waterspouts (drawing: Olympia II, 1896)



Fig. 6_3: Sima with tubular water drainage (drawing: Olympia II, 1896)

3. Drainage via gutters

Rainwater is collected by a gutter and drained via short pipes attached laterally or vertically. Downpipes could be connected to these. Examples have been published for the eastern Mediterranean region (for this specific type see, for example, Bingöl 1976; Sarantidis 2013; Sarantidis 2015).



Fig. 6_4: Roof tile with gutter and attachment for vertical drainage (Kerameikos in Athens: Z 575, Z 724, Z 728)

Literature: Kavas 2012; Klingborg 2017, 35–36; Papaioannou 2014.

7_Classification terminology

The classification of ancient roof tiles in the digital roofs project is based on a multi-level system which, with regard to database entry, allows for precise documentation and comparison across sites, chronological contexts, and building traditions. It follows the workflow of excavation documentation in that the fragments are first documented in purely formal terms and only subsequently subjected to typological classification or assigned to roofs. This system takes into account both the shape of the individual roof tiles and their combination within a roof assemblage, insofar as this is known, as well as their technical and production-related characteristics.

Form

Form describes the individual roof element in its basic geometric shape. A distinction is made according to the cross-profile of the tile (e.g. curved under tile, flat under tile, curved/polygonal over tile). Form constitutes the basis of the classification, as it is largely independent of chronological context, find location, or workshop and allows for an initial assignment as well as cross-cutting searches within the database. See Chapter 11.

System

System describes the combination of different forms on a roof. It designates the formal and functional unit that results from the combination of several forms (e.g. Laconian system = combination of curved under tiles and curved cover tiles; Corinthian system = flat under tiles with polygonal cover tiles, etc.). The system is thus defined by the combination of forms. See Chapter 12.

Type

Type designates the specific configuration and technical characteristics within a form. It describes characteristic features such as specific functional elements and shapes. Subtypes can, of course, also be defined. Type is important for dating. See Chapters 16 and 17.

Series

Series describes the specific production line, production batch, or workshop attribution within a type. Here, workshop-specific details, dimensions, clay composition, and also painting are recorded, allowing conclusions to be drawn regarding dating, production, trade, or the organization of construction projects. For the definition of series, markings by craftsmen or workshops as well as stamps are of particular importance.

Group

Group brings together several types that are linked by functional, regional, or chronological similarities.

Interlocking components

Interlocking components are structural elements on ancient roof tiles that are specifically intended to mechanically connect rows of tiles to one another. They prevent lateral or vertical displacement and ensure stable overlapping. Such components can take various forms, including strips, raised borders, recesses or hooks. They constitute an essential typological feature for technical classification, the reconstruction of roof systems, as well as for dating and attribution to workshops. See Chapter 15.

Pseudo interlocking components

Pseudo interlocking components refer to design features or elements whose function cannot be clearly determined and which, at first glance, appear to act as connecting elements but do not fulfil any demonstrable mechanical function for fixing adjacent tiles. These include, for example, engraved lines or profiles that allow neither clear interlocking nor hooking. In the digital roofs project, these elements are recorded separately. They are of great importance for typology, yet at the same time they are not easily distinguishable from markings made by craftsmen or workshops. See Chapters 16 and 17.

Marks

Different types of marks occur on the top and underside of ancient roof tiles. These include stamps, imprints such as animal paw prints or finger lines, also referred to in research as signatures, as well as incisions. These marks may have been created before firing. In the case of incisions, however, they may also have been added later, for example as assembly or alignment marks. See Chapter 18.

8_Orientation

Within the project, it was agreed that roof tiles are described according to their intended position on the roof. A distinction is made between a rear side oriented towards the ridge and a front side oriented towards the eaves. Accordingly, the right and left edges as well as the corners are also described.

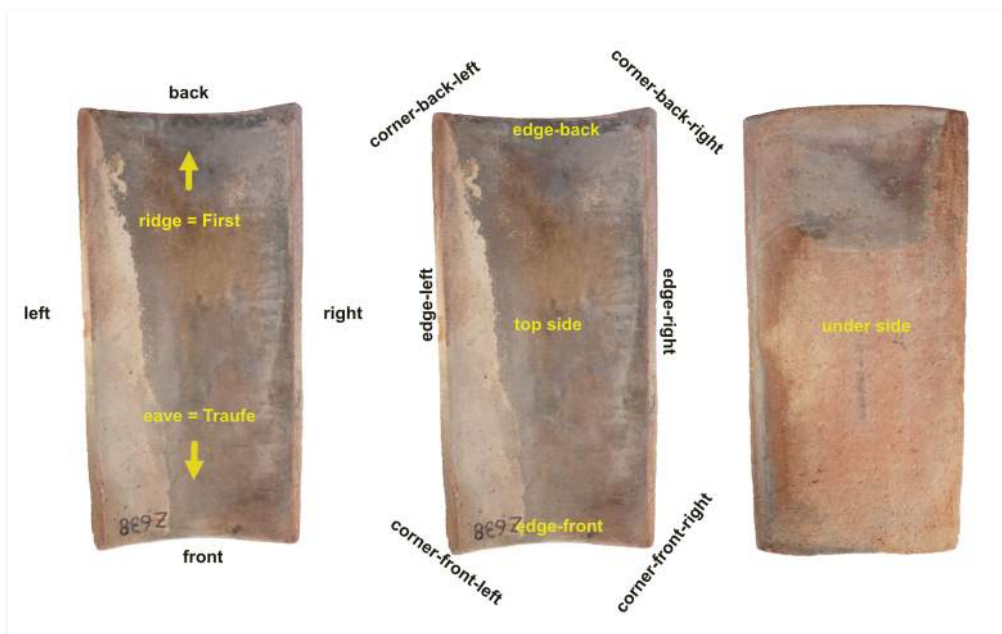


Fig. 8.1: Athens, Kerameikos Z 638

Note on ridge tiles: For roof tiles that cover the ridge, the principle of orientation differs. In these cases, the position must be defined individually, as a clear front and rear side, such as can be identified for flat tiles and under tiles laid on the roof slope, cannot be defined in the same way.

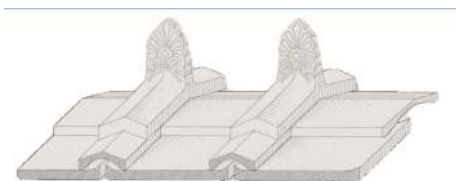


Fig. 8.2: Ridge tile of a Corinthian roof (Treasury of Megara) from Olympia (drawing: Olympia II, 1896)

9_Top side and underside

Ancient roof tiles generally exhibit a clearly smoothed top side and a rougher underside. The top side in particular may additionally be provided with paint or a coating (slip). Sometimes, however, a similar effect can also occur as a result of smoothing with water.

This distinction between the treatment of the top side and the underside is helpful even for the identification of small fragments. In the case of curved under tiles, for example, the smoothed surface is located on the inward-curving side, whereas for curved over tiles it is found on the outward-curving surface.



Fig. 9.1: Olympia, curved under tile (CUT) (without inventory number OLY-DE-MAG-00251-1993), dated by stamp to the 2nd century AD

The undersides of roof tiles provide information on different manufacturing processes. Some examples show traces of scraping or smoothing on the underside (scraping or wiping marks), while others preserve remains of a parting agent made of sand, ash, or similar materials. Such materials prevented the clay from sticking and facilitated the removal of the roof tile after forming.



Fig. 9.2: Curved under tiles (CUT) from Olympia, Gymnasium OLY-GYM-2013-2015-P17-S0018 and OLY-GYM-2013-2015-P17-S0041, showing different treatments of the underside



Fig. 9.3: Curved under tile (CUT) from Olympia, Gymnasium OLY-GYM-2013-2015-P17-S0006, remains of a parting agent

Literature on production: Winter 1993; Sapirstein 2008; Sapirstein 2009; Warry 2006a.

Examples of videos on the manual production of roof tiles:

1951, Sardinia: <https://www.youtube.com/watch?v=Zvus5bKre2U> (Abruf: 06.02.2026); 1991, Spain: <https://www.youtube.com/watch?v=GVhvzRY00Jc> (Abruf: 06.02.2026); 1997, Italy: https://www.youtube.com/watch?v=OLN129kE_tM&t=8s (Abruf: 06.02.2026); 2025, Ukraine: https://www.youtube.com/watch?v=9r_aui0Gd3I (Abruf: 06.02.2026).

10_Classification by function

In addition to classification by form, roof tiles in the *digital roofs* project are also classified according to their position and function within the roof construction. The function of a tile has a significant influence on its form and technical design. Six main positions can be distinguished: roof slope, eave, ridge, hip, valley, and gable.

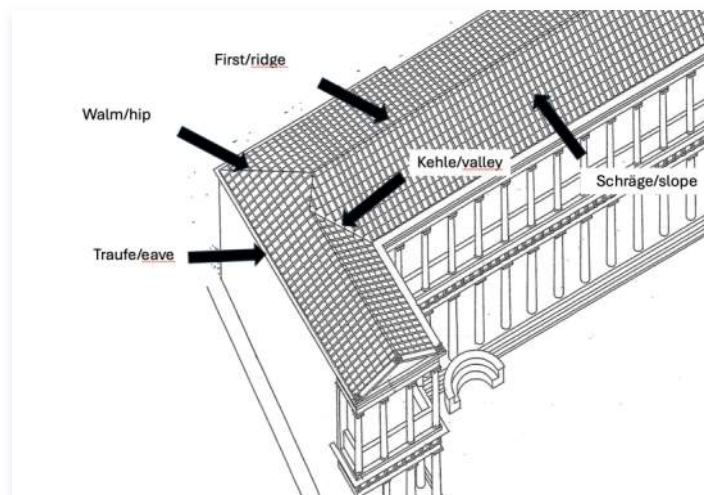


Fig. 10.1: Schematic representation of the main positions on an ancient roof (modified drawing, after M. Wolf)

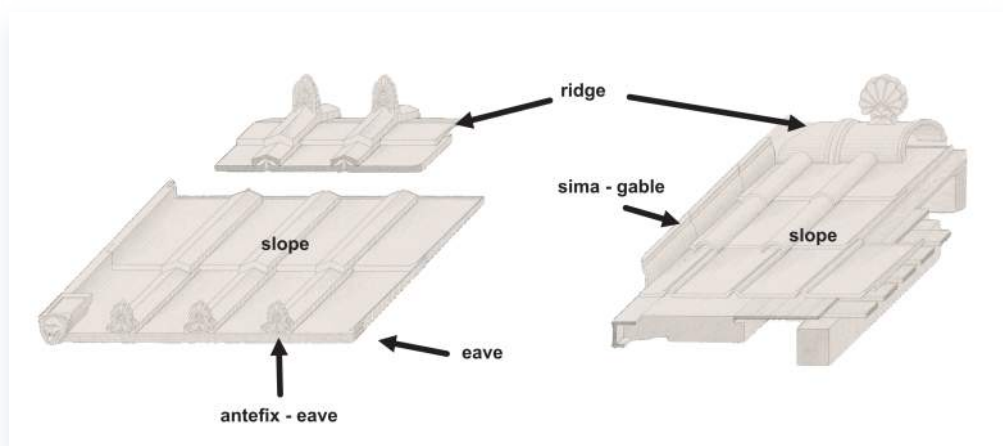


Fig. 10.2: Schematic representation of key positions on an ancient roof and exemplary configurations of roof edges (modified drawing after Olympia II, 1896)

Ancient roofing systems employ, for these respective positions, in part specific roof tile forms that are precisely adapted to the functional requirements. In other cases, standard tiles fulfil several functions.

Roof slope

This is the inclined surface between ridge and eaves on which the majority of roof tiles are laid. Rainwater is directed here vertically towards the eaves.

Eave

The lower termination of the roof slope, where rainwater is deliberately discharged in order to prevent damage to the underlying building elements or foundations. Eaves tiles, sima tiles, waterspouts, gutters, or special drip elements (drip noses) support the controlled drainage of water at this position.

Ridge

The ridge forms the uppermost line of the roof, where two roof slopes meet. Here, roof tiles must be used that provide a secure closure and prevent the ingress of rainwater.

Hip

The hip denotes the outward-facing angle between two roof slopes. At this position, special hip tiles may be required to ensure adequate coverage and to prevent water penetration. Roof tiles adjacent to the hip must be correspondingly chamfered along the hip line.

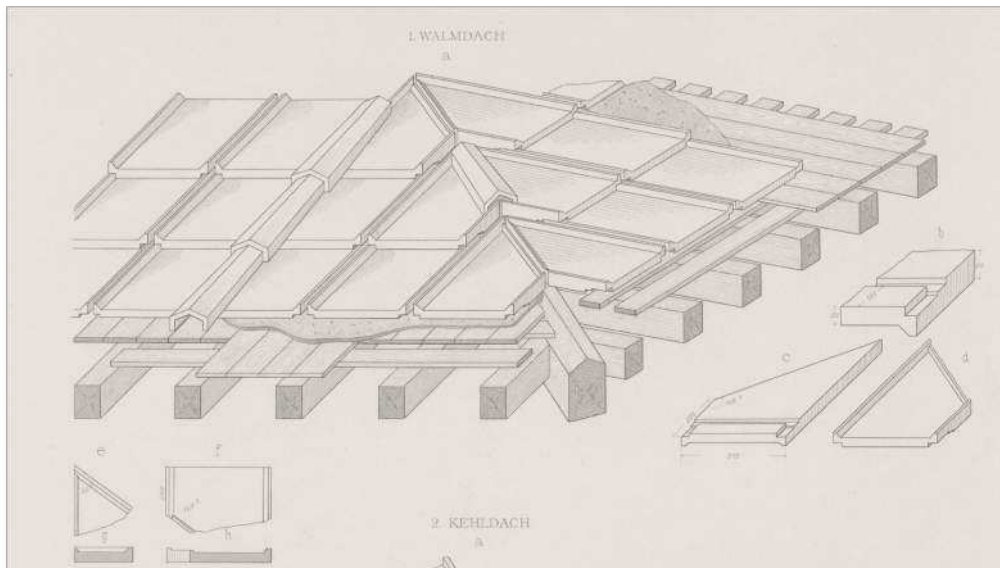


Fig. 10.3: Reconstruction of a hipped roof covering (drawing: Olympia II, 1896)

Valley

The valley is the inward-facing angle where two roof slopes meet. At this position, special roof tiles may be required in order to reliably channel the water flowing together from the roof slopes towards the eaves. Roof tiles adjacent to the valley must be correspondingly chamfered along the valley line.

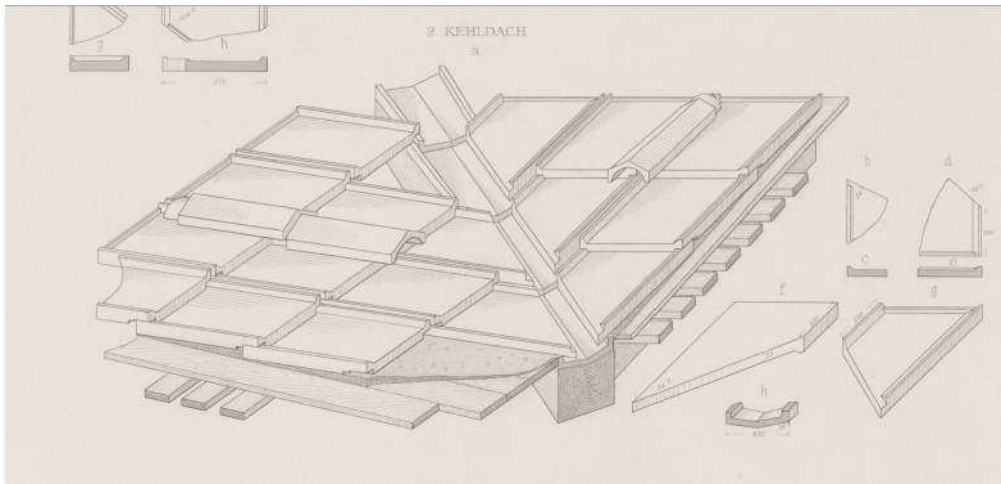


Fig. 10.4: Reconstruction of a valley roof (drawing: Olympia II, 1896)

Gable

Along the gable sides of the roof, one function of the roof tiles was to direct rainwater deliberately towards the eaves and, especially in more elaborate buildings, to decorate the gable side.

11_Classification by form

In the *digital roofs* project, roof tiles are classified, as a first step, according to their basic geometric form. For the purposes of this study, the neutral terms under tile and over tile are used in a functional sense. The central form-descriptive criterion is the cross-sectional profile between the left and right sides. This form-based classification is applied in a neutral manner, independent of find location, chronology, or workshop, and forms the basis for further typological, functional, and system-related classifications. The main basic types are distinguished below.

