21 2018 ISSN 1301-2746

ADALYA

The Annual of the Koç University Suna & İnan Kıraç Research Center
for Mediterranean Civilizations

(OFFPRINT)

AKMED
KOÇ UNIVERSITY
Suna & İnan Kıraç
Research Center for
Mediterranean Civilizations

ADALYA

The Annual of the Koç University Suna & İnan Kıraç Research Center for Mediterranean Civilizations (AKMED)

Adalya, a peer reviewed publication, is indexed in the A&HCI (Arts & Humanities Citation Index) and CC/A&H (Current Contents / Arts & Humanities)
Adalya is indexed in the Social Sciences and Humanities Database of TÜBİTAK/ULAKBİM TR index.

Mode of publication Worldwide periodical
Publisher certificate number 18318
ISSN 1301-2746
Publisher management Koç University
Rumelifeneri Yolu, 34450 Sarıyer / İstanbul
Publisher Umran Savaş İnan, President, on behalf of Koç University
Editor-in-chief Oğuz Tekin
Editor Tarkan Kahya

English copyediting Mark Wilson

Production Zero Production Ltd.
Abdullah Sok. No. 17 Taksim 34433 İstanbul
Tel: +90 (212) 244 75 21 • Fax: +90 (212) 244 32 09
info@zerobooksonline.com; www.zerobooksonline.com
Printing Oksijen Basım ve Matbaacılık San. Tic. Ltd. Şti.
100. Yıl Mah. Matbaacılar Sit. 2. Cad. No: 202/A Bağcılar - İstanbul
Tel: +90 (212) 325 71 25 • Fax: +90 (212) 325 61 99
Certificate number: 29487
Mailing address Barbaros Mah. Kocatepe Sok. No. 22
Kaleiçi 07100 Antalya - TURKEY
Tel: +90 (242) 243 42 74 • Fax: +90 (242) 243 80 13
https://akmed.ku.edu.tr
E-mail address akmed@ku.edu.tr

KOÇ ÜNİVERSİTESİ

AKMED
KOÇ UNIVERSITY
Suna & İnan Kıraç
Research Center for
Mediterranean Civilizations

Contents

Gizem Kartal
The Neolithic Cave Settlements of the Antalya Region in Southwestern Anatolia: A Comparative Perspective in Terms of Chipped Stone Assemblages 1

Derya Yalçıklı
Two Neolithic Ritual Centers in East Mysia (NW Turkey): The Baltalıin and İnkaya Caves 19

Nurcan Kayacan
Oval Points and Cattle-Hunting Practices in Central Anatolia during the 8th Millennium BC 45

Yalçın Kamış
Acemhöyük Buluntuları Işığında Erken Tunç Çağı'nda Orta Anadolu'nun Güneyinde Çark Yapımı Seramiğin Ortaya Çıkışı 63

Murat Akar – Demet Kara
Into the Hinterland: The Middle Bronze Age Building at Toprakhisar Höyük, Altınözü (Hatay, Turkey) 85

Gonca Dardeniz – K. Serdar Girginer – Özlem Oyman-Girginer
A Pottery Kiln from Tatarlı Höyük (Adana, Turkey) and its Implications for Late Bronze Age Pottery Production in Cilicia and Beyond 117

S. Gökhan Tiryaki
The Sanctuary with the Relief of the "Twelve Gods" in the Elmalı Highlands: On the Iconography of "Leto, her children, and the Nymphs" in Ancient Southwest Anatolia 135

Elif Özer – Murat Taşkıran
The Sillyon Main City Gate 151

Şükrü Özüdoğru – Düzgün Tarkan
Kibyra Geç Antikçağ Hamamı 175

Mustafa Adak
Die Melas-Brücke bei Kotenna und die Familie des Stanamoas 211

Urs Peschlow
Die Gabriel-Platte in Antalya. Rekonstruktion und ursprünglicher Kontext 229

Ünal Demirer – Nilgün Elam
Lead Seals of the Kibyra Excavations 245

Aytaç Dönmez
Xanthos West Agora II: Alteration and Transformation in the Byzantine Period 277

Hüseyin Metin – Salih Soslu
The Altıkapılı Cave Church at Pisidia ... 315

Merih Erol
Becoming Protestant: Greek Orthodox Responses to Conversion in 19th-Century Ottoman Anatolia ... 335

Evren Dayar
1853 Antalya İsyanı ... 363

Funda Solmaz Şakar – Neriman Şahin Güçhan
Building System Characterization of Traditional Architecture in Cappadocia, Turkey ... 379

Building System Characterization of Traditional Architecture in Cappadocia, Turkey

Funda SOLMAZ ŞAKAR – Neriman ŞAHİN GÜÇHAN*

Abstract

Located in central Anatolia, Cappadocia presents a spectacular landscape created by characteristic geology and architectural patterns. Throughout the region an indigenous settlement pattern has been generated by using rock carving and masonry techniques. This article aims to identify and characterize the building system specific to this region and to analyze it through a systematic study. For this analysis more than twenty representative examples of traditional houses from Ürgüp and the nearby villages of Mustafapaşa and İbrahimpaşa have been studied in detail. System sections and details of the buildings were drawn, and interviews were conducted with local masons who are still working in the field. Therefore, every building part is evaluated in terms of material, technique, and relationship to each other.