Under tiles

Curved under tiles (CUT)

Elongated rectangular roof tiles with a shallow concave cross-section, usually tapering towards the eaves. Towards the rear edge, the tile typically increases in thickness and may display a specific formal feature, such as a pseudo-interlocking component.



Fig. 11.1.1: Example with a simply thickened rear edge and a handprint on the underside (Athens, Kerameikos Z 614)

Flat under tiles (FUT)

Square to rectangular roof tiles with a flat cross-section and raised lateral edges. Additional interlocking components are usually formed at the front and rear.

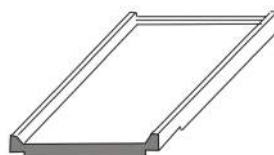


Fig. 11_1_2: Idealised representation of a FUT

Hybrid under tiles (HUT)

Rectangular roof tiles with a hybrid cross-section, for example with a flat underside and a concave top side. Additional interlocking components are usually formed at the front and rear.

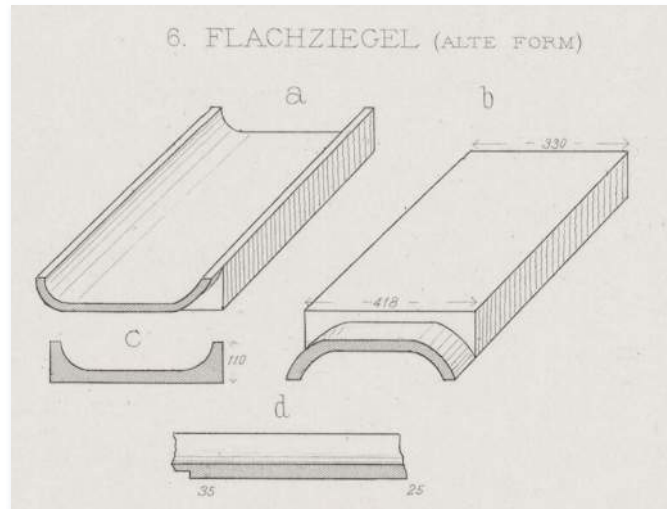


Fig. 11_1_3: Reconstructed representation (drawing: Olympia II, 1896)

Over tiles

Curved over tiles (COT)

Elongated rectangular roof tiles with a strongly curved, convex cross-section. They may widen slightly towards the eave and usually display interlocking or pseudo interlocking components at the front edge, more rarely at the rear edge.

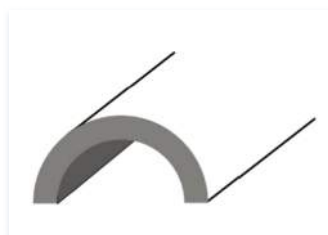


Fig. 11_2_1: Idealised representation of a COT

Polygonal over tiles (POT)

Elongated rectangular roof tiles with an outer cross-section that may be triangular (triangular) or pentagonal (pentagonal). The inner cross-section may be rounded. Interlocking components may occur at the front and rear edges as well as on the underside.

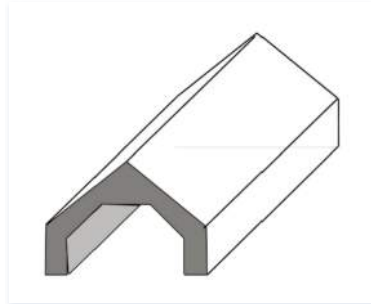


Fig. 11_2_2: Idealised representation of a pentagonal POT



Fig. 11_2_3: Idealised representation of the profile of a triangular POT

Hybrid over tiles (HOT)

Elongated rectangular roof tiles with an outer cross-section that initially rises vertically and then transitions into a convex profile. Profile strips may occur at the transition points. The cross-section may vary slightly. Interlocking components may occur at the rear edge.



Fig. 11_2_4: Idealtypische Darstellung des Profils eines HOT

Special forms

Combination tiles

Rectangular to square roof tiles in which flat under tiles and polygonal cover tiles are formed in a single piece.

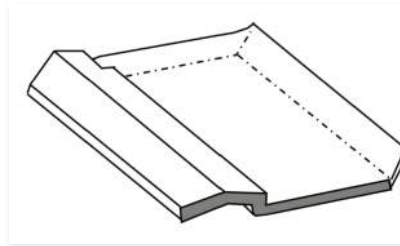


Fig. 11_3_1: Idealised representation of a combination tile

Monk-and-nun tiles

Elongated rectangular, narrow roof tiles in which under tiles and cover tiles share the same basic design. The channel-shaped under tiles (nun tiles) taper towards the eaves, while the semicircular cover tiles (monk tiles) widen towards the eaves. At the eaves, the orientation of the tiles may be reversed.



Fig. 11_3_2: Experiment using modern roof tiles and idealised representation

Other special shapes occur at the intersections of the roof slopes and at the roof edges ((see Chapter 17.4). The wide variety of decorated roof terracottas, as well as other special tiles, will not be discussed further here, as extensive publications on these are already available.

12_Classification according to roof system

The most important ancient roof systems are presented below in their ideal-typical forms. In this context, the term system refers to the combination of specific roof tile forms within a roof construction. These combinations may vary considerably between regions and can, in some cases, be characteristic of particular chronological phases.

Laconian roof system

The Laconian roof system is characterised by broad, shallowly curved under tiles and narrow, curved over tiles. Individual find contexts suggest that curved under tiles may also have been used as cover tiles.

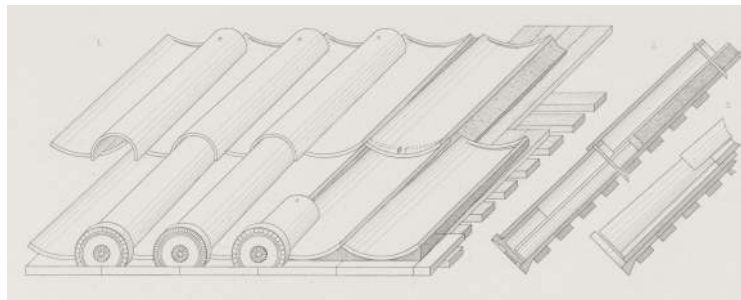


Fig. 12_1: Reconstruction drawing of the roof of the Temple of Hera in Olympia (drawing: Olympia II, 1896)

Corinthian roof system

The Corinthian roof system employs flat under tiles with raised lateral edges in combination with polygonal over tiles, which may be triangular or pentagonal in shape.

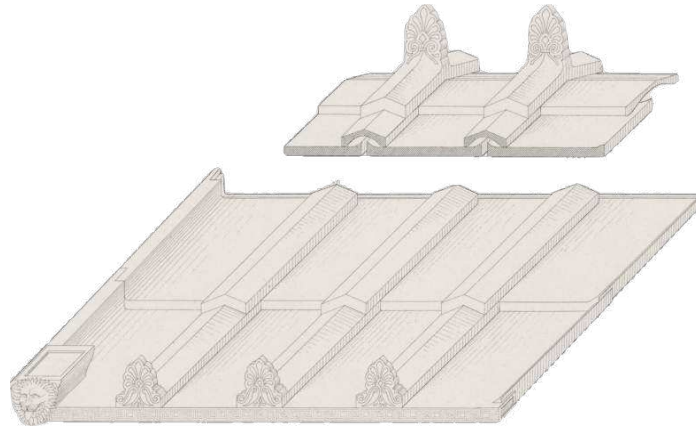


Fig. 12_2: Reconstruction drawing of a Corinthian roof in Olympia (drawing: Olympia II, 1896)

Hybrid roof system

The hybrid roof system combines flat under tiles with semicircular cover tiles. This configuration is also typical of most Roman terracotta roofs, which continue this hybrid principle by pairing flat under tiles with curved over tiles.

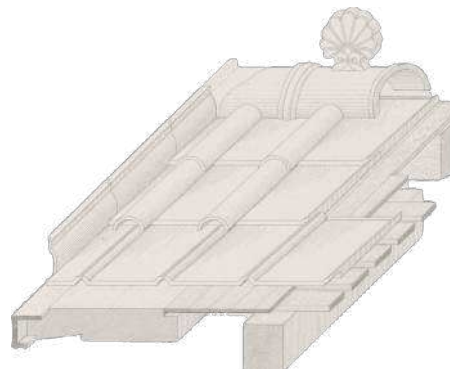


Fig. 12_3: Reconstruction drawing of a hybrid roof in Olympia (drawing: Olympia II, 1896)

Monk-and-nun system

This system uses identically shaped, gutter-like tiles as both under tiles (nun tiles) and cover tiles (monk tiles). Evidence from post-antique roofs shows that in some cases the orientation of the cover tiles at the eaves may be reversed.



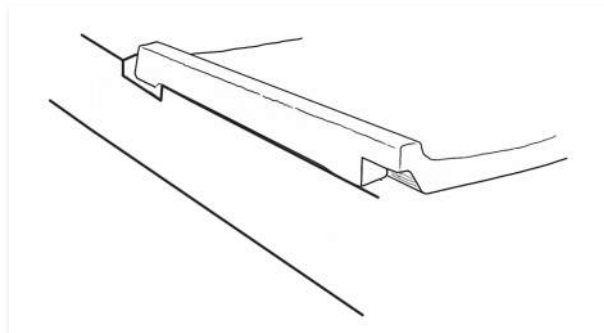
Fig. 12_4: Messene (Mavromati), Agios Ioannis (2024)

Variations

While these roof systems are understood as ideal-typical models, archaeological evidence demonstrates a wide range of regional adaptations and variations. For example, roofs such as an Archaic roof from Selinunte may combine polygonal and semicircular cover tiles (Jonasch 2009). Further variations are related to the use of different materials. On Roman marble roofs, polygonal cover tiles are frequently attested, whereas in Pompeii terracotta roofs predominantly employ curved cover tiles. In Olympia, hybrid cover tiles dating to the Roman period are also documented, combining semicircular and polygonal forms.

13_Methods of fastening

A particular feature of ancient roof tiles is that, unlike modern roof tiles, they were generally not hooked onto battens, screwed, or nailed in place. There are, however, exceptions. Some marble under tiles from the Acropolis in Athens, for example, display marble bosses or marble hooks on the rear underside. These indicate that the tiles were hung into corresponding notches in the roof rafters.



*Fig. 13_1: Sketch of the fastening of the marble “flat tiles” on the Acropolis of Athens, based on the current presentation on the south side of the Parthenon

In most cases, the roof tiles of ancient roofs simply rested loosely on the roof structure. Fastening holes occur occasionally on cover tiles, but more frequently on eave tiles. Examples include the cover tiles of the Heraion at Olympia, which show round nail holes on their rear side, and the eave tiles of the Leonidaion, which feature rectangular openings for fastening to the geison.

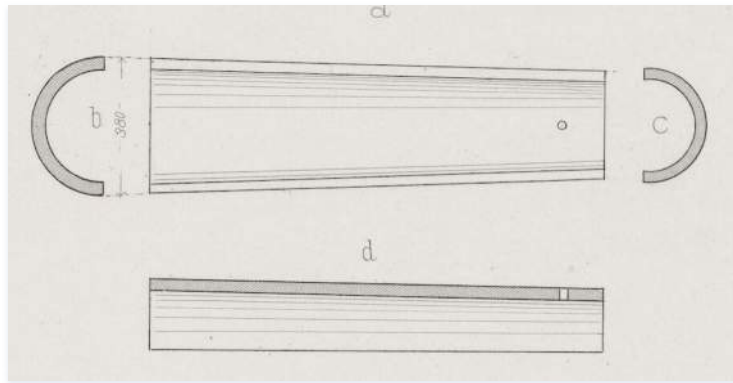


Fig. 13_2: Reconstruction drawing of a cover tile from the Heraion at Olympia with a round fastening hole on the rear side (drawing: Olympia II, 1896)



Fig. 13_3: Sima tile from the Leonidaion at Olympia, based on a 3D model, with a rectangular opening for fastening to the geison (Olympia, roof tile storeroom, inv. 04R394)

Since the majority of undecorated roof tiles show no fastening devices, it has been discussed in scholarship whether the tiles rested, for example, on continuous wooden lathing set into a mortar bedding, or directly on roof rafters or individual battens without additional fixation. The archaeological evidence suggests that both solutions were used.

As most ancient roof tiles were not fixed with nails or hooks, the majority must have been held in position solely by their own weight or by a mortar bedding. The thrust force ran along the roof slope from the ridge towards the eaves, where the lower rows of tiles absorbed the pressure exerted by the tiles above. Accordingly, ancient roofs generally exhibit lower pitches than modern roofs. For roofs at Olympia, Heiden reconstructed slopes of approximately 10–15° (Heiden 1995, 13, 24, 29, 135).



Fig. 13_4: Modern roof in Aigeira. The curved roof tiles rest in rows on the roof rafters without fastening (2025)

In modern roofing, many clay roof tile types are equipped with complex interlocking systems that provide mechanical connections both longitudinally and laterally. In ancient roof tiles, comparable systems generally occur primarily in the longitudinal direction, that is, along the roof slope from ridge to eaves. The systems of vertical connection differ markedly between curved and flat under tiles. Exceptions include, for example, sima tiles at the gable edge and Corinthian combination tiles, which additionally display lateral overlap.

Selected further reading on fastening: Heiden 1995; Sarantidis 2015.

14_Weight and dimensions

In comparison with modern roof tiles, ancient roof tiles were remarkably large. Modern interlocking clay tiles usually have an overall length of approximately 43–49 cm and a width of about 25–30 cm; tiles of the so-called monk-and-nun system measure around 40–50 cm in length.

By contrast, the roof tiles of the Temple of Hera at Olympia reach a reconstructed length of about 125.5 cm (cover tiles) and widths of approximately 60 cm (under tiles) and 38–39 cm (cover tiles). At the Heraion, only four rows of roof tiles were therefore sufficient to cover a single roof slope of the temple from ridge to eaves.

Evidence for the standardisation and norming of Laconian roof tiles is provided by standard measures displayed on the Agora in Athens, as well as in Messene and Assos. At these sites, roof tiles in standard dimensions were represented in relief and publicly exhibited—comparable to procedures used for the standardisation of measures and weights (Stevens 1950).

Exemplary measurements of fully preserved curved under tiles from the Kerameikos in Athens

Inv. no.	Length	Width	Weight
Z 647	80 cm	43 cm	14,895 kg
Z 655	84,5 cm	47 cm	13,880 kg
Z 638	88,5 cm	46 cm	14,480 kg
Z 618	99 cm	51 cm	14,095 kg
Z 641	100 cm	50 cm	15,295 kg
Z 620	100 cm	50 cm	14,940 kg
Z 615	100,5 cm	52 cm	15,985 kg
Z 617	103 cm	53 cm	20,795 kg

For curved under tiles (CUT), width can be recorded either as the internal measurement (clear width between the inner edges) or as the external measurement (outer edge to outer edge), both at the front (eaves) and at the rear (ridge). It is therefore essential to define consistently where measurements are taken within a project. Comparing the front and rear widths allows the degree of tapering to be determined (separately for internal and external measurements). Due to handmade production, dimensional variation is to be expected, even though the moulds or wooden frames used in production generally defined the intended size.

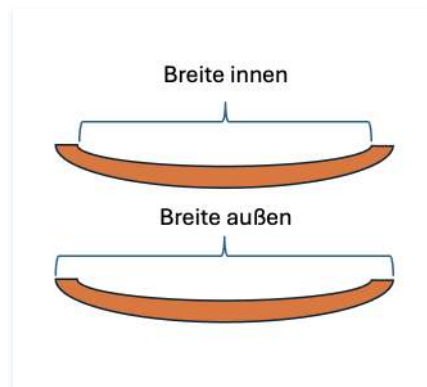


Fig. 14_1: Diagram of a cross-section through a CUT

Tile Z 647, with a length of 80 cm, shows approximately the following widths:

- profile at the front, internal: 37 cm
- profile at the front, external: 41 cm
- profile at the rear, internal: 40 cm
- profile at the rear, external: 43.5 cm

Tile Z 641, with a length of 100 cm, shows approximately the following widths:

- profile at the front, internal: 43 cm
- profile at the front, external: 45 cm
- profile at the rear, internal: 47 cm
- profile at the rear, external: 50.5 cm

Exemplary measurements of fully preserved flat under tiles from the Kerameikos in Athens

The ratio of length to width varies between a factor of 1.09 (almost square) and 1.35 (clearly elongated). At individual sites, this ratio can reach values of up to 1.40 (70.5 × 50.5 cm; Özcan 2022, cat. no. S13).

Inv. no.	Length	Width	Weight
Z 652	56,5 cm	50,5 cm	19,485 kg
Z 669	66 cm	52 cm	20,130 kg
Z 662	67 cm	55 cm	24,480 kg
Z 717	68 cm	56 cm	20,465 kg
Z 708	69 cm	56 cm	23,545 kg
Z 668	70,5 cm	56,5 cm	29,295 kg
Z 701bis	71,5 cm	54 cm	23,185 kg
Z 583	72 cm	66 cm	24,980 kg
Z 651	74 cm	55 cm	21,955 kg
Z 626	74 cm	55,5 cm	26,360 kg

Weight

A modern roof covering with interlocking tiles weighs between 35 and 55 kg/m², depending on the product. If a Laconian roof tile of type Z 620 (Kerameikos) was used, the two under tiles required to cover one square metre would weigh to approximately 30 kg, to which must be added the weight of two over tiles.

The total weight of a Laconian roof covering therefore does not differ significantly from that of modern roofing systems. The situation is quite different, however, in the case of the considerably heavier Corinthian tiles, where the flat under tiles alone weigh around 20 to nearly 30 kg each.

Among the finds from Olympia there are also fragments of significantly smaller roof tiles. This applies both to a flat Roman under tile and to curved roof tiles. Smaller dimensions are not surprising, since alongside large temple buildings there were also smaller building types, such as naiskoi (small cult buildings), whose roofs likely employed correspondingly smaller tile formats.

15_Terminology of interlocking components

Interlocking components are fundamental for the development of a typology. The term refers to constructive elements on roof tiles that create a mechanical connection or overlapping guidance between individual tiles. They secure the position of the tiles on the roof and prevent lateral or vertical displacement. A clear distinction between interlocking components and pseudo interlocking components is not always straightforward or possible.

Descriptions are oriented to the position of the tile on the roof, that is, the front side (eaves), rear side (ridge), and the right and left sides.

Interlocking components are key indicators for:

- the reconstruction of ancient roofing systems
- the technical classification of individual tile forms
- typological classification within form and system groups
- attribution to workshops or regional building traditions
- chronological assessment

There is no standardized terminology in current scholarship; terms vary depending on publication, author, and region. In the *digital roofs* project, the following terms are used:

Indentation

A cut-out or opening extending through the entire thickness of the roof tile, usually located at the front left or right corner of flat under tiles (FUT).

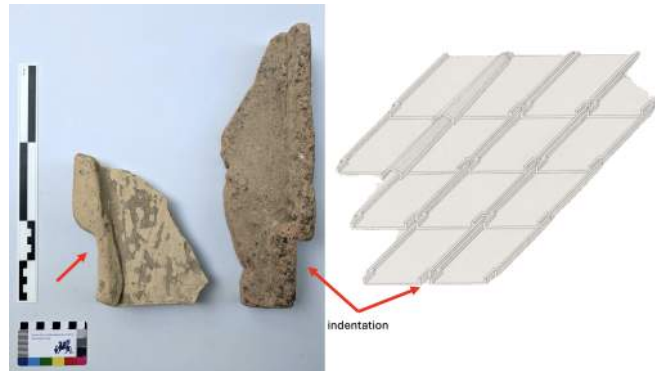


Fig. 15_1: Roof tiles from Olympia, Gymnasium P21-S0001 and P10-S0012, reconstruction of a Roman roof in Olympia (drawing: Olympia II, 1896)

Notch

A notch may occur, for example, on the underside of the front right or left corner, as well as on the upper surface of the lateral raised border of flat under tiles (FUT) in the rear area.

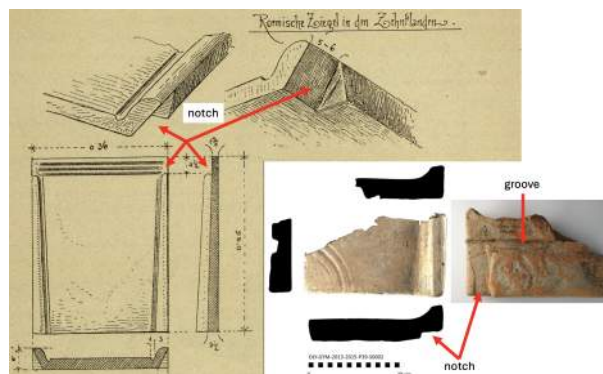


Fig. 15_2: Olympia, Gymnasium P39-S0002 and Durm 1885, p. 213

Rabbet / recessed surface

A recessed or cut-back surface (rabbet or recessed surface) along the edge of a roof tile.

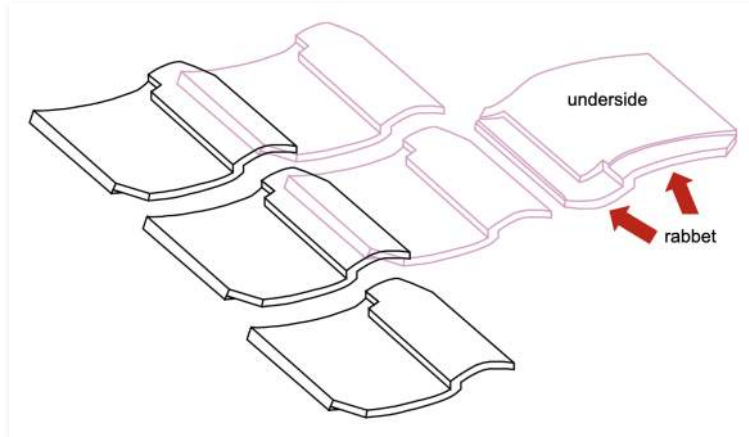


Fig. 15_3: Protocorinthian combination tiles after Sapirstein 2008, 58 fig. 3.8



Fig. 15_4: Drawing: Olympia II, 1896; LAP-picture: Olympia, Gymnasium P07-S0001

Hook

On roof tiles, hooks occur primarily on the underside at the front edge of cover tiles and serve to prevent the tile from sliding towards the eaves.

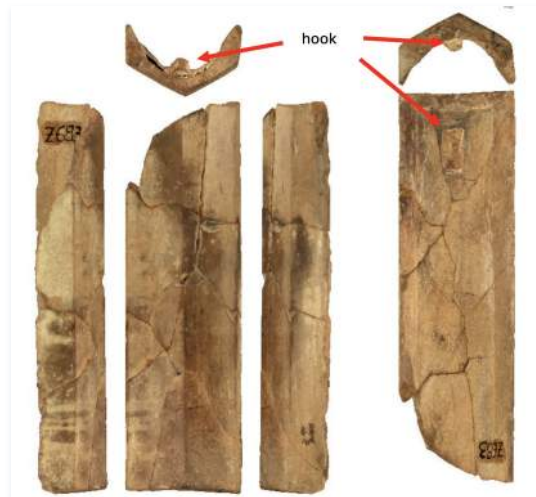


Fig. 15_5: Athens, Kerameikos Z 693

The term hook is also used for pseudo interlocking components. In types with engraved lines running parallel to the edge, hooks refer to the lines branching off from these base lines at right angles, either upwards or downwards.

Raised strip

A narrow, slightly raised strip, usually located on the rear part of the upper surface of curved or flat under tiles. It functions either as a water barrier or, in the case of flat under tiles, as part of a vertical overlap or rebate. Two variants can be distinguished:

Raised strip at the edge

A narrow strip formed directly at the rear edge of the roof tile.

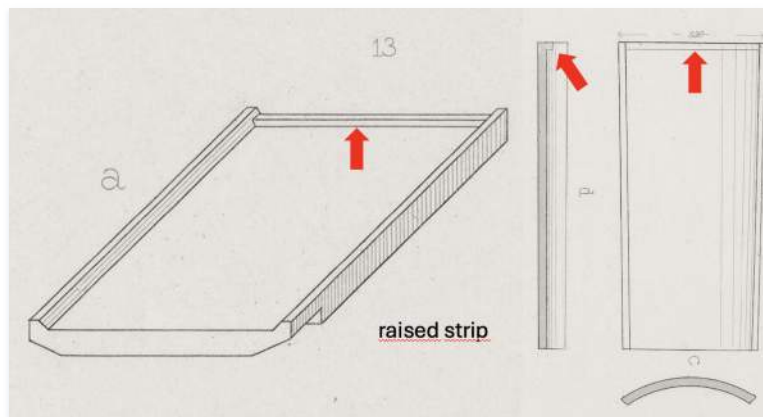


Fig. 15_6: Modified drawing (Olympia II, 1896) with examples of a FUT and a CUT

Raised strip, offset

A narrow strip that is not located directly at the edge, but slightly offset towards the interior.

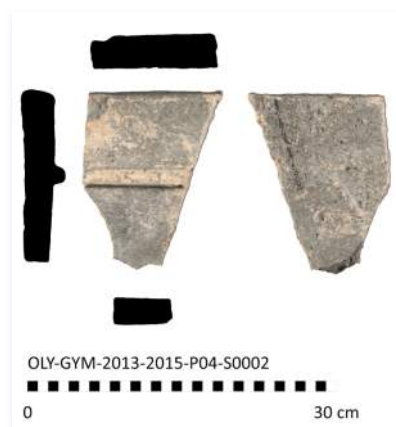


Fig. 15_7: FUT from Olympia, Gymnasium P04-S0002

Groove

An elongated depression, often located on the underside at the front of flat under tiles, intended to receive a raised strip. In the *digital roofs* project, wider channels are also referred to as grooves, even in cases where the indentation appears rather to serve the formation of a drip edge.

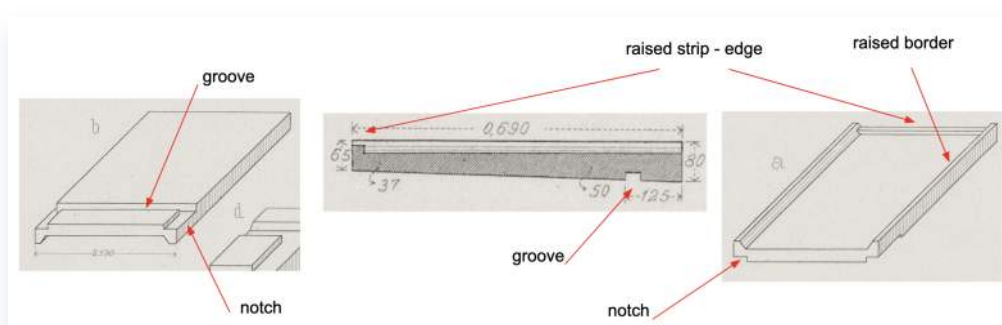


Fig. 15_8: Modified drawing: Olympia II, 1896

Raised border

A deliberately raised border, typically occurring along the long sides of flat under tiles. It serves to channel water, reinforces the joint with adjacent tile rows, and acts as a guide for cover tiles.

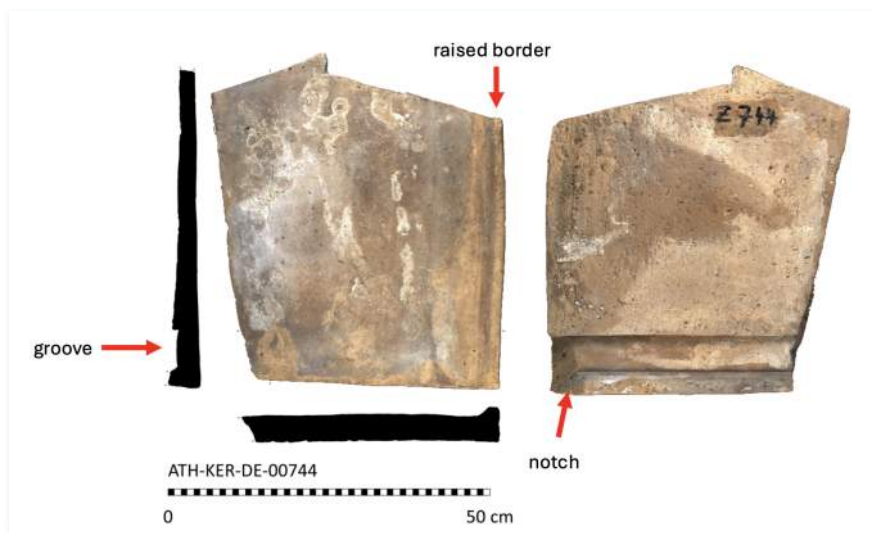


Fig. 15_9: Athens, Kerameikos Z 744



Fig. 15_10: Athens, Kerameikos Z 626, Z 627, Z 674

Drip edge

Drip edges are, strictly speaking, not interlocking components, but they may form part of an overlapping system when two roof tiles overlap. Their functional delimitation is therefore not always clear-cut. In antiquity, drip edges were usually applied to the underside of projecting architectural elements or roof tiles, especially at the roof edge. Their purpose is to prevent rainwater from running along the underside by adhesion and being drawn beneath the roof covering. Instead, they ensure controlled dripping of water away from the tile.



Fig. 15_11: Section through the eaves of the Heraion roof with geison tile showing a drip edge (drawing: Olympia II, 1896)

16_Typology - under tiles

16.1_Curved under tiles (CUT)

Curved under tiles are laid in rows from the eaves towards the ridge. As they taper slightly towards the eaves, a gap is created between the lateral edges of adjacent tiles that widens towards the front. There is also a certain degree of flexibility in the vertical arrangement; the exact extent of overlap between successive rows cannot yet be determined with certainty.



Fig. 16_1_1: Photomontage: Athens, Kerameikos Z 638

The right and left edges of curved under tiles do not fulfil a specific function in mechanically connecting adjacent tiles. The curved over tiles rest with their edges merely on top of the under tiles. This tile form therefore allows considerable flexibility in the width of the gaps formed between tiles during installation.

Edge profiles often differ between the right and left sides and may also change along the longitudinal axis of the roof (from eaves to ridge). For this reason, they are only of limited relevance for typological classification.

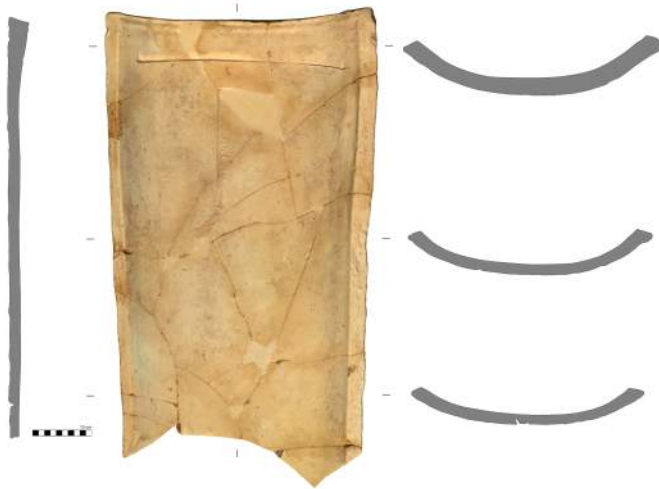


Fig. 16.1.2: Olympia, CUT (without inv. no. OLY-DE-MAG-00251-1993), dated by stamp to the 2nd century AD

All CUT share the characteristic that the profile increases in thickness towards the rear. This is the point at which the next higher roof tile rests on the one below. In this area, different forms of interlocking and pseudo-interlocking components occur, which are relevant for typological classification. Functionally, the rear thickened edge thus forms the bearing surface for the overlapping tile and serves as a barrier against rainwater driven beneath the roof tiles by wind. The front edge facing the eaves shows a slight bevel in some examples, presumably in order to improve water runoff.

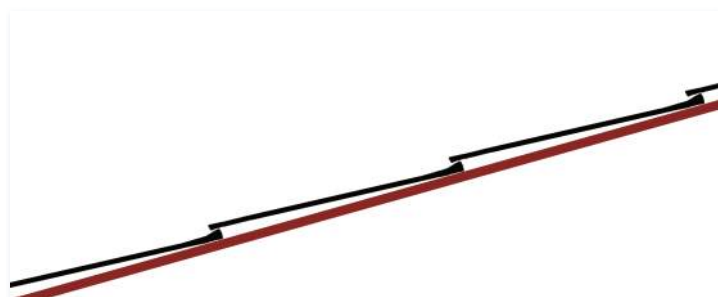


Fig. 16.1.3_Model cross-section of a roof covering using the roof tile Athens, Kerameikos Z 638

Type overview: CUT

The documentation of the curved under tiles in the Sanctuary of Zeus at Olympia reveals a wide range of variation in the shape of the rear edge. The typological overview presented here constitutes a first proposal for a systematic classification. The information provided on chronological classification is still provisional; in particular, the period during which individual types were produced has not yet been clearly established. Moreover, given the numerous earthquakes in Olympia, it must be assumed that later repairs deliberately imitated earlier models.