Keywords: Cappadocia, Vernacular architecture, Construction technique, Traditional house, Masonry building, Rock-cut architecture

Öz

Kapadokya Anadolu'nun ortasında kendine özgü jeolojisi ve mimari dokusuyla etkileyici bir kültürel peyzaj alanı sunar. Kapadokya'da kaya oymacılık, yığma tekniklerle birlikte geleneksel yapım tekniklerini oluşturur. Bu iki tekniğin bir arada kullanılması, Kapadokya'da bölgeye özgü bir yerleşim dokusu ve mimarinin gelişmesini sağlamıştır. Bu çalışma bölgeye özgü bu yapım sistemini tanımlamak ve sistematik bir çalışmayla analiz etmeyi amaçlamaktadır. Bu amaçla Ürgüp ve yakın köyleri Mustafapaşa ve İbrahimpaşa'dan geleneksel konutları temsil eden 20'den fazla örnek seçilerek detaylı olarak çalışılmış, sistem kesitleri ve detayları çizilmiş, hala aktif olarak çalışan yerel yapı ustaları ile mülakatlar yapılmıştır. Böylece geleneksel konutlardaki her yapı öğesi malzeme teknik ve birbirleri ile ilişkileri bağlamında değerlendirilmiştir.

Anahtar Kelimeler: Kapadokya, Vernaküler mimari, Yapım tekniği, Geleneksel konut, Yığma yapı, Kaya oyma mimari

Introduction

This article focuses on characterizing the building system evidenced in the Cappadocia, settlement of Ürgüp and two nearby villages Mustafapaşa and İbrahimpaşa. In the first part, Cappadocia is considered as a cultural landscape, and a brief description of the region's

* Funda Solmaz Şakar, M.Sc. Architect, Graduate Program in Restoration, ITU Faculty of Architecture, 34437, Beyoğlu - İstanbul. E-mail: solmazfunda@gmail.com

Prof. Dr. Neriman Şahin Güçhan, Graduate Program in Conservation of Cultural Heritage, METU Faculty of Architecture, Universiteler Mahallesi, Dumlupınar Bulvarı No: 1 06800 Çankaya-Ankara E-mail: neriman@metu.edu.tr

A shortened version of this study was presented at the 9th International Conference on the Structural Analysis of Historical Constructions (SAHC 2014, Mexico City). A summarized part relating to arches and walls was also presented at the 5th International Congress on Construction History in 2015 (5ICCH, Chicago). This article is an extended version of both studies.

geography and geology, history and local settlement culture, human and natural relations is given. In the second part, a general description of traditional architecture in Cappadocia and the nearby environment is presented. The methodology of the study is explained in the third part. The characterization of the building system is laid out in the fourth part. Finally, the article ends with a general evaluation and suggestions for future research.

Cappadocia Region as a Cultural Landscape

The region named Cappadocia is located in the center of Turkey and comprises five provinces that contain several towns and villages sharing a common geological formation (Fig. 6a, 6b). Nevşehir Province, which covers an area of approximately 5500 km^2 and includes dense, natural volcanic formations, is the core of the region. The geology of the land consists of numerous polygenetic volcanoes and monogenetic cones spread throughout the region[1] (Fig. 1). The climate in the region is very hot and arid in the summer and cold in the winter[2]. The geography is formed by tuff layers of changing colors and mineralogical structures and is affected by climatic factors[3]. Rain, wind and temperature differences between day and night have shaped the land in various ways and created the colorful formations today called fairy chimneys and badlands (Fig. 2).

Today Cappadocia is considered as an attractive natural property displaying a spectacular geological landscape. The region has been settled since the early Christian period[4], and many monks lived in Cappadocia's valleys in the Middle Byzantine period. Many rock-cut churches and chapels were also built[5]. The churches of Tokalı, El Nazar, St. Barbara, Saklı, Elmalı, and Karanlık are some of the most important churches in the region. Monastic life in the Christian period of Cappadocia has been the subject of scholarly studies such as those of Giovannini[6], Rodley[7], Ousterhout[8], and Kalas[9].

The settlement pattern and architectural style that developed in that early period affected the subsequent settlement organizations. Some of the rock-carved spaces from this period are still used as dwellings, shelters, and storage spaces for agricultural production[10]. Together with the masonry technique, the rock-carving technique also continued to be used to form residential and/or monumental architecture.

It can therefore be said that the importance of the region comes from its historic background, unique nature, topography, and land use. The landscape of Cappadocia has been shaped as a consequence of human activities including changes in natural vegetation, landform, and hydrology as well as the generation of a man-made environment[11]. This interaction makes the region one of the most visible examples of cultural landscapes in which a strong

1 Toprak 1998.
2 Göreme Long-Term Development Plan 1968, 9.
3 Topal – Doyuran 1998
4 Rodley 1985.
5 Kalas 2004, 101-119.
6 Giovannini 1971.
7 Rodley 1985.
8 Ousterhout 1995.
9 Kalas 2000; 2004.
10 Öztürk 2010, 18-27.
11 Tuna Yüncü 2015, 123.

and interlocked relationship between human and nature is evident. The daily life-style of local people, agricultural activities, connection with the nature, and methods of utilizing existing geological material as well as nature itself are key points that formed the Cappadocia cultural landscape (Fig. 3).

Hence, an important area of Cappadocia was designated as part of the World Cultural and Natural Heritage in 1985, which cited the region's natural features, historical background, and traditional human settlement pattern. Although Cappadocia is one of the best examples of a cultural landscape, it is listed as a cultural and natural site (mixed site) since the term "cultural landscape" was not used by the World Heritage Center in the 1980s.

General Description of Traditional Architecture in Cappadocia and its Environs

Climate, topography, local building materials, agricultural productivity, and defensive requirements were the factors that impacted the development of vernacular architecture[12]. The Cappadocia traditional house has been discussed in some studies. However, the majority of these deal with house units and spatial features as well as the process of transforming these houses into touristic facilities. The integrated usage of rock-cut and masonry construction techniques found in this region has not been subjected to detailed and systematic study.

The most significant studies about Cappadocian traditional architecture include Erençin's doctoral dissertation that examined the renewal of Cappadocian traditional houses with touristic purposes[13], Tatar Akman's master's thesis prepared at METU that focused on a preservation and rehabilitation project in Mustafapaşa[14], and Ulusoy Binan's doctoral dissertation prepared at YTU that discussed a conservation method for the masonry houses in Güzelyurt, Cappadocia[15].

The region's geology and rich history created a unique building tradition in Cappadocia. In many of its rural settlements the impact of climate, topography, local building materials, and agricultural productivity are very noticeable. The topography of Cappadocia has allowed its inhabitants to generate an extraordinary settlement pattern and an indigenous architecture style. The soft structure of the tuff makes it possible to easily carve out living spaces. Humans started to carve these rock masses to provide spaces for basic requirements such as living, cooking, and providing shelter for their livestock. Moreover, the need to find safety against attack was a factor in founding entire settlements underground. The Cappadocian underground city complexes are multi-level and allowed whole communities to survive potential attack for long periods of time[16].

Rock-carving is a significant activity in construction. It is accepted that the construction process in Cappadocia started with carving out the tuff mass[17]. When extra space was needed, the carving would continue both in horizontal and vertical directions. People also wanted to use the material which they had carved out from the tuff mass as a construction material. Thereby stone masonry buildings began to be made adjacent to the rock-carved spaces from the

---

12 Kazmaoğlu – Tanyeli 1979, 29.
13 Erençin 1979.
14 Tatar Akman 1985.
15 Binan Ulusoy 1994.
16 Erguvanlı – Yüzer 1977, 15-17; Ayhan 2004.
17 Erençin 1979.

carved-out material and also from stones of nearby quarries (Fig. 4). The general architectural features of the traditional buildings are determined by the combined usage of carved spaces and stone masonry spaces. In this way a remarkable architectural style in Cappadocia was generated over time[18] (Fig. 3).

The traditional Cappadocian houses, the subject of this study, were built in the late 19th and early 20th centuries as two- or three-storied buildings located on slopes. The plans of such houses are not specialized for the purpose, as in other traditional houses in Turkey. There is a main room and secondary rooms allocated for living and/or sleeping. A *sofa*, iwan, storage spaces, and livestock areas are the other units forming a traditional house. The courtyard surrounded by these spaces was the area for the women's daily domestic duties. The cooking and food preparation activities took place in the courtyard.

The tuff stone, which is the main construction material, has a soft structure when it is quarried. It then becomes strengthened on contact with air. Because of this feature, it is used in almost every part of the building including both architectural and decorative elements. Stone-carved ornaments are characteristically found on the facades, especially those comprising window frames and the cornices of floors and roofs (Fig. 5). Interior decorative elements such as a *sedir* (architectural element on which to sit or lie), a *seki* (elevated platform in a room separated from the room's entrance), and a *lambalık* (element to place a lamp on) are also constructed from local tuff stone.

Besides the main building materials of stone and rock, some secondary materials are used in traditional houses. A limited amount of iron and timber may also be found in these houses. Timber is mainly used for structural purposes such as beams in floorings and tie beams in the walls. Besides these, window and door profiles are also built with timber. Although seldom used, iron has a structural purpose as iron tie bars are used to reinforce the stone walls of the upper floors.

Methodology

This study helps us understand the traditional building characteristics of Ürgüp, Cappadocia. Although several studies have discussed construction techniques in nearby regions[19], none of them presents the dimension of building units and technical details. It is known that similar studies which address traditional masonry houses examine "the way of construction" in architectural perspective; however, expressions of construction technique and material cannot measure up to rebuild the houses. One of the main differences between this study and previous ones is that the method used in this study gives information to rebuild the traditional house by measuring and drawing the building details systematically. The other difference is that our method proposes a new and different approach for the documentation of historic buildings by using system sections to understand better the building units. The method applied in this study was first used for timber houses of Birgi in Filiz Diri's master's thesis in 2010. This method then was adjusted for traditional stone masonry houses of Cappadocia, which are the irreplaceable elements of Cappadocia's cultural landscape.

---

18 Rock-cut or -excavated architecture can also be seen in some other settlements such as Matera (Italy), Bulla Regia and Matmata (Tunisia), Maresha (Israel), and Cirene (Libya) as mentioned by Bixio 2002.

19 Diri 2010; Tunçoku et al. 2015; Sağıroğlu 2017; Şahin Güçhan 2018.

Understanding this local technique is of primary importance both for the preservation of these buildings and to learn from this tradition. For these reasons this study aims to determine the character of the building system used in the traditional houses of Cappadocia, specifically in Ürgüp (Fig. 6c). After an observational typological study in Ortahisar, Göreme, and Uçhisar (neighboring settlements of Ürgüp), twenty partially demolished traditional buildings which preserve original features were selected in Ürgüp and nearby villages (Figs. 6c, 6d, 6e, 6f). Ürgüp was the earliest town in Cappadocia whose traditional buildings were listed in 1974; however, the decision to conserve the entire region was taken in 1976[20]. It can thus be said that Ürgüp has some representative vernacular buildings in its city center and surrounding villages.