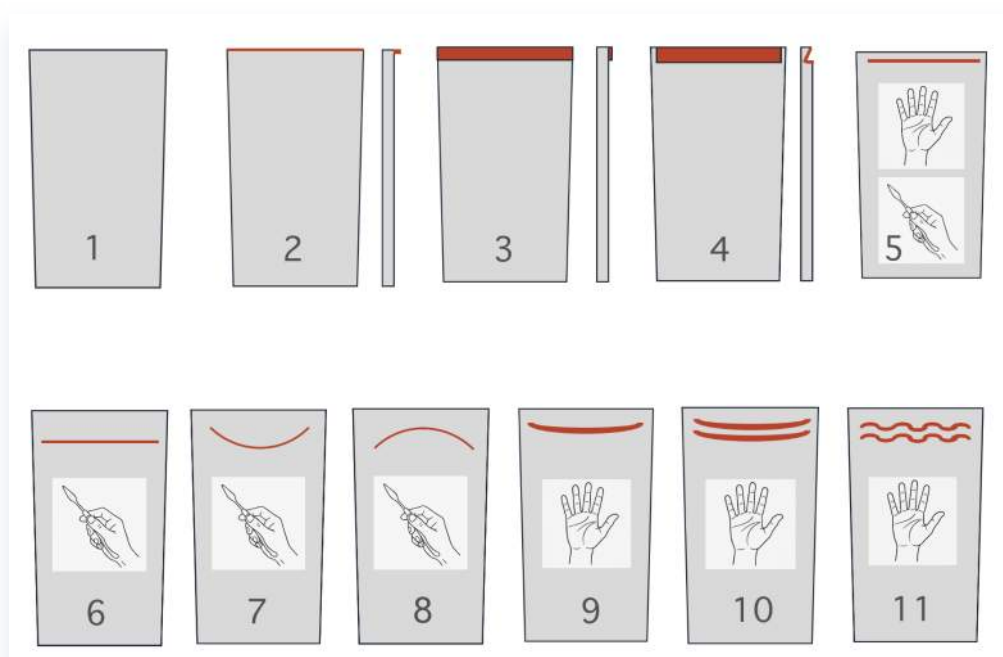


Fig. 16.1.4: Schematic type overview of CUT with interlocking and pseudo-interlocking components, based on examples from Olympia and the Kerameikos. The open hand indicates lines drawn with fingers, while the hand holding a spatula refers to lines engraved with a tool. Types illustrated are: (1) without interlocking components (with a slightly raised edge); (2) raised strip; (3) flat raised border; (4) slanted profile, horizontal (with and without hooks); (5) horizontal line near the edge (often irregular); (6) engraved horizontal line, offset (with and without hooks); (7) engraved concave line; (8) engraved convex line; (9) concave finger line; (10) concave multiple finger lines; (11) wavy lines (numerous variants)

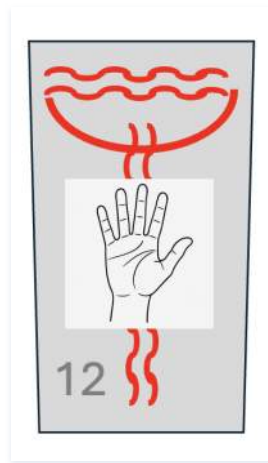


Fig. 16.1.5: Schematic representation of a CUT with surface-wide finger-line decoration, based on examples from Olympia.

At present, in the case of fragmentarily preserved roof tiles, it is not always possible to distinguish typologically relevant interlocking and pseudo-interlocking components from craftsmen's marks. Such a distinction is possible above all when they occur in combination.

CUT – 1: with a slightly raised edge



Fig. 16.1.6: Athens, Kerameikos Z 614 – length 96 cm, maximum width 52 cm

Description: The rear edge is thickened across its entire width.

Dating: The period of use of this type cannot yet be clearly defined.

CUT – 2: raised strip

Description: A narrow, slightly raised strip along the rear edge.

Dating: Archaic period, based on attribution to the Heraion.

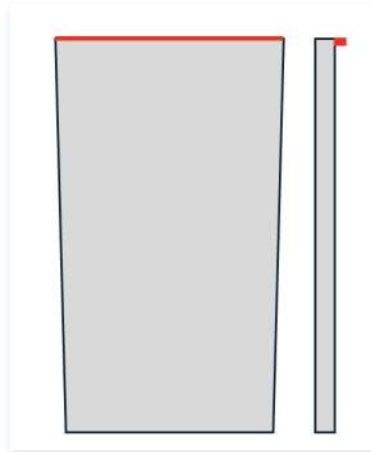


Fig. 16.1.7: Schematic representation



**Fig. 16.1.8: CUT from the Heraion – Olympia, Gymnasium P21-S0004*

CUT – 3: flat raised border

Description: A flat, raised border that may gradually taper off laterally or transition into a short, downward-sloping border section. Some examples display a white or beige slip.

Dating: On the basis of the very sharply cut, almost vertical border profiles of certain examples, the type appears to begin in the pre-Roman period. The period of use of this type cannot yet be defined more precisely.

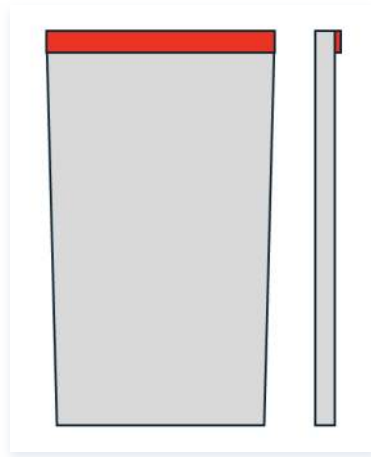


Fig. 16.1.9: Schematic representation



Fig. 16_1_10: Olympia, Gymnasium P23-S0011, P23-S0013



Fig. 16_1_11: Olympia, Gymnasium P17-S0035, P17-S0043, P17-S0054, P21-S0060, P21-S0046



Fig. 16_1_12: Olympia, Gymnasium P17-S0032, P17-S0043, P17-S0057, P23-S0013



Fig. 16_1_13: Olympia, Gymnasium P17-S0035, P17-S0043, P21-S0060

CUT – 4: slanted profile – horizontal (with and without hooks)

Description: A diagonally cut, recessed surface running parallel to the rear edge, occasionally accompanied by small lateral hooks. Painted variants (red or reddish-brown) usually display a straight profile of the recessed surface, whereas unpainted examples show a slightly undulating profile.

Dating: A pre-Roman date can be assumed for the painted variants. One example with a curved profile is dated to the Hellenistic period by Fiedler (2013, 110 no. Ss7). A further example is classified as pre-Roman by Koskinas (2011, 553–554, II 4, a). The chronological range of this type cannot yet be defined more precisely.

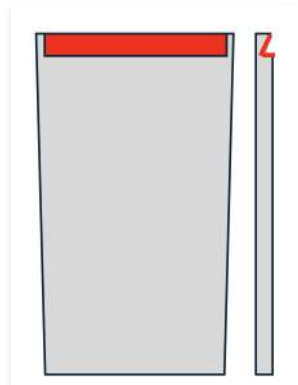


Fig. 16_1_14: Schematic representation



Fig. 16_1_15: Olympia, Gymnasium P08-S0006, P08-S0009, P08-S0018, P17-S0008, P17-S0016, P17-S0018, P17-S0041, P17-S0030, P25-S0005

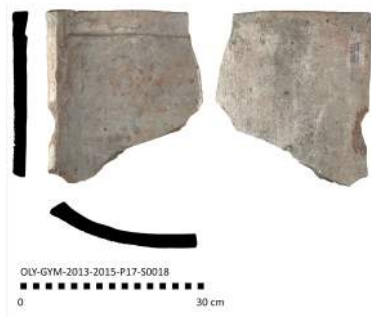


Fig. 16_1_16: Olympia, Gymnasium P17-S0018



Fig. 16_1_17: Olympia, Gymnasium P17-S0016



Fig. 16_1_18: Olympia, Gymnasium P17-S0048

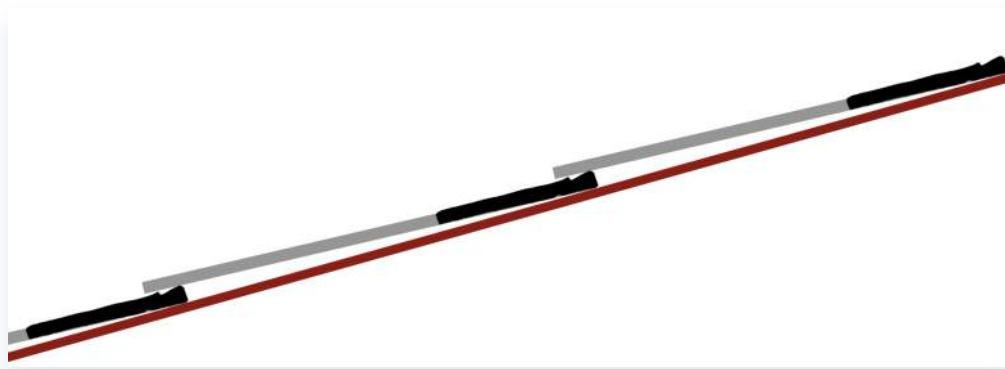


Fig. 16.1.19: Schematic model showing that the overlapping roof tile does not engage with the slanted profile

CUT – 5: horizontal line near edge (often irregular)

Description: A more or less regular line drawn with a finger or tool near the border at the rear.

Dating: Examples from Nemea date to the late 4th century BC (Early Hellenistic; Miller 1994; Miller et al. 2001, 162–173 figs. 196–311) and are painted in a reddish-brown colour. In the published drawings, the engraved line appears rather concave, whereas the examples displayed in the museum predominantly show a more horizontally running line. The period of use of this type cannot yet be defined more precisely.

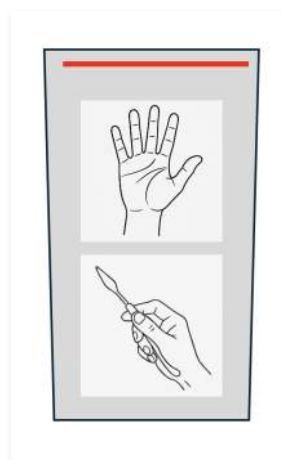


Fig. 16_1_20: Schematic representation



Fig. 16_1_21: Olympia, Gymnasium P17-S0025



Fig. 16_1_22: Olympia, Gymnasium P21-S0008

CUT – 6: engraved horizontal line (with and without hooks)

Description: A precisely engraved horizontal line, sometimes slightly concave or convex, clearly set off from the rear edge and in some cases combined with small lateral hooks.

Dating: One example is dated to the 2nd century AD by a stamp; the period of use of this type cannot yet be defined more precisely.

Remarks: May occur in combination with craftsman's marks.

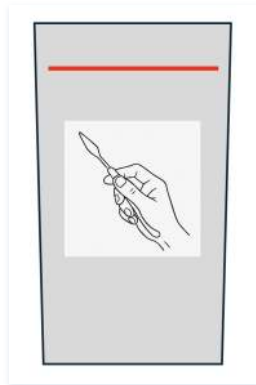


Fig. 16_1_23: Schematic representation



Fig. 16_1_24: Olympia, Gymnasium P09-S0006, P09-S0007, P09-S0008, P10-S0005, P17-S0039, P17-S0034, P17-S0196, P21-S0072, P22-S0001



Fig. 16_1_25: Olympia, Gymnasium P21-S0072



Fig. 16_1_26: Olympia, Gymnasium P22-S0001. Stempel datiert Dachziegel in das 2. Jh. n. Chr.

CUT – 7: engraved concave line

Description: A concavely engraved line running between the left and right corners of the rear.

Dating: One example is dated by a stamp to the period from the 1st century BC to the 1st century AD; the period of use of this type cannot yet be defined more precisely.

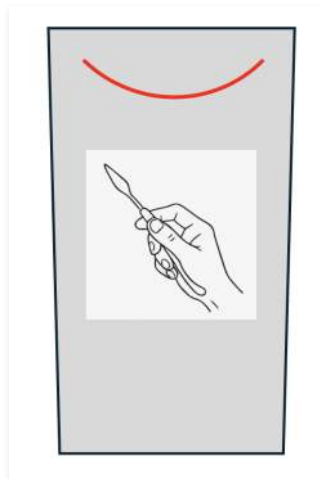


Fig. 16_1_27: Schematic representation



Fig. 16_1_28: Olympia, Gymnasium P25-S0007 a and b

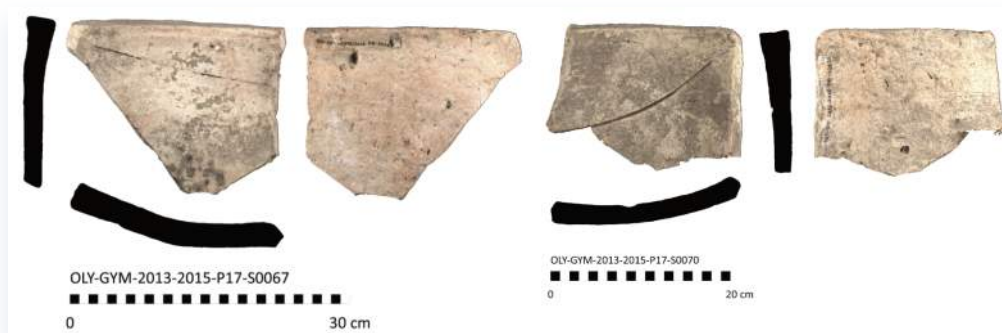


Fig. 16_1_29: Olympia, Gymnasium P17-S0067, P17-S0070

CUT – 8: engraved convex line

Description: A convexly engraved line, curved towards the rear side of the roof tile.

Dating: One example is dated to the 2nd century AD by a stamp; the period of use of this type cannot yet be defined more precisely.

Remarks: In some cases difficult to distinguish from type CUT–6.

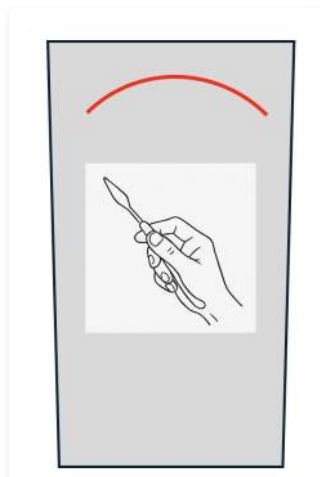


Fig. 16_1_30: Schematic illustration



Fig. 16_1_31: Olympia, Magazin of roof tiles (without inventory number, OLY-DE-MAG-00251-1993), CUT, 2nd century AD



Fig. 16_1_32: Olympia, Gymnasium P17-S0199, P21-S0019



Fig. 16_1_33: Olympia, Gymnasium P10-S0006, P10-S0013, P17-S0204-P21-S0034



Fig. 16_1_34: Olympia, Gymnasium P11-S0001, P17-S0091, P17-S0219, P17-S0224, P21-S0019, P21-S0050

CUT – 9: concave finger line

Description: A concave finger line running between the left and right corners of the rear.

Dating: Among the reddish-brown painted roof tiles from the Apodyterion at Nemea are examples in which the drawings show a slightly concave line running relatively close to the rear edge (Miller 1994; Miller et al. 2001, 162–173 figs. 196–311). The examples exhibited in the museum, by contrast, display a more horizontal line (cf. CUT–05). According to the drawing, the type would already be attested in the early Hellenistic period. Painted examples are so far absent at Olympia, which may point to a Roman-period dating there. The period of use of this type cannot yet be defined more precisely.

Remarks: The appearance varies depending on the point of application and the lifting movement of the finger.

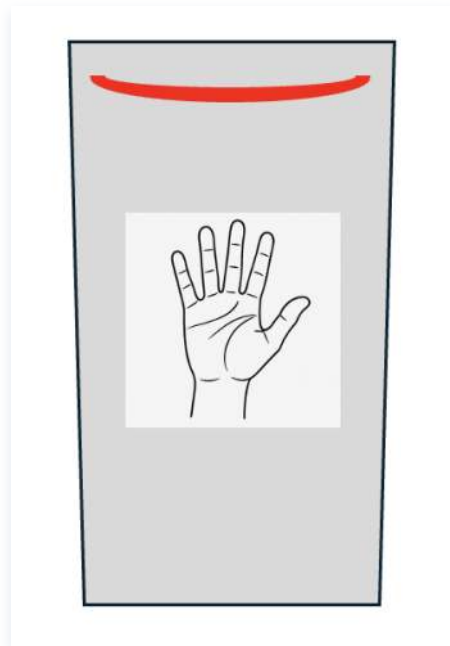


Fig. 16_1_35: Schematic illustration



Fig. 16_1_36: Olympia, Gymnasium P21-S0030, P21-S0058



Fig. 16_1_37: Olympia, Gymnasium P43-S0006, P43-S0007, P21-S0018, P21-S0026, P21-S0110, P21-S0116

CUT – 10: concave multiple finger lines

Description: Two or more concave finger lines running between the left and right corners of the rear.