The criteria for selecting the houses are: they are representative examples of vernacular architecture displaying material, form, and construction detail, being partially demolished in order to make construction details visible, and able to present some different construction solutions. The study aimed to select enough houses that all the variations of building techniques would be displayed. Increasing the numerical amount of the houses was not the primary purpose of the selection, but a wide range of variety of construction details was considered important. It was believed that the information gathered from the buildings would be repeated if the number of houses studied was extended, since these twenty houses showed almost all the variations in building characteristics in Ürgüp.

During the field work, the construction system and techniques were studied in detail from foundations to roof, as well as some other important architectural elements included in the research. In addition to this work, demolished buildings where the debris was still extant were also surveyed to collect data about the main sections of the structural system and to gather information which could not be seen under normal circumstances. Along with these direct and *in situ* observations and documentations, two interviews were carried out with local masons who are still working in construction. Some missing parts and social interactions related to the buildings were obtained via these interviews.

To better understand the structural system and its building techniques, a methodology was adopted by the use of system sections and detailed drawings that more clearly showing the structural system. To determine systematically the building parts and to display differences in these parts, a code system was generated (Fig. 7a). These codes were used in the system sections to understand where the construction technique is changing. After coding the horizontal/vertical structural elements and their connections, it was possible to observe that some variations may occur in the different levels of a single building element. To be able to see this diversity, building elements were classified according to their location (e.g. lower, middle and/or upper part of the wall). Thus a code system was developed as follows:

Parts of the building were coded from foundation to roof with appropriate abbreviations (e.g. FD-foundation, W-wall, Wn-window). Ground floor and first floor vertical structural elements such as walls were coded to show three parts which represented the lower, middle, and upper parts of the element (e.g. G1, G2, G3, F1, F2, and F3) (Fig. 7b). The purpose of this type of coding was to understand whether the construction system varies at the lower, middle, or upper part, or not at all. Different details were shown with varying subscript numbers. For instance, the code "FD_1" indicates the first type of foundation. When the foundation detail is

[20] Conservation decision date/number: 09.03.1974/7737

varied, the code adds further numbers like "FD_2, FD_3" (Fig. 7b). After the whole building parts of the studied houses were coded in this way, all coded data were transposed to a table which shows all the buildings and details at the same time. All details of a single house, the total number of types, and all variations of a building part can be found in this table. Futhermore, it is possible to see how many types the wall has or in which houses wall type 3 exists (Fig. 7c).

Characterization of the Building System of Traditional Houses in Cappadocia

Foundations are one of the most difficult building parts to survey since they are not visible. Although the foundations of four houses were not reachable, the details of twenty-eight foundations were studied in sixteen houses. Surveys show that foundations of traditional houses in Cappadocia are formed according to the ground conditions. Most of the foundations are made of the base rock itself or are comprised of foundation walls made either entirely of stone or of stone and rock, or entirely of rock. The width changes according to the masonry wall set upon the foundations, and the height depends on the ground's condition. Foundations can be defined into four groups according to classifications done by considering material, width of foundation walls, height of foundation walls, connections with rock ground, and relations with inner and outer space levels.

The first type is the rock foundations seen in eleven examples (39%) and is one of the most common types of foundation in Cappadocia (Fig. 8).

The second type is that known as canal foundations, in which rock is shaped like a canal and a stone wall is constructed into this canal. This wall acts as a footing which is approximately 80 cm in width and 40 cm in height. It is also seen that the floor is raised 60-100 cm from the ground in order to generate a level difference between the inner and outer space. This type is seen in only one example (Fig. 9).

The third type is shallow foundations, which are seen in thirteen examples (46.5%) built in two different ways. In the first, usually seen in houses located on level ground, the foundation walls sit directly on the base rock. Construction of the foundation starts with opening gaps of approximately 40 cm on the rock. The dimension of the gaps changes according to the structure of the ground. The foundation walls are then raised 30-40 cm upon these gaps up to the ground-floor level, thereby a 70-80 cm level difference emerges between the inner and the outer ground level. This level difference protects the house from rising damp and bad weather conditions such as rain and snow. The thickness of the foundation walls ranges between 40 cm and 70 cm. If the outer faces of the foundation wall can be seen from the outside, then these faces are constructed with fine-cut stone, while the inner faces between rock and outer faces, which are not seen, are constructed with rough-cut stone (Fig. 10).

In the second way, shallow-inner foundations are constructed by opening a 50 cm indent and bonding a single row wall on the rock ground. In houses that are built on these foundations, it is possible to see some rock beneath the wall on the building facade. The level difference between the inner and the outer space is not large (Fig. 11).

The fourth type – deep foundations – is seen in three examples (11%) and may also be built in two ways. In the first way, deep-slope foundations are used for buildings located on steeply sloping land. The approximate width of the foundation wall is 45-50 cm, and the height is at least 100 cm. Thus, a plinth level difference over 1 m is generated between the outer ground and the inner ground. While the outer faces are usually built with fine-cut stones, rough-cut stones can also be seen due to the height of the wall (Fig. 12).

The second way of constructing deep foundations gives rise to what is known as deep-inner foundations. These are built with a technique similar to that used for shallow-inner foundations. The main difference is that the height of the foundation wall in this latter case reaches 100-150 cm and generates a significant level difference. In these cases, a raised floor is necessitated, and timber pillars are used for this purpose (Fig. 13).