Dating: Roman. Painted examples are absent. The period of use of this type cannot yet be defined more precisely.

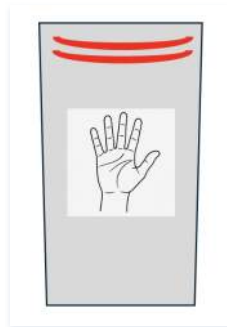


Fig. 16_1_38: Schematic illustration

CUT – 10A: two concave finger lines

Description: Two concave finger lines running between the left and right corners of the rear.

Dating: Roman. Painted examples are absent. The period of use of this type cannot yet be defined more precisely.



Fig. 16_1_39: Olympia, Gymnasium P21-S0106, P21-S0129, P41-S0015, P43-S0005



Fig. 16_1_40: Olympia, Gymnasium P21-S0129

CUT – 10B: concave and horizontal finger lines combined

Description: Two to four concave finger-drawn lines combined with two to four horizontally running lines parallel to the rear edge, which may intersect the concave finger lines.

Dating: Roman. Painted examples are absent. The period of use of this type cannot yet be defined more precisely.



Fig. 16_1_41: Olympia, Gymnasium P10-S0010, P21-S0006, P21-S0007, P41-S0014

CUT – 11: wavy lines

Description: Roof tiles with wavy finger lines. This group has not yet been fully subdivided into subtypes. At present, a clear distinction between pseudo interlocking components and craftsman's marks is not always possible.

Dating: Probably Roman. Painted examples are absent. Owing to the wide range of variants, a more detailed chronological differentiation cannot yet be defined more precisely.

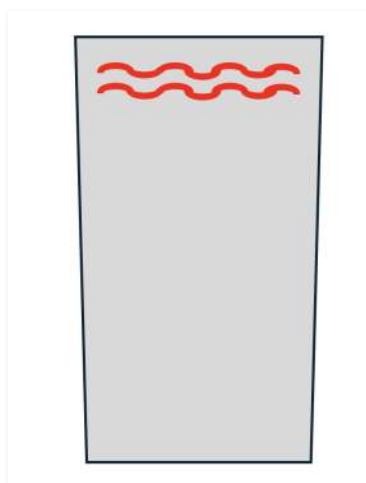


Fig. 16_1_42: Schematic illustration

CUT – 11A: regular wavy lines

Description: Regular wavy finger lines running parallel to the rear edge, drawn with two to three fingers.



Fig. 16_1_43: Olympia, Gymnasium P17-S0098, P17-S0213, P17-S0218, P17-S0223

CUT – 11: not yet defined

Description: Further variants of wavy lines that have not yet been typologically differentiated.



Fig. 16_1_44: Olympia, Gymnasium P08-S0011, P26-S0005, P35-S0003



Fig. 16_1_45: Olympia, Gymnasium P17-S0088, P21-S0022, P21-S0089, P35-S0002, P38-S0002



Fig. 16_1_46: Olympia, Gymnasium P06-S0005, P09-S0001, P17-S0089, P21-S0021



Fig. 16_1_47: Olympia, Gymnasium P06-S0126, P08-S0015, P17-S0087, P17-S0221



Fig. 16_1_48: Olympia, Gymnasium P08-S0019, P26-S0006, P32-S0002

CUT – 12: surface-wide decoration with wavy and other finger lines

Description: Wavy, concave, vertical, or other finger-drawn lines covering large parts of the upper surface of the roof tile and not confined to the rear. A wide range of forms can be observed.

Dating: Roman–Byzantine. Painted examples are absent. The period of use of this type cannot yet be defined more precisely.

Remarks: A detailed typology of this variant is not yet possible.

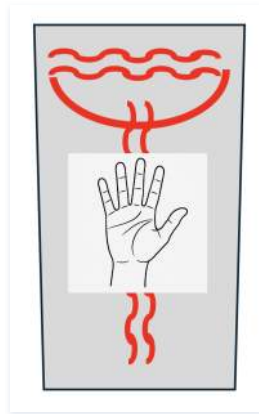


Fig. 16_1_49: Schematic illustration



Fig. 16_1_50: Olympia, Gymnasium P18-S0006, P26-S0003, P31-S0012



Fig. 16_1_51: Olympia, Gymnasium P31-S0015



Fig. 16_1_52: Olympia, Gymnasium P18-S0006



Fig. 16_1_53: Olympia, Gymnasium P31-S0012

16_2: flat under tiles (FUT)

The flat under tiles have an approximately square to slightly rectangular shape. Of particular typological relevance are the form of the lateral borders and the sides/corners facing the eaves and the ridge. The lateral borders function as interlocking components in conjunction with the cover tiles.

interlocking components – lateral edges

The profile of the lateral edges is typologically significant for roof tile types attributed to specific regions and for chronological assessment.



Fig. 16_2_1: Edge profiles (Rheeder 2024, fig. 4)

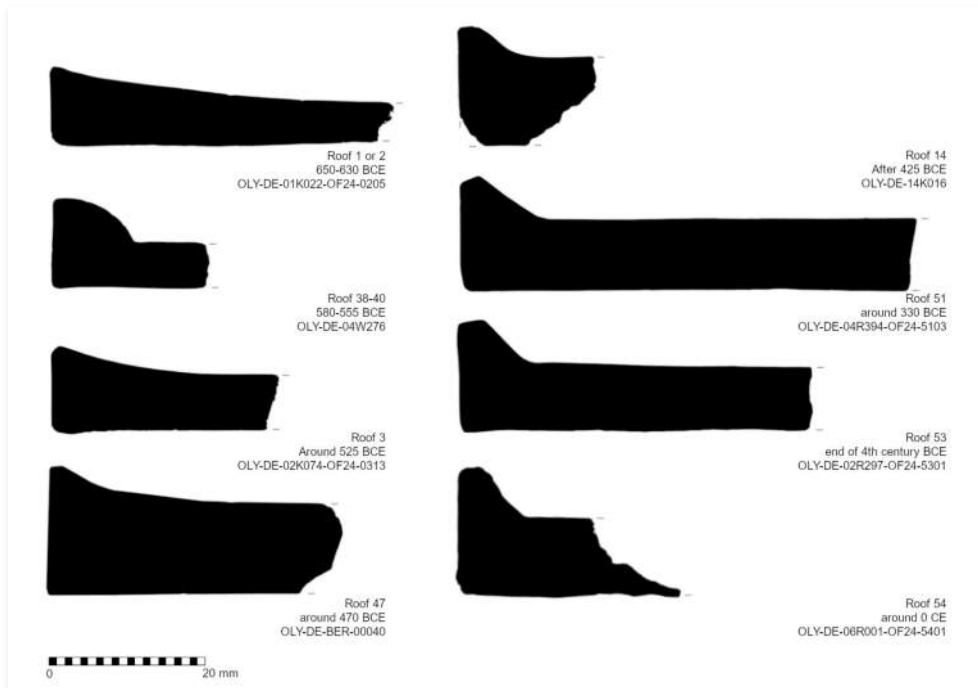


Fig. 16_2_2: Edge profiles (Rheeder 2024, fig. 6) with dating indications after Heiden 1995

In plan view, the lateral edges generally show straight profiles. In some cases, however, edge profiles widening towards the front occur. Such forms are attested, for example, among Etruscan roof tiles as well as Roman *tegulae*.

interlocking components – front and rear edges

For flat under tiles, two basic systems of connection can be distinguished, which may occur either individually or in combination:

Horizontal interlocking components

On the upper surface at the rear there is often a narrow raised strip (cf. Chapt. 15). This corresponds to a groove of varying width on the underside at the front of the following tile. Together, these two elements form an interlocking joint that prevents slipping and channels rainwater away.

Variants with a recessed surface/rabbit parallel to the front edge are also attested.



Fig. 16_2_3: Athens, Kerameikos Z 591, Z 569, Z 570

Corner interlocking components

In addition to horizontal connections, interlocking components may also occur to provide a vertical mechanical connection between the roof tiles. In such cases, small areas are cut out or recessed at the left and right corners, either at the rear of the lateral edges or at the front edge of the tile.

The recesses at the front edge may take the form of:

- **indentations** (lateral recesses extending through the thickness of the tile),
- **notches** (cut-outs on the underside with varying profiles).



Fig. 16_2_4: Front left and right corners of two Roman flat tiles with indentations (Olympia, Gymnasium P21-S0001 and P10-S0012)



Fig. 16_2_5: Reconstruction of sima tiles, Olympia, roof tile storeroom: OLY-DE-03W128ab-OF24-3728 and OLY-DE-03W002-OF24-3701 (after Rheeder 2024, fig. 3)

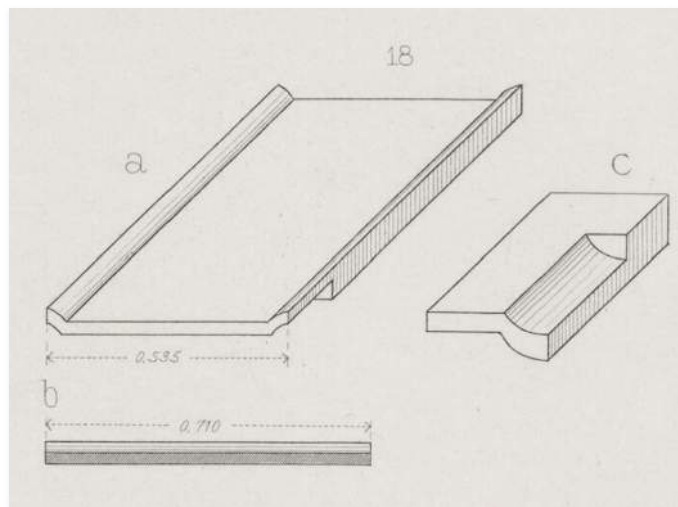


Fig. 16.2.6: Cut-out on the underside of the front left and right corners following the curved profile of the tile (drawing: Olympia II, 1896)

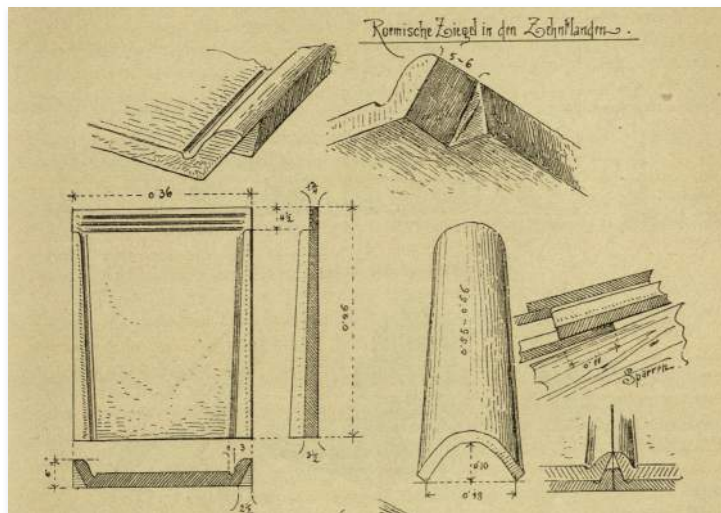


Fig. 16.2.7: Roman roof tile with worked lateral edges at the rear and a diagonally cut notch beneath the front left and right corners (after Durm 1885, 213)

This vertical system has been studied for Roman *tegulae* as a typologically and chronologically significant feature (cf. Warry 2006a; Mills 2013). The combination of both systems — horizontal and vertical interlocks — can be observed on numerous fragments in Olympia. At present, however, a detailed typology for Olympia cannot yet be established.

Finger lines

In contrast to curved under tiles, flat under tiles from the Roman period typically show characteristic finger lines on the upper surface at the front. These lines were impressed with the finger before firing and may occur singly or in multiple form.



Fig. 16.2.8: Roman flat tile with a finger line at the front edge (Olympia, Gymnasium P03-S0001)



Fig. 16_2_9: Roman flat tile with finger lines at the front edge and a groove and notch on the underside (Olympia, Gymnasium P39-S0002)

17_Typology - over tiles

The cover tiles vary in shape and size as well as in the design of the overlapping areas. The front edge facing the eaves is usually specially crafted.

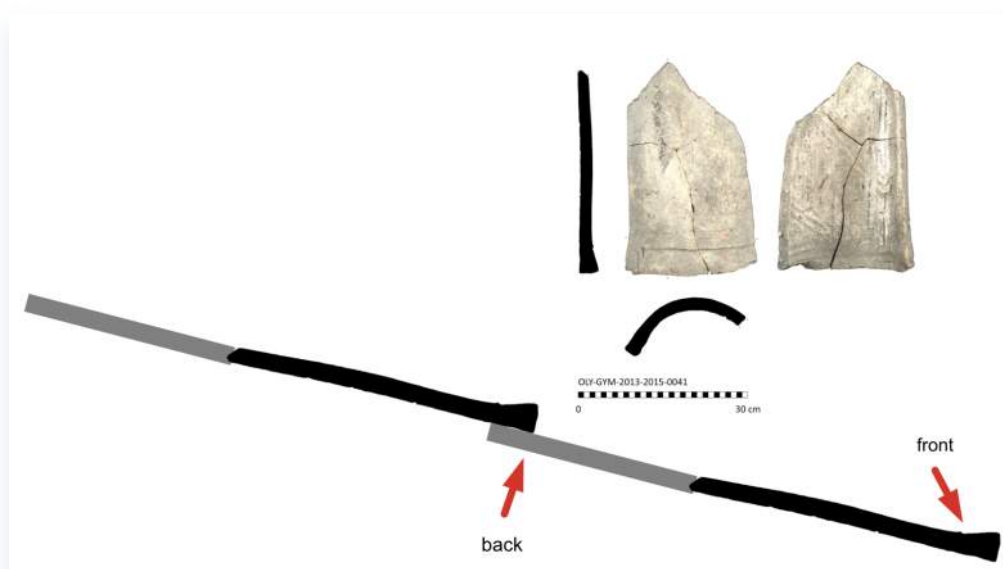


Fig. 17_0_1: Section through the profile of cover tiles laid on a roof (length unknown) – (Gymnasium P17-S0025)

A specific design of the rear side facing the ridge is less frequently attested; it may have a rabbet. Likewise, the presence of a hook on the underside of polygonal cover tiles is only rarely documented. The external profile of the cover tiles shows greater variation.

The typological classification of the cover tiles is therefore based on the design of the external profile as well as on the interlocking and pseudo-interlocking components.

In plan view, cover tiles either display a uniform elongated rectangular profile or widen towards the front.

17_1: polygonal over tiles (POT)

Within the group of polygonal cover tiles, those with a simple triangular cross-section (triangular) can be distinguished from those whose side faces rise in straight lines and terminate in a gable-like top (pentagonal). If classification is not possible in the case of fragmentarily preserved examples, they are grouped under the category “polygonal”.

Fig. 17_1_1: Olympia, Magazin of roof tiles OLY-DE-04W230-OF24-3821

pentagonal



Fig. 17_1_2: Athen, Kerameikos Z 601

17_2: curved over tiles (COT)

Curved over tiles often have a profile that is thicker at the front. On the upper surface they show pseudo-interlocking components corresponding to those of the curved under tiles.

Due to the largely absent stamps, the dating remains uncertain. It may be assumed that the types can be dated analogously to the CUTs.