Vertical structural elements consist of walls and rock-cut form are the next stage of construction. Rock-cut walls and columns themselves are considered one of the vertical elements since they have a wide usage in generating living spaces and other structural parts of the building. Rock-cut structures, usually used on ground floors and basements, become integrated with masonry parts in the upper floors.

It is difficult to make classifications of rock-cut elements which are randomly shaped in different forms and dimensions according to the needs of users. It is not possible to make a categorization with regard to the shape of space or carving periods since rock-carved spaces are formed with respect to rock type and carving risks but not to shape. On the other hand, the surfaces of rock-cut spaces are trimmed regularly, so it is impossible to determine the original time of carving or excavating of the space. According to interviews with local masons and visual observation studies in the site, the basic classification of rock as a vertical element can be made based on 'finishing' workmanship. In the first type, marks of carving and fixing tools such as pickaxe and bellow and anvil[21] can be easily seen on the rock surfaces. Window and door openings are not shaped in regular forms and dimensions. In the second type, rock is shaped elaborately with smooth edges and details, and living spaces, window/door openings, and niches are organized in regular geometric forms. In some examples of this type where lime wash has been used, it may even be hard to recognize the rock surfaces (Fig. 14).

Walls – the other main vertical structural elements – are built using a masonry technique with both fine-cut and rough-cut local tuff stone. The choice between rough-cut and fine-cut stone depends on the economic situation of the owner and the quarry's tuff reserves during the construction period[22].

Ground floor walls are double-sided with infill and/or mortar between these sides. Broken pieces of rock and stones are used as infill material, and then a special mixture of soil and water is poured into the gaps between the wall sides. Thus the wall stones and infill materials become integrated. Upper floor walls are usually constructed single-sided, but some rare double-sided examples can be found. Because they are single-sided, these upper floor walls need to be strengthened against lateral loads. To solve this problem, iron tie bars and timber tie beams are used in the walls.

The walls can be classified into three groups according to their construction technique.

The first stone wall type is that of single-sided walls between 18 cm and 30 cm thick. This type, seen in 17% of the houses studied, is very specific to Cappadocia in terms of its dimensions since this kind of thin wall used as a main-bearing element is not seen anywhere else in the greater region. On the ground floor, single-sided walls are used as partition elements which often enclose a part of rock-carved space. On the upper floors they are used as the main bearing walls of masonry buildings (Fig. 15). One of the basic characteristics of this type is the use of iron tie bars within the walls to keep the walls of the upper floor together (Fig. 16). These

---

[21] For more information about carving techniques and tools, see Öztürk 2009.

[22] Öz – Ayan 2011.

iron tie bars, of 3 cm width and 0.3 cm thickness, are located along the wall above and below the window openings. They are tightened from outside the wall with another vertical tie bar of 3 cm width and 50 cm length. These horizontal and vertical iron tie bars create a strengthening system against lateral loads.

The second type of stone wall is that of thin double-sided walls, which have a width varying between 40 cm and 60 cm. This type is represented by 57% of the walls. While there are some rare examples using rough-cut stones, fine-cut stones are usually preferred for this wall bonded by putting two stones measuring 18-25 cm with a 5 cm gap between them. The gap is filled with mortar and infill materials such as stone/rock debris. The outer faces of the cut stones are finely shaped, while the inner faces confronting the gap are shaped roughly. Thus, the mortar and infill materials became better integrated with the stones of the wall. Outer and inner cornices are used between the double-sided walls on the ground floor and the single-sided walls of the upper floor (Fig. 17).

The third type is that of thick double-sided walls that are constructed similar to the thin double-sided walls. These are seen in 26% of the walls. The differentiating characteristic of this type is the width of the gaps between the stone sides. In some cases, this gap reaches 35 cm and is filled with pumice, stone/rock debris, and mortar. Thus the total thickness of the wall extends to 60-85 cm. Due to the wide gap between the sides, some stone blocks are set regularly while the others are set perpendicular to them to make the wall stronger. It is possible to recognize these perpendicular stones on the building façade by their squarish form as seen in the Labraunda Andron A building. This technique has been used since Antiquity[23]. However, it is not used as systematically as that of single-sided walls. Iron tie bars can be used on the thick, double-sided walls of the upper floor. These tie bars do not extend along all the walls of the upper floors, although they are seen on the walls of the side and front façade. The other, alternative practice involves using timber tie beams instead of iron tie bars. Timber tie beams are used above and below the window openings, approximately two per story, without any tightening system on the outside of the wall (Figs. 18-19).

After identifying vertical elements, it is important to describe the horizontal structural elements, which consist of flooring/ceiling units and other components connected to them. Being on the ground floor or upper floor is the main determining factor for preferences of flooring techniques in these houses. Due to ground humidity and other climatic conditions, the durability of materials is also an important parameter.

Stone flooring is one of the types used on ground floors (Fig. 20a). To prevent rising dampness, a 3 to 10 cm layer of pumice is placed on the rock ground before laying the stone flooring. In many traditional houses a stone *sedir* is used with the stone flooring on ground floors. To make a *sedir,* a single row of stones measuring 30-40 cm in height are placed 80 cm inside from the wall, and the area between them is filled with some infill materials. The upper part of the infill can be covered with a thin, stone layer or be left as rammed earth. Stone floors are seen in 18% of the ground floors.

The other type used on ground floors is timber flooring. Sometimes timber flooring is raised by posts 50-100 cm in height. Timber floor coverings are carried by timber posts. The main purpose for this technique is again to avoid ground humidity. Timber floorings are seen in 18% of the ground floors.

---

23 Altinöz et al. 2013.

The last flooring type used in the ground floors of these houses is the simple rock ground. In the rock-carved spaces, no other covering material is needed for the floor: bedrock is left as it was. This type is seen 64% of the ground floors.

The first floors also show some variety in flooring types. Timber beams and timber planks located on the inner cornices constitute the timber floorings (Fig. 20b). There is also another type made of stone. Stone flooring in the upper floors is often seen when arched vaults are used on the ground floors.

The spanning/horizontal structural elements can be classified into two groups: arched vaults (specific to Cappadocian traditional architecture) and timber beams.

A special type of vault generated by the use of inner and outer rows of arches is the distinctive feature of the local construction technique and is seen in 58% of the floors (Fig. 21). However, 64% of these arched vaults are on ground floors, and 36% on the first floors. Vaults are used as covering elements in ground floors, first floors, and iwans, while at the same time they compose the flooring element of upper stories. Pumice and other light materials are laid over the extrados of the vault, and a flat surface is thus formed. Then to cover the infill and complete the flooring, the area is covered by stones measuring 30-40 x 50-70 cm.

According to field studies and interviews with local masons, the construction process of traditional vaults is as follows (Fig. 22): all four sides of the room are constructed up to the impost level. After this level, the walls of the front and back facade continue to be constructed, but the two side walls generate an arch system. Timber arch molds are placed between the side walls, and the inner face of the side walls is formed as an arch while the outer face is smoothly bonding as a wall. Two types of arches are used as an arch pair in this construction system: one is a rib arch while the other is a cover arch. Rib arches – the main bearing elements of this system – are 20-30 cm in thickness and 60-80 cm in width and located at intervals of 60-80 cm. Indents measuring 5 to 10 cm are opened on both sides of the extrados of rib arches. Cover arches, usually thinner than rib arches, are placed above these indents. Thus, 500-700 cm vaults are generated by these arch pairs (Figs. 21-22). Although there are some rare examples which cover the arches' width and extend 100-120 cm while the rib arches remain the same size, these were not considered as variations of this type due to concerns of authenticity. It is believed that these houses were probably altered previously.

The area between the extrados of the vault and the side walls is filled with light materials such as pumice and stone/rock debris. This type of arch pair is not only used in traditional rooms but also in rock-cut and semi-open spaces such as iwans. In this case the width of the arches can be adjusted according to the rock forms.

Timber beams, after vaults, are the most used spanning elements. They are constructed differently on the ground and upper floors, due to the nature of materials. Timber floorings are often used on upper floors to avoid rising dampness. Timber beams are rarely made in regular geometric forms: wooden logs measuring 5 x 10 cm are often used on ground floors and logs measuring 15 x 15 cm on upper floors. The beams on the upper floors are placed above the inner cornices at 30-50 cm intervals. Timber floor plates measuring 30 cm in width and of any length are overlaid on the beams. The bottom parts of the beams are also covered with timber boards which form the ceiling of the lower floor (Fig. 23).

Inner cornices between the ground floor and first floor are located on the inner sides of the wall and at a level below the outer cornices. The width of the inner cornices changes between 15 and 30 cm. More durable stone types are preferred for the inner cornices because of their importance to horizontal structural elements. The flooring system can be replaced if the inner cornices remain steady. If a timber *sedir* is constructed with timber flooring, two rows of rough-cut stone are placed on the inner cornices of the front façade before its timber posts are positioned on the floor beams. The 5 x 5 cm *sedir* beams are then placed on these timber posts and rough-cut stones. Finally, the structure is surrounded by timber coverings.

The other most common and specific floor construction type on first floors are wooden logs, locally called a *hezen,* covered with woven straw. Logs spanning the side walls are placed side by side on the inner cornices. Straw mats are laid on the logs. A pumice infill is overlaid on the straw mats, and timber laths of 5 x 5 cm or 5 x 10 cm are placed on top of this infill. Finally, the floor is completed with timber planks (Fig. 24).

Although it is not very common, timber flooring is sometimes used on ground floors. In the simplest technique, pumice is laid on the ground, and clay is spread over the pumice layer to prevent rising damp. Timber planks are covered with timber beams or logs measuring 5 x 10 cm. In another technique, the flooring is raised about 40-100 cm on timber posts that sit directly on ground and are placed parallel to the long side of the room. Before the floor is finished with a covering of timber planks, longitudinal beams measuring 15 x 15 cm followed by transverse beams measuring 10 x 10 cm are put in place.

Timber flooring including *hezen*s, timber beams, and raised floors mentioned above accounts for almost 24% of all floors. Of these timber floors 44% are found on ground floors, 56% on first floors.

The last part of construction system in Cappadocian houses concerns roofs and superstructures. This is one of the most difficult parts of the buildings to analyze since they are hard to reach and have in most cases undergone extensive alterations. The roof details of 15 out of 20 houses (75%) have provided information about overall roof structures. Three types of roof and/or superstructure technique have been found on these houses: timber roofs, earth roofs, and carved rock.