Fig. 17_2_1: Athens, Kerameikos Z 523, painted

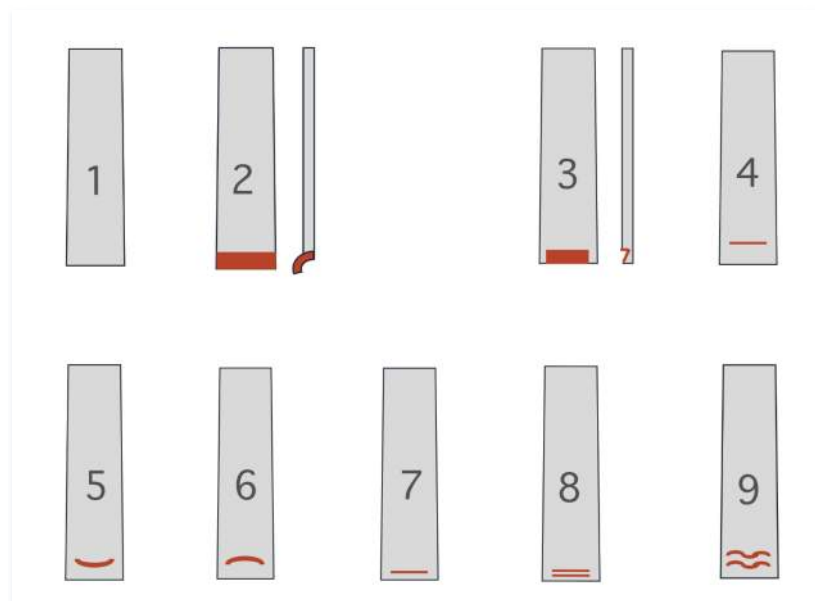


Fig. 17_2_2: Schematic illustration of types: 1. without interlocking components; 2. upturned front edge; 3. slanted profile (with and without hooks); 4. engraved horizontal line offset; 5. concave line; 6. convex line; 7. horizontal line near edge; 8. multiple horizontal lines; 9. wavy lines

COT – 01: thickened front edge

Description: A profile that thickens towards the front edge.

Dating: The period of use of this type cannot yet be defined more precisely.



Fig. 17_2_3: Olympia, Gymnasium P17-S0104

COT – 02: upturned front edge

Description: A front edge that is bent upwards, forming a narrow strip or rounded bulge.

Dating: The period of use of this type cannot yet be defined more precisely.

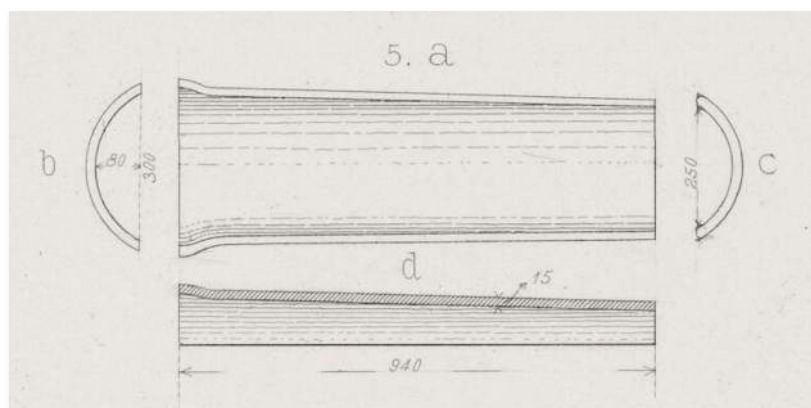


Fig. 17_2_4: Drawing: Olympia II, 1896

COT – 03: slanted profile – horizontal

Description: A diagonally recessed surface along the front edge, in some cases with laterally engraved hooks.

Dating: The period of use of this type cannot yet be defined more precisely.

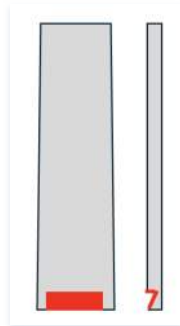


Fig. 17_2_5: Schematic illustration

COT – 03A

The recess gradually diminishes towards the corners.

Dating: One example is dated to the 1st century BC on the basis of a stamp. The period of use of this type cannot yet be defined more precisely.



Fig.: 17_2_6: Olympia, Gymnasium P37-S0001



Fig.: 17_2_7: Olympia, Gymnasium P37-S0001

COT – 03B

The recess forms small hooks on one or both sides.

Dating: The period of use of this type cannot yet be defined more precisely.



Fig. 17_2_8: Olympia, Gymnasium P17-S0025



Fig. 17_2_9: Olympia, Gymnasium P06-S0004, P17-S0025, P17-S0027

COT – 04: horizontal line (offset)

Description: An almost horizontal, recessed line along the front edge.

Dating: The period of use of this type cannot yet be defined more precisely.



Fig. 17_2_10: Olympia, Gymnasium P17-S0158

COT – 05: concave engraved line

Beschreibung: A concavely engraved line, set slightly back from the front edge.

Dating: The period of use of this type cannot yet be defined more precisely.

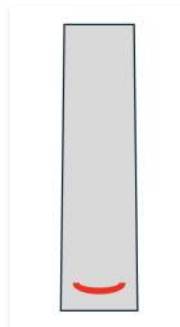


Fig. 17_2_11: Schematic illustration



Fig. 17_2_12: Olympia, Gymnasium P17-S0157

COT – 06: convex engraved line

Description: A convex engraved line, set slightly back from the front edge.

Dating: The period of use of this type cannot yet be defined more precisely.

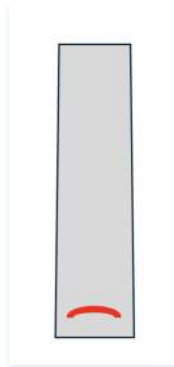


Fig. 17_2_13: Schematic illustration



Fig. 17_2_14: Olympia, Gymnasium P17-S0155

COT – 07: horizontal line near edge

Beschreibung: An irregular horizontal line near the front edge, usually impressed with a finger or tool.

Dating: The period of use of this type cannot yet be defined more precisely.

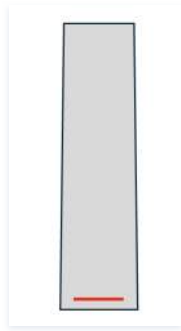


Fig. 17_2_15: Schematic illustration



Fig. 17_2_16: Olympia, Gymnasium P17-S0172



Fig. 17_2_17: Olympia, Gymnasium P06-S0007, P17-S0172

COT – 08: multiple horizontal finger lines near the edge

Description: Two or more horizontal finger lines parallel to the front edge.

Dating: The period of use of this type cannot yet be defined more precisely.

Remarks: Several variants are known.

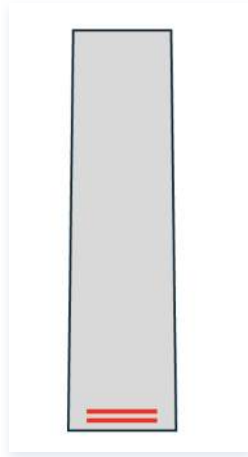


Fig. 17_2_18: Schematic illustration

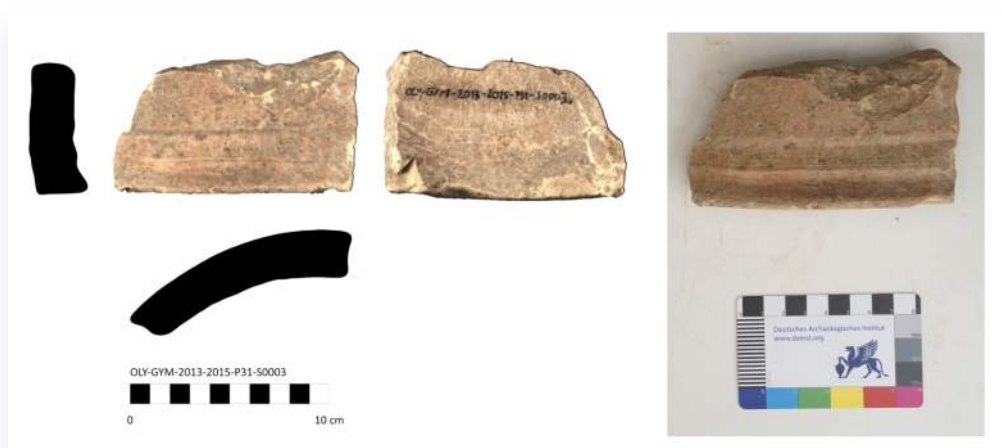


Fig. 17_2_19: Olympia, Gymnasium P31-S0003



Fig. 17_2_20: Olympia, Gymnasium P17-S0090



Fig. 17_2_21: Olympia, Gymnasium P06-S0011, P17-S0090, P31-S0003

COT – 9: wavy lines

Description: Wavy finger lines along the front edge.

Dating: The period of use of this type cannot yet be defined more precisely.



Fig. 17_2_22: Olympia, Gymnasium P21-S0038

17_3: Hybrid over tiles

Description:

Roof tiles with an external cross-section that initially rises vertically and then transitions into a convexly curved section.

17_3_1: Hybrid over tile without applied strips

Beschreibung: The transition from the vertical to the curved form is not particularly accentuated. Some tile types feature an interlocking component at the rear (rabbet).

Datierung: Attested in the Black Sea region in the Archaic period (Stepanova 2023). Heiden (1995, 160 pl. 120, 2), with reference to Graeber (1896, pl. 97, 21), dates a comparable example to the Roman period.



Fig. 17_3_1: Schematic illustration of profile

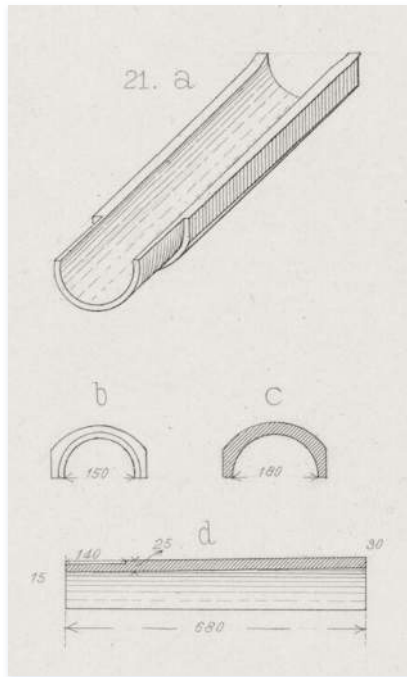


Fig. 17_3_2: Drawing: Olympia II, 1896



Fig. 17_3_3: Olympia, Gymnasium P07-S0001

17_3_2: Hybrid over tile with applied round rods / strips

Description: The transition from the vertical to the curved form is accentuated by applied round rods. Some tile types feature an interlocking component at the rear (rabbet). In one group, the profile displays a more continuous arched form.

Dating: Graeber (1892) dates this type to the Roman period. The period of use of this type cannot yet be defined more precisely.

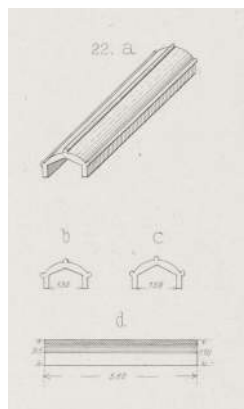


Fig. 17_3_4: Drawing: Olympia II, 1896

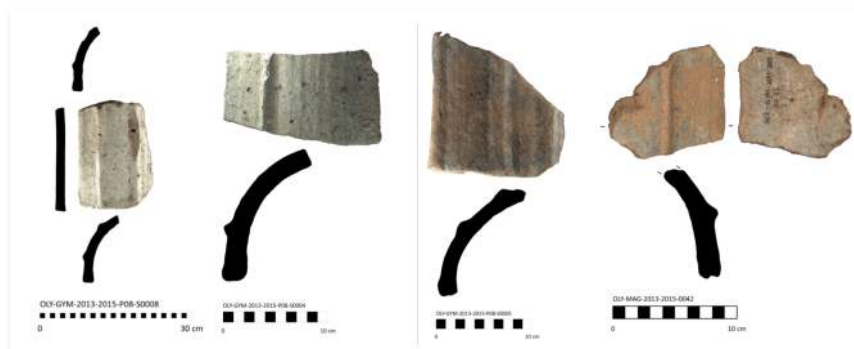


Fig. 17_3_5: Olympia, Gymnasium P08-S0005, P08-S0008, P17-S0026



Fig. 17_3_6: Olympia, Gymnasium P03-S0002

17_4: Hip and valley

When two roof planes meet, an external angle forms a hip, while an internal angle forms a valley. This requires that the flat tiles laid along the slope of the hip or the valley must also be cut diagonally. Friedrich Graeber produced reconstruction drawings for both hip and valley. He writes with regard to the roof tiles at the hip: “Wenn von den schräggeschnittenen Gratziegeln auch keiner unzerbrochen gefunden ist, so war doch Grösse und Form aus den Stücken genau zu bestimmen.” (Olympia II, 1896, S. 169).

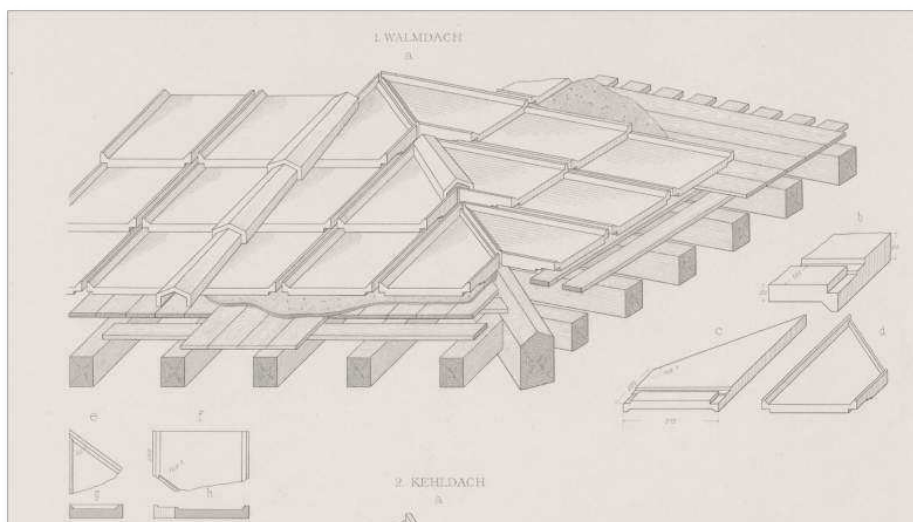


Fig. 17_4_1: Drawing Olympia II, 1896

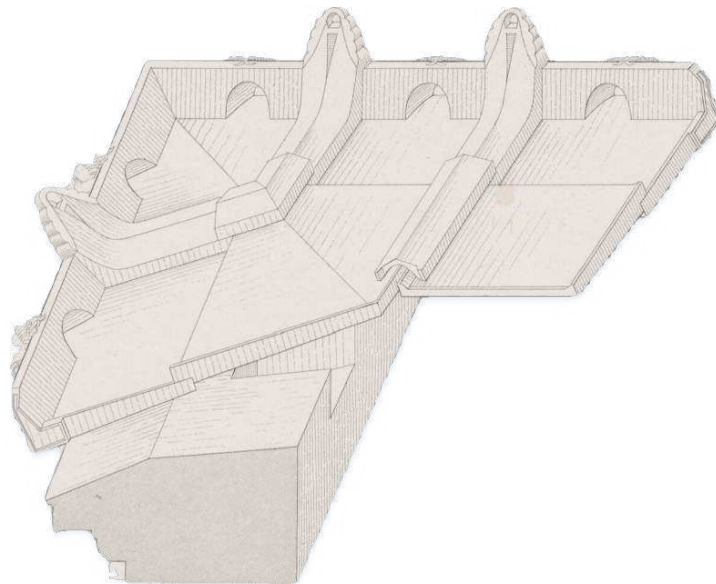


Fig. 17_4_2: Drawing: Olympia II, 1896

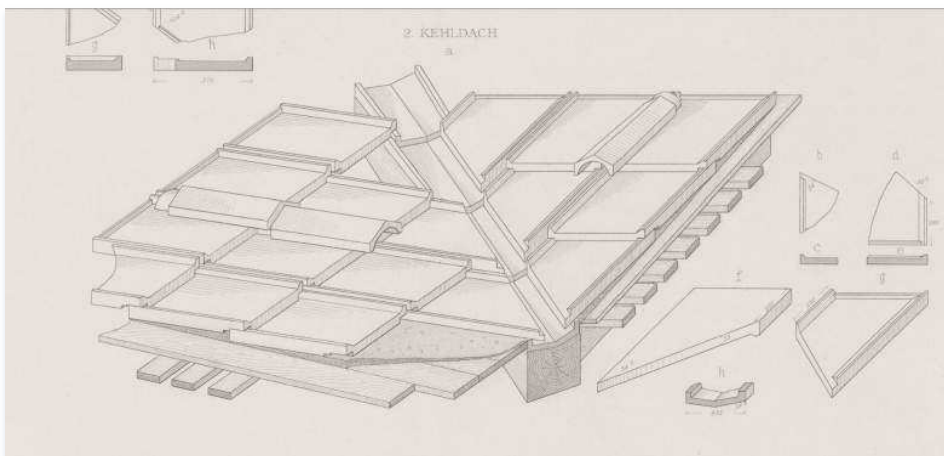


Fig. 17_4_3: Drawing: Olympia II, 1896

For Roman roofs, Durm reconstructed the covering of valley roofs using special tiles.