Timber roofs are mostly used for the house of wealthy people and may be seen on 25% of the buildings. They are built with timber laths and inclined in one way or two ways. They are often used as a hipped roof with a 35% inclination. With timber roofs, roof cornices have a significant role just as floor cornices did. Outer roof cornices indicate the finishing level of the story while the inner ones bear the roof beams. Outer cornices built with a slight incline also function as dripstones for roof water. In construction, 10 x 10 cm roof beams are set on the inner cornices parallel to the short edge, and a central beam is placed transverse to the others. Roof posts, which measure 10 x 10 cm or 15 x 15 cm, are placed above the beams, and bracings are placed between them. Purlins, girders and rafters are set on the roof structure, followed by covering plates of 2 cm thickness and 20-25 cm width. Then, the roof is completed by covering it with over- and under-tiles. It is important to make the first course of tiles stationary to prevent the movement of the entire tiled structure. For this reason, 5 x 5 cm timber laths as long as two or three tiles are nailed onto the roof covering planks at 20-50 cm intervals. Wiring the over- and under- tiles to each other is another method used for the same purpose. Girders extending 15-20 cm across the building generate the eaves of the buildings. The ends of these eaves are closed with fascia boards while the bottoms are sealed with covering boards. Thus birds and other animals are kept away from the inside of the roof. Another type of timber eave, which extends 70-90 cm across the building and is supported by a timber brace, is seen very rarely because of the climatic conditions of the region.

As an older technique, earth roofs are seen in 50% of the buildings and are very common in buildings in which arched vaults and *hezen*s are also used (Fig. 25). In the vaulted spaces, the extrados of the vault is filled with pumice and/or rock pieces, and a special mixture of water and soil is poured into the infill. Afterwards clay soil, which has a high water-holding capacity, is laid on the infill and compressed with a special tool made of a cylindrical stone block and called a *yuvak*. In order to get ready for the winter, earth roofs have to be weeded and recompressed every autumn. In the *hezen*-covered spaces, straw mats are laid on the *hezen*s, and again pumice, rock debris, and afterwards clay soil are spread over the straw. The stone eaves used with earth roofs are located on the outer cornices. Eave stones measuring 30 x 80 cm are set side by side while projecting 60 cm and extending across the entire building (Fig. 26).

No other superstructure is needed in rock-carved spaces or semi-carved masonry spaces. In this regard, the rock itself should be considered as a third type of roof found in the region. The outermost surface of the rock can be shaped to prevent penetration of rain and snow water, and it works as a superstructure when needed.

General Evaluation

The architecture in Cappadocia represents kind of a challenge of humanity with nature. It has a unique architectural style that completely integrates with nature and understands its occasions. The characteristics of traditional architecture have never been intent upon consuming the natural assets nor to override them. On the contrary there is a peaceful relation between nature and humans.

This relationship has endowed us with an impressive historic environment with special building techniques. The technique of rock carving has a significant role in forming this authentic settlement pattern. It is a very exceptional technique that can be used in almost every part of local buildings, such as their foundations, vertical and horizontal structural elements, and superstructures. Rock carving is preferred even in architectural elements (e.g. niche, *taka, sedir, lambalık*, etc.) and ornaments which are not structurally significant parts of the buildings. This shows us that rock carving is preferred not only because of its structural or economic advantages but also because it is the ordinary way of space/object-producing in this area. The masonry building technique identified in this article is the other much-used method in this region.

As an overall evaluation, it can be said that rock foundations are used in rock-carved spaces if the building is constructed on flat ground, while type 2 is used on foundations. If it is on moderately sloping land, foundation type 3 is used. If it is on steeply sloping land, foundation type 4 is used. Rock-cut spaces have a vertical and horizontal structural system made of rock. The masonry part of a traditional building is formed with vertical structural elements of thin single-sided walls; double-sided walls consist of two stone sides with mortar in between and without any other binding element. Double-sided walls are often used in ground floors while single-sided walls are found in upper floors with the iron tightening system. As a horizontal structural system, the first type of flooring system is created by placing timber logs (*hezen*) side by side. This utilizes a pumice infill and clay soil for the flat roof/covering system. The second type, and most specific to this region, is the arched vault composed of inner and outer rows of arches. In Cappadocia this arch vault is the most characteristic covering system for architectural spaces.

To sum up the building characteristics described above, rock carving or excavating is the earliest technique used for housing, and it is still used in the region. At a later date, masonry was used, which has become the main building method today. These two techniques have been used simultaneously for a long time, and some materials such as timber and iron have been used as secondary materials with these techniques.

All the information in this research could serve as an extensive data source for future restoration and maintenance works. In further studies, the number of representative traditional houses in other settlements should be extended to make a comprehensive database. In this way, it could be determined whether or not the building characteristics of nearby rural settlements show variety. Moreover, the features of the mortar and pumice material used in the buildings could be analyzed in order to understand their effects on the structural condition of the houses. Besides, engineering studies could be conducted concerning the performance of the buildings.

Although it becomes difficult to find traditional masons in Turkey, Cappadocia still has its own masons working on traditional buildings. It therefore seems important that these local masons be recorded while they are working. The documentation of their construction process would help further research as well as the restoration and maintenance practices of the future.

As a consequence, this spectacular landscape is considered as an important source for the requirements of living and housing. The geological structure of the region provides an important opportunity not only for obtaining construction materials but also for creating living spaces. Rock-carving and masonry techniques generate an architectural pattern which is completely compatible with the surroundings and with human necessities. Thus architecture in Cappadocia has an indigenous character which is an open-ended and reproducible layout.

Abbreviations and Bibliography

Altınöz et al. 2013 A. G. Bilgin Altinöz – S. Coutignies – B. Erdil – U. Akyüz – T. Topal – G. Akoğlu – F. Diri – N. Şahin Güçhan, Restoration Project for "Andron A" in Labraunda, Project Report (Unpublished Report) (2013).