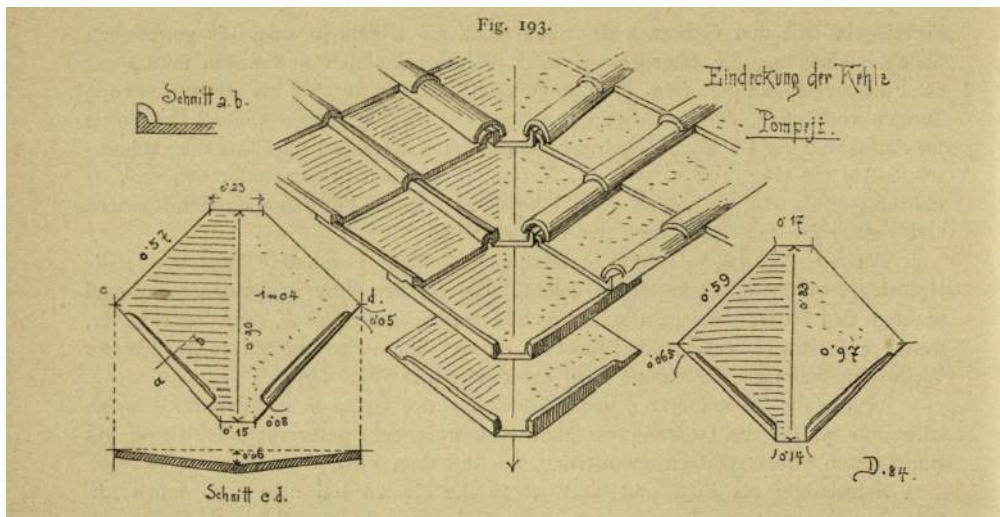
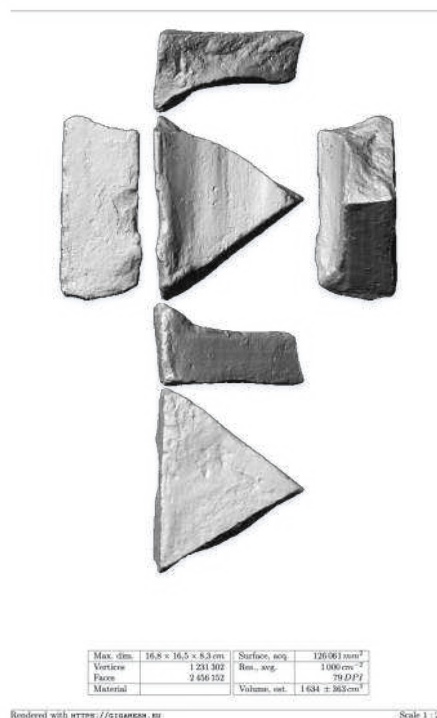


Fig. 17_4_4: Reconstruction of a Roman valley roof with special tiles (after Durm 1885, p. 216).

17_4_1: New examples from Olympia

Among the finds from the excavation of the Gymnasium at Olympia, several fragments of triangular tiles were identified. Two fragments can be assigned to the transition from the roof slope to the valley, and one to the transition to the hip.



Rendered with <https://github.com/3D-Scan-Viewer>

Scale 1:2.5

Fig. 17_4_5: 3D-Scan, Olympia, Gymnasium P06-S0003

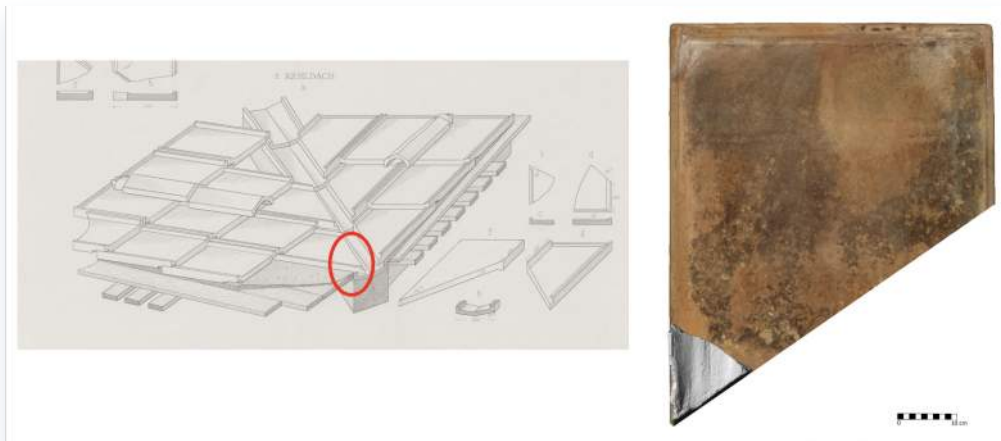


Fig. 17_4_6: First reconstruction attempt of the fragment – the original size of the roof tile cannot be reconstructed (photomontage using a roof tile from the Kerameikos).

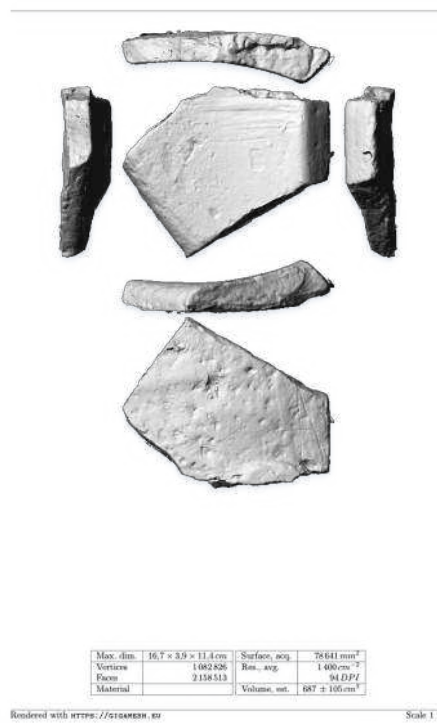


Fig. 17_4_7: 3D-Scan, Olympia, Gymnasium P10-S0003



Fig. 17_4_8: Traces of paint are preserved on the right edge, which was protected by the cover tile. The left edge, over which the water drained, is more heavily weathered.

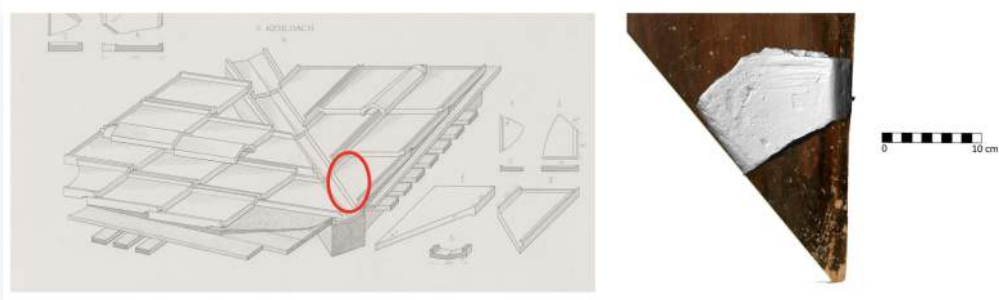


Fig. 17_4_9: First reconstruction attempt of the fragment – the original size of the roof tile cannot be reconstructed (photomontage using a roof tile from the Kerameikos, Athens).

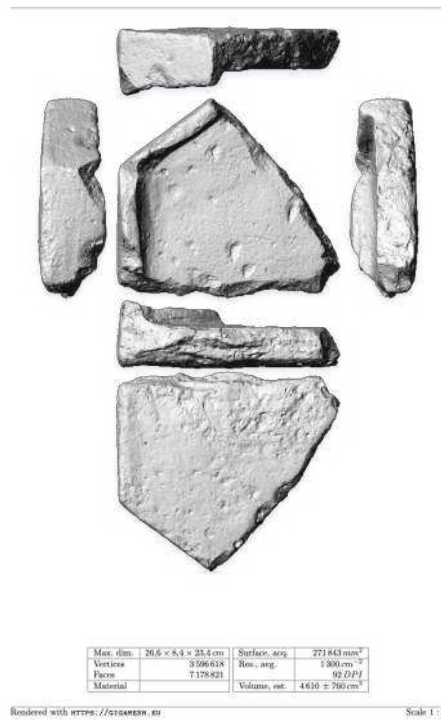


Fig. Fig. 17_4_10: 3D-Scan, Olympia, Gymnasium P10-S0004

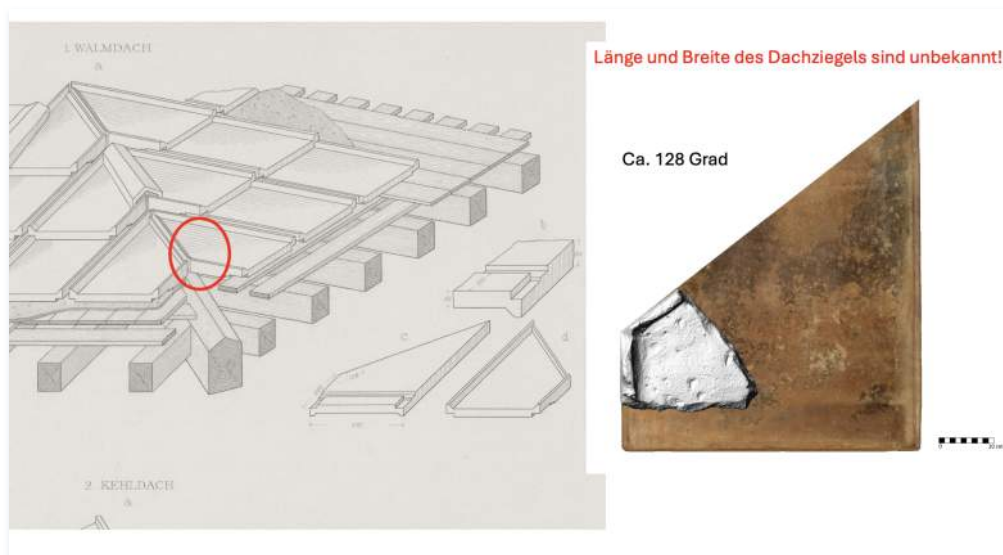


Fig. 17_4_11: First reconstruction attempt of the fragment – the original size and exact form of the roof tile cannot yet be reconstructed (photomontage using a roof tile from the Kerameikos, Athens; parallel in Heiden 1995, 108 cat. no. 43.24, pl. 74, 2).

18_Classification of marks

Different forms of markings, traces, and surface features can be distinguished on ancient roof tiles:

- imprints
- stamps and inscriptions
- assembly marks
- craftsmen's marks
- production traces
- decoration

Literature: Goulpeau et al. 1989; Shepherd 2006, 172–174; Wikander 2017, 216; Hamari et al. 2019, pl. 1 (overview of interpretations).

Imprints

In addition to fingerprints created during the production process, various imprints made by humans and animals can be observed, which were unintentionally left in the wet clay. As these impressions are assumed to have been created while the roof tiles were laid out for drying, they are used in scholarship, among other things, to reconstruct the production environment (Vipard 2007; McComish 2012).



Fig. 18_1: Olympia, Gymnasium P43-S0001

Stamps and inscriptions

Roof tiles may bear ornamental and figural stamps, as well as stamped inscriptions (e.g. Felsch 1990; de Domenico 2015; de Domenico 2021; Conti 2018). Since stamps are often published separately or only as transcriptions, their potential for the classification and dating of roof tile types has so far been systematically exploited only for certain regions.

In rare cases, roof tiles are also preserved with inscriptions that were incised after firing or written into the wet clay before firing. The latter are considerably rarer than stamped inscriptions.

Of particular importance for roof tile studies are some inscriptions incised before firing that contain information on the organisation of pottery workshops (Gallo-Roman examples: Gatta 2018).



Fig. 18_2: Stamp, Olympia, Gymnasium P39-S0001



Fig. 18_3: Stamp, Olympia, Gymnasium P06-S-0001

Assembly marks

Several roof tiles show markings that were incised after firing. In the literature, these are interpreted as setting or assembly marks (e.g. Heiden 1995, 173–174 cat. no. 3.1).



Fig. 18_4: Olympia, roof tile storeroom: OLY-DE-02K062-OF24-0301

Craftsmen's marks versus production traces

During the production of roof tiles, parallel finger lines are frequently observed, particularly on the underside. It is not always easy to determine whether such parallel lines result from the manufacturing process or were deliberately applied by the craftsman as marks.

On a group of roof tiles from Olympia, the underside shows traces attributable to the scraping of the clay with a tool, alongside finger lines running parallel to the front edge. These can clearly be interpreted as production traces.



Fig. 18_5: Olympia, Gymnasium P17-S0135

By contrast, the underside of a fragment from the left or right edge of a curved under tile (CUT) shows a sharply jagged wavy line that cannot be explained by the production process. This feature must be interpreted as a deliberate mark made by the craftsman. Comparable craftsmen's marks on the underside are also found on CUT and FUT from the Kerameikos in Athens.



Fig. 18_6: Olympia, Gymnasium P38-S0001

Clearly identifiable craftsmen's marks

A group of curved under tiles (CUT) from Olympia displays clearly identifiable craftsmen's marks. These can be clearly distinguished from interlocking components or pseudo interlocking components, as they occur combination with them. When the roof tiles were laid on the roof, however, most of these marks must have been largely concealed.



Fig. 18_7: Horizontal line with sigma-like mark (Olympia, Gymnasium P09-S0009, P18-S0009) (Olympia, Gymnasium P09-S0009, P18-S0009)



Fig. 18_8: Horizontal and concave line with mark "<" (Olympia, Gymnasium P08-S0002, P10-S0007, P17-S0193, P17-S0194, P17-S0197, P17-S0198)



Fig. 18_9: Flat raised border with mark "<", Olympia, Gymnasium P23-S0011, P23-S0013



Fig. 18_10: Horizontal line combined with an engraved wavy line, Olympia, Gymnasium P06-S0006, P06-S0010

In scholarly discussion, finger lines on Roman *tegulae* are also interpreted, among other things, as craftsmen's marks. They are usually found on the upper surface facing the eaves (Fig. 16_2_9).

Craftsmen's marks versus decoration

On a pre-Roman curved roof tile from the Kerameikos in Athens (Z 650), a finger-drawn double-loop motif appears on the underside. The same double-loop motif also occurs on a flat tile from the Kerameikos (Z 626). The same ornament, however, is also found on the upper surface of curved roof tiles from the 5th century CE, for which Hamari (Hamari et al. 2019, fig. 2 pl. 2) assumes a function as workshop marks (signatures) within workshop organisation.

The boundaries between functional features, craft signatures, and decorative design are therefore not easy to define. On flat and curved roof tiles, combinations of straight lines, large arcs, and wavy lines occur in various forms, sometimes also in combination with combed decoration covering almost the entire surface (Heiden 1995 pl. 120 cat. no. 68.43; Gossel-Raeck 2020). Gossel-Raeck has compiled a group of Byzantine

flat tiles from Priene. Such surface-covering combed and finger-drawn lines can hardly be interpreted solely as craftsmen's marks.



Fig. 18_11: Athen, Kerameikos Z 650



Fig. 18_12: Olympia, Gymnasium P13-S0001, finger lines on the upper surface of a CUT

19_Dating of undecorated roof tiles

A range of criteria can be used for the chronological attribution of roof tiles. In general, however, it must be emphasized that not all criteria are equally meaningful for every period or cultural context:

- From the Hellenistic period onwards, inscribed stamps occur with increasing frequency. By naming individuals or, in the Roman world, military units (legions), they may provide indications for absolute dating (Warry 2006a). Further indications for dating may be derived from the mention of a specific building or from palaeographic evidence (e.g. de Domenico 2015; de Domenico 2021).
- The date of construction of a building, as inferred from other sources, may provide a dating indication for the first roof.
- Stratigraphy may offer evidence in the sense of a *terminus ante quem* or a *terminus post quem*, that is, for a point in time before or after which a roof must have been in place.

For the roof of the Gymnasium at Olympia, a coin of the 4th century AD found beneath the roof collapse provides a *terminus ante quem* (Kolia 2024). Stamps on roof tiles from the collapse layer, bearing the stamp DIOR OLYMPIOU, can be dated to the 2nd century AD.

On the basis of further stratigraphic evidence, the excavators propose that the roof of the Gymnasium was re-covered in the 3rd century AD during a phase of repairs, probably following an earthquake in the early 3rd century AD. Other buildings likewise show extensive repair measures involving reused material in the 3rd century AD (Haseley 2006).

The repair of the Gymnasium, however, does not allow for a more precise chronological classification of all roof tile finds from the Greek excavation. This is complicated, on the one hand, by the fact that evidently much older, pre-Roman roof tiles were reused for the covering of the roof (see Chapter 20 – Recycling). On the other hand, not all roof tile fragments belong to the roof collapse, but derive from other contexts of reuse. The site can thus be shown to have remained in use into the

early Byzantine period (Kolia – Leventouri – Mourtzini 2020).

In the case of undecorated roof tiles, further features provide indications for a relative chronological classification:

- Painting, slip, and its absence
- Form of the border profiles
- Features such as interlocking components and pseudo-interlocking components

For the lateral profiles of flat under tiles, Annalize Rheeder (Rheeder 2024) has convincingly proposed that the better-datable decorations of eave tiles and sima decoration may help to establish a chronology for the adjoining flat tiles, since each eaves tile is connected to a section of flat under tile with a lateral profile. This would also provide indications for dating the profiles of undecorated flat under tiles.

In the case of curved under tiles, the profiles are less easily classified, although an overall development from more sharply profiled to more rounded forms can be observed.

Hamari summarises the current state of research on surface treatment at Greek sites as follows (Hamari 2015, 6–7):

„The Archaic Laconian pan tiles were usually painted or glazed (black, red, and brown) in solid colour, and this glazing was still present in the Hellenistic period, possibly even in the beginning of the Roman period (Koskinas 2011: 554–555, 558; Lawson 1996: 121; Skoog 1998; Winter 1993: 95). In contrast, the Late Roman Laconian-style pan tiles are unpainted. They might be slipped, but by using the same clay as the paste was, thus producing a reddish-brown colour similar to the general clay paste (see Hamari forthc.). To the category of decoration might be added also the usually smoother finish of the earlier tiles, also due to the finer-grained clay pastes used (Koskinas 2011). However, what the Roman Laconian-style tiles display but the Archaic tiles do not, is the finger-line decoration (signatures) on the upper surface of the tiles (Koskinas 2011, 559).“

Koskinas (2011), on the basis of archaeological survey material, proposed a classification into five phases, thereby highlighting the fundamental problems of establishing a fine-grained chronological framework for roof tiles, whose form, technique, and surface treatment are often very similar across the individual phases:

1. Pre-Roman
 - Archaic – Hellenistic
2. Roman
3. Late Roman
4. Medieval
 - Byzantine / Frankish
5. Ottoman
 - Ottoman / Early Modern

Stamps

The stamps on the roof tiles from Olympia are currently being studied by Konstantinos Biliás (Biliás – Fless 2025). They provide indications for the chronological classification of individual types of undecorated roof tiles. It must be emphasised, however, that the dating of individual examples on the basis of stamps does not allow conclusions to be drawn regarding the chronological range of the respective types.

The largest group of stamps known to date bears the inscription DIOR (ΔΙΟΡ, “of Zeus”). This Elean rhotacism finds parallels in Roman-period inscriptions of the 2nd century AD. This is further confirmed by palaeographic features of individual stamps.



Fig. 19_1: COT – 03a: slanted profile – horizontal - 1st century BC



Fig. 19_2: CUT – 7: engraved concave line - 1st century BC - 1st century AD



Fig. 19_3: CUT – 6: engraved horizontal line - 2nd century AD (stamp DIOR (ΔΙΟΡ))



Fig. 19_4: CUT – 6: engraved horizontal line - 2nd century AD (stamp DIOR (ΔΙΟΡ))



Fig. 19_5: CUT – 8: engraved convex line - 2nd century AD (stamp DIOR (ΔΙΟΡ))

Painting and coating

In the case of undecorated curved under tiles and curved over tiles, the treatment of the surface changes over time.

A painted surface reminiscent of black-glazed pottery is attested for roof tile fragments attributed to the Heraion.



Fig. 19_6: Fragment of the right rear corner of a CUT from the Heraion at Olympia.

These Heraion tiles differ from roof tiles bearing a partially intense red to reddish-brown paint. This reddish-brown surface treatment can also be observed, for example, on the early Hellenistic roof tiles of the Apodyterion at Nemea (Miller 1994; Miller et al. 2001, 162–173, figs. 196–311).



Fig. 19_7: Whitish slip along the borders, painted red (the dark discoloration is sinter).



Fig. 19_8: OLY-GYM-2013-2015-P17-S0021

On CUT with a slanted profile that runs out laterally without upward-projecting hooks, a reddish-brown to intense red paint is likewise present.



Fig. 19_9: OLY-GYM-2013-2015-P08-S0006; OLY-GYM-2013-2015-P08-S0018

Roof tiles with a beige to white slip cannot yet be clearly classified. This surface treatment occurs predominantly in tiles of the type with a slightly raised border.



Fig. 19_10: USB microscope image of the clay, beige-white slip (grey-beige sinter visible at the break).

All roof tiles securely dated to the Roman period by stamps show, to date, no paint and no separate slip. However, smoothing the surface with water may create the impression of a slip.

Chronologically relevant features of the curved under tiles and curved over tiles

Research has identified two formal elements that may provide indications for dating curved under tiles (CUTs) and curved over tiles (COTs): first, the profile of the lateral borders, and second, the occurrence of features referred to in the digital roofs project as interlocking components and pseudo-interlocking components.

With regard to the lateral borders of the curved under tiles, Koskinas (2011) has identified differences across his five phases. By way of example, the material from Olympia illustrates the differences between the borders of Archaic and Roman roof tiles, such as those between the Archaic tiles from the Heraion and a specimen datable to the 2nd century AD. Whereas the Archaic roof tile exhibits an almost vertical, sharply defined border profile, the 2nd-century tile shows a more rounded, obliquely set profile inclined upwards.



Fig. 19_11: Differences in border profiles between an Archaic roof tile and one of the 2nd century AD.

At the same time, Roman roof tiles in particular exhibit considerable variability not only between the right and left lateral borders, but also along the profile from rear to front. The configuration of the lateral borders is therefore only of limited use as a fine-grained chronological dating criterion or for assigning fragments to a specific roof tile.



Fig. 19_12: CUT - roof tile of the 2nd century AD.

In the case of curved roof tiles, the design of the upper surface at the rear edge is typologically significant. For the occurrence of interlocking and pseudo-interlocking components, individual indications for chronological classification can be identified, although no definitive conclusions can be drawn regarding the period of use or sequence of specific variants; for example:

- CUT – 2: raised strip (Archaic) – attribution to the Heraion – black-brown paint
- CUT – 4: slanted profile – horizontal (Hellenistic) – Leukas (Fiedler 2013, 110 no. Ss7)
- COT – 4: slanted profile – horizontal (Late Hellenistic) – stamp
- CUT – 4: horizontal or slightly concave finger line near edge (Early Hellenistic) – Apodyterion, Nemea – reddish-brown paint, partly

slightly concave line execution (Miller 1994; Miller et al. 2001, 162–173, figs. 196–311)

- CUT – 6: engraved horizontal line (Roman – 2nd century AD) – stamp – without paint or slip
- CUT – 7: engraved concave line (Late Hellenistic / Early Imperial) – stamp – without paint or slip
- CUT – 8: engraved convex line (Roman – 2nd century AD) – stamp – without paint or slip

A group of roof tiles with single and multiple finger lines is assigned by Koskinas (2011, II.12) to the Roman and Late Roman phases. The finds from the collapse layer of the Gymnasium roof demonstrate that finger-drawn wavy lines were already characteristic in or before the 3rd century AD. Further studies are necessary in order to achieve a more precise classification.



*Fig. 19_13: Roof tiles from the collapse layer of pile 17: S0217, S0218, S0221, S0223

Chronologically relevant features of the flat under tiles

Research has identified two formal elements that may provide indications for dating flat tiles (flat under tiles, FUTs): first, the configuration of the lateral borders, and second, the interlocking components at the front right and left corners. The form of the lateral borders in Greek FUTs may, however, also vary regionally and thus allow conclusions to be drawn regarding regional traditions. For example, West Greek roof tiles display border profiles corresponding to an outwardly curved quarter circle; comparable profiles are also found on roofs of West Greek type in Olympia.

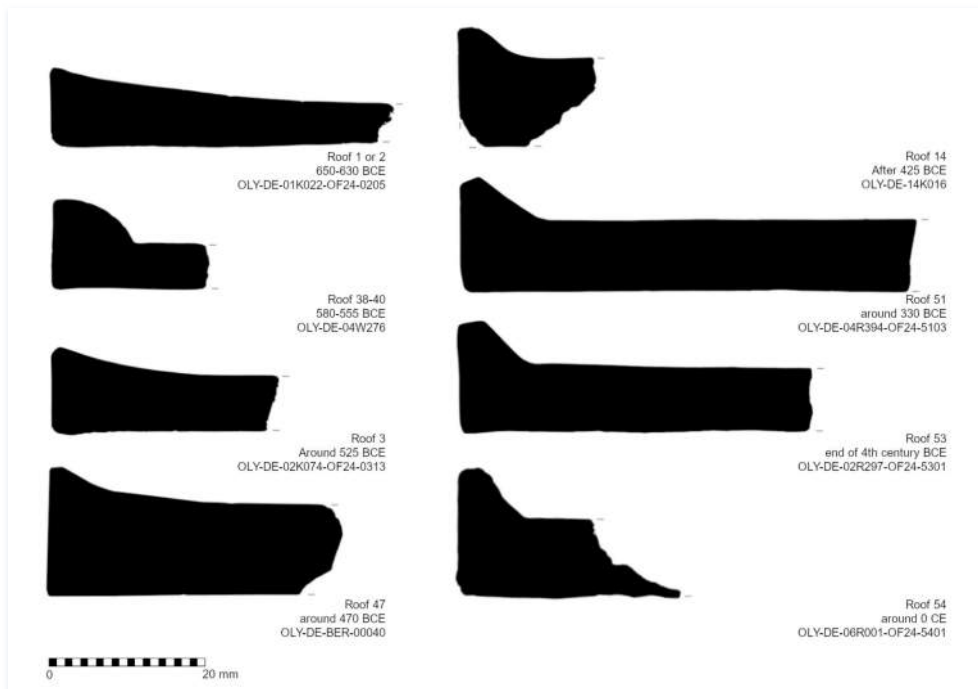


Fig. 19_14: Border profiles (Rheeder 2024, fig. 6) with dating according to Heiden 1995.

The so-called Corinthian FUTs from Olympia, by contrast, display a border form that rises towards both the right and the left sides. In the Archaic and Classical periods, the border profile is initially characterised by a gently rising curve towards the edge. Subsequently, the border becomes increasingly set off from the tile surface by means of a concave curve. In the early Hellenistic Leonidaion, the border finally appears as a sharply defined diagonal set off from the horizontal. This high degree of

formal precision is lost again in later phases; it remains characteristic, however, that the border continues to be clearly set off from the horizontal.

A comparable development of the lateral border profiles, as observed in Olympia for Corinthian roof tiles, has also been traced by Philip Mills (Mills 2013) in other regions. His focus lies on the period from the 3rd century BC to the 7th century AD and thus primarily on the later phases of this development.

Earlier, Peter Warry, in numerous studies (fundamental: Warry 2006), pointed out that *tegulae* can be dated on the basis of the form of the so-called cut aways—that is, the cut-outs at the front right and left corners (notch and indentation). By correlating these forms with stamps of Roman legions, he was able to demonstrate that some forms occur over longer periods, whereas others are characteristic only of limited time spans or specific production centres.

In order to clarify which of these formal developments can be transferred to other regions of the *Imperium Romanum* and which remain workshop- or region-specific, further comparative studies are required (Hamari 2023).

20_Durability and recycling

Roof tiles made of clay belong to those categories of artefacts that, although usually preserved only in a fragmentary state in the archaeological record, are overall exceptionally well preserved. What is far more difficult to determine, however, is how long roof tiles were actually used as roof tiles—that is, over what periods they remained in use within a roof structure or were reused for roofing in the course of repairs. In modern building practice, clay roof tiles are generally assigned a lifespan of approximately 75–100 years (Bechthold – Kane – King 2015, 54). The roof tiles from Olympia, however, provide indications that roof tiles could in fact remain in use on roofs for considerably longer periods.

On the basis of archaeological evidence, it is not easy to determine over what time spans roof tiles were actually used for roofing or reused. Research has indicated that there was a trade in used roof tiles (e.g., Bauch – Kastenmeier 2024).

For the East Stoa of the Gymnasium at Olympia, it can be shown that during a repair phase in the 3rd century AD roof tiles of very different dates and typologies were reused. Within a clearly defined roof-collapse context containing both curved under tiles and cover tiles, several curved under tiles with different interlocking and pseudo-interlocking components are attested, including:

- flat raised border
- slanted profile
- engraved concave line
- engraved horizontal line
- wavy lines

The stamps indicate that some of the reused roof tile types were manufactured in the 2nd century AD. Others, on the basis of their painted surface, clearly date to the pre-Roman period.

In the same context, curved cover tiles were found that had been deliberately modified for secondary use. These are curved roof tiles in which curved cut-outs were worked into the sides; their diameter approximately corresponds to that of the cover tiles.



Fig. 20_1: OLY-GYM-2013-2015-P17-S0028; OLY-GYM-2013-2015-P17-S0027

Several examples clearly show that these cutouts were made after firing and are not accidental breaks. Tool marks are visible along the edge of OLY-GYM-2013–2015-P17-S0113.



Fig. 20_2: OLY-GYM-2013-2015-P17-S0113

The very hard-fired cover tile OLY-GYM-2013–2015-P17-S0021 shows a comparable secondary incision. The edge appears as if it had been ground smooth, while the painted surface shows marks that may have been caused by pliers.



Fig. 20_3: OLY-GYM-2013-2015-P17-S0021

Comparable forms are attested on roofs, particularly in the case of ridge cover tiles (*Firstkalypteren*). It therefore seems highly probable that regular curved cover tiles were reworked for use as ridge tiles on the gabled roof of the hall.

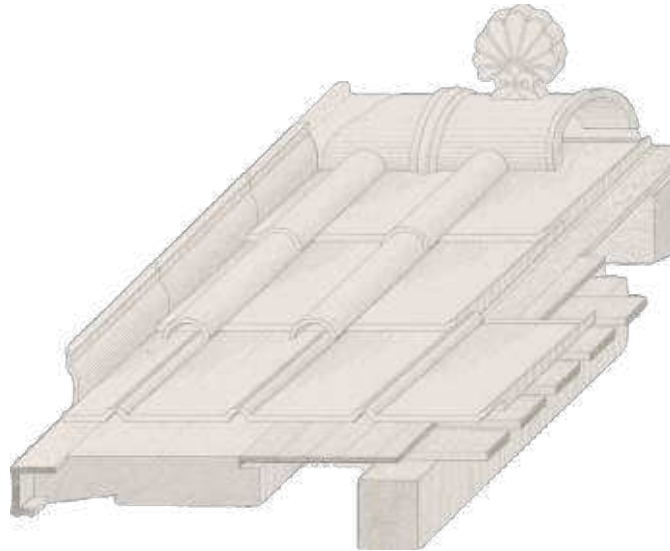


Fig. 20_4: Reconstruction drawing of curved ridge tiles with lateral cut-outs (drawing: Olympia II, 1896).

In Olympia, further forms of secondary use of roof tiles can also be demonstrated. Fragments of flat and curved under tiles were reused, often in similar dimensions, for the construction of walls. The early Imperial naiskos at the altar of Artemis (Heiden 2003) represents an early example of wall construction using roof tiles.

The reuse of flat roof tiles as paving slabs, as well as of roof tile fragments for wall construction, is widespread in Olympia and increases markedly from the 3rd century AD onwards (Haseley 2006). To what extent the reasons for this intensive recycling lay in a shortage of building material or in the necessity of finding solutions for the disposal of construction debris cannot be determined with certainty.



Fig. 20_5: View of the rear side of the naiskos at the altar of Artemis, protected by a shelter roof.



Fig. 20_6: Section of the wall of the naiskos.

It can furthermore be demonstrated that buildings in Olympia were repeatedly repaired and that, in addition to simple patching and various forms of reuse, replacement elements were produced on a considerable scale. Arndt Hennemeyer (2013) has demonstrated this for the architecture of the Temple of Zeus. Achim Heiden (1995) demonstrated for several roofs in Olympia that replacement pieces, for example for a sima with scroll motifs, were deliberately produced.

The decoration of the sima was mechanically replicated, as is evident from the progressively diminishing forms obtained from moulds. When a mould is taken from an existing decorated sima, the newly produced piece shrinks during firing. If further replacement pieces are produced on the basis of such a replacement sima, this shrinkage process continues and results in the successive reduction of the decorative form.

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Fig. 19_14: Olympia, roof-tile storeroom, compilation of edge profiles (Annalize Rheeder, DAI) – © Hellenic Ministry of Culture (L. 4858/2021), Ephorate of Antiquities of Ilia

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