Ayhan 2004 A. Ayhan, Geological and Morphological Investigations of the Underground Cities of Cappadocia Using GIS (Middle East Technical University Unpublished PhD Dissertation 2004).

Binan Ulusoy 1994 D. Binan Ulusoy, Güzelyurt örneğinde, Kapadokya bölgesi yığma taş konut mimarisinin korunması için bir yöntem araştırması (Yıldız Technical University Unpublished PhD Dissertation 1994).

Bixio 2002 R. Bixio, "Origini del costruire net sottosuolo", in: R. Bixio – V. Castellani – C. Succiarelli (eds.), Cappadocia, Le città sotterranee (2002) 21-30.

Diri 2010 F. Diri, Construction Techniques of Traditional Birgi Houses (Middle East Technical University Unpublished Master Thesis 2010).

Erençin 1979 A. Erençin, Kapadokya Yerel Konutlarında Turizme Yönelik Yenileme Çalışmalarına Bir Yaklaşım: Örnek Avcılar Köyü (Istanbul Technical University Unpublished PhD Dissertation 1979).

Erguvanlı – Yüzer 1977
A. K. Erguvanlı – A. E Yüzer, "Past and present use of underground openings excavated in volcanic tufts at Cappadocia area", in: Proceedings on Rock Storage (1977) 15-17.

Giovannini 1971 L. Giovannini (ed.), Arts of Cappadocia (1971).

Göreme Long-Term Development Plan 1968
Göreme Long-Term Development Plan, Orman Genel Müdürlüğü (1968).

Kalas 2000 V. Kalas, Rock-Cut Architecture of the Peristrema Valley: Society and Settlement in Byzantine Cappadocia (New York University Unpublished PhD Dissertation 2000).

Kalas 2004 V. Kalas, "Early explorations of Cappadocia and the monastic myth", Byzantine and Modern Greek Studies 28.1, 2004, 101-119.

Kazmaoğlu – Tanyeli 1979
M. Kazmaoğlu – U. Tanyeli, Anadolu Konut Mimarisinde Bölgesel Farklılıklar", Yapı 33, 1979, 29-41.

Ousterhout 1995 R. Ousterhout, "Historical design in the environment: examination of a Byzantine settlement in Cappadocia", in: Proceedings, ACSA West Central Region Conference, Urbana-Champaign (1995) 13-19.

Öz – Ayan 2011 O. Öz – M. Ayan, Interview by Funda Solmaz. Tape recording. Nevşehir (November 2011).

Öztürk 2009 F. Öztürk, Rock Carving in Cappadocia from Past to Present (2009).

Öztürk 2010 F. Öztürk, A Comparative Architectural Investigation of The Middle Byzantine Courtyard Complexes in Açıksaray - Cappadocia: Questions of Monastic and Secular Settlement (Middle East Technical University Unpublished PhD Dissertation 2010).

Rodley 1985 L. Rodley, Cave Monasteries of Byzantine (1985).

Sağıroğlu 2017 Ö. Sağıroğlu, "Characteristics and Construction Techniques of Akseki Bucakalan Village Rural Dwellings", International Journal of Architectural Heritage 11.3, 2017, 433-455.

DOI: 10.1080/15583058.2016.1243277

Solmaz Şakar – Şahin Güçhan 2015
F. Solmaz Şakar – N. Şahin Güçhan, "Traditional Structural Elements in Ürgüp: Walls and Vaults", in: B. Bowen – D. Friedman – T. Leslie – J. Ochsendorf (ed.), 5ICCH - 5th International Congress on Construction History, Chicago, 3-7 June 2015 (2015) III, 363-371.

Solmaz Şakar – Şahin Güçhan 2014
F. Solmaz – N. Şahin Güçhan, "A Unique Example of Vernacular Construction in Anatolia: The Construction Technique in Traditional Cappadocia Houses", SACH 2014-9th International Conference on the Structural Analysis of Historical Constructions (proceedings), Mexico City, 14-17 October 2014 (2014) 33-34.

Şahin Güçhan 2018 N. Şahin Güçhan, "History and Characteristics of Construction Techniques Used in Traditional Timber Ottoman Houses", International Journal of Architectural Heritage, 12.1, 2018, 1-20, DOI: 10.1080/15583058.2017.1336811

Tatar Akman 1985 S. Tatar Akman, The Preservation and Rehabilitation Project of "Yeni Mahalle", Mustafapaşa (Middle East Technical University Unpublished Master Thesis 1985).

Topal – Doyuran 1998
T. Topal – V. Doyuran, "Analyses of deterioration of the Cappadocian Tuff, Turkey", Environmental Geology 34.1, 1998, 5-20. DOI: 10.1007/s002540050252

Toprak 1998 V. Toprak, "Vent distribution and its relation to regional tectonics, Cappadocian Volcanics, Turkey", Journal of Volcanology and Geothermal Research 1998, 85, 55-67.

Tuna Yüncü 2015 Z. Tuna Yüncü, A Proposal for a Method of Cultural Landscape Character Assessment: A Research on the Context, Method and Results for the Cappadocia Landscape, Turkey (Middle East Technical University, Unpublished PhD Dissertation 2015).

Tunçoku et al. 2015 S. S. Tunçoku – Ü. İnceköse – T. Akış – M. A. Yalçın, "Assessment of Construction Techniques and Material Usage in İzmir Rural Houses", International Journal of Architectural Heritage 9.8, 2015, 1005-1022.

DOI: 10.1080/15583058.2014.903446

Makale Geliş / Received : 31.12.2017

Makale Kabul / Accepted : 15.03.2018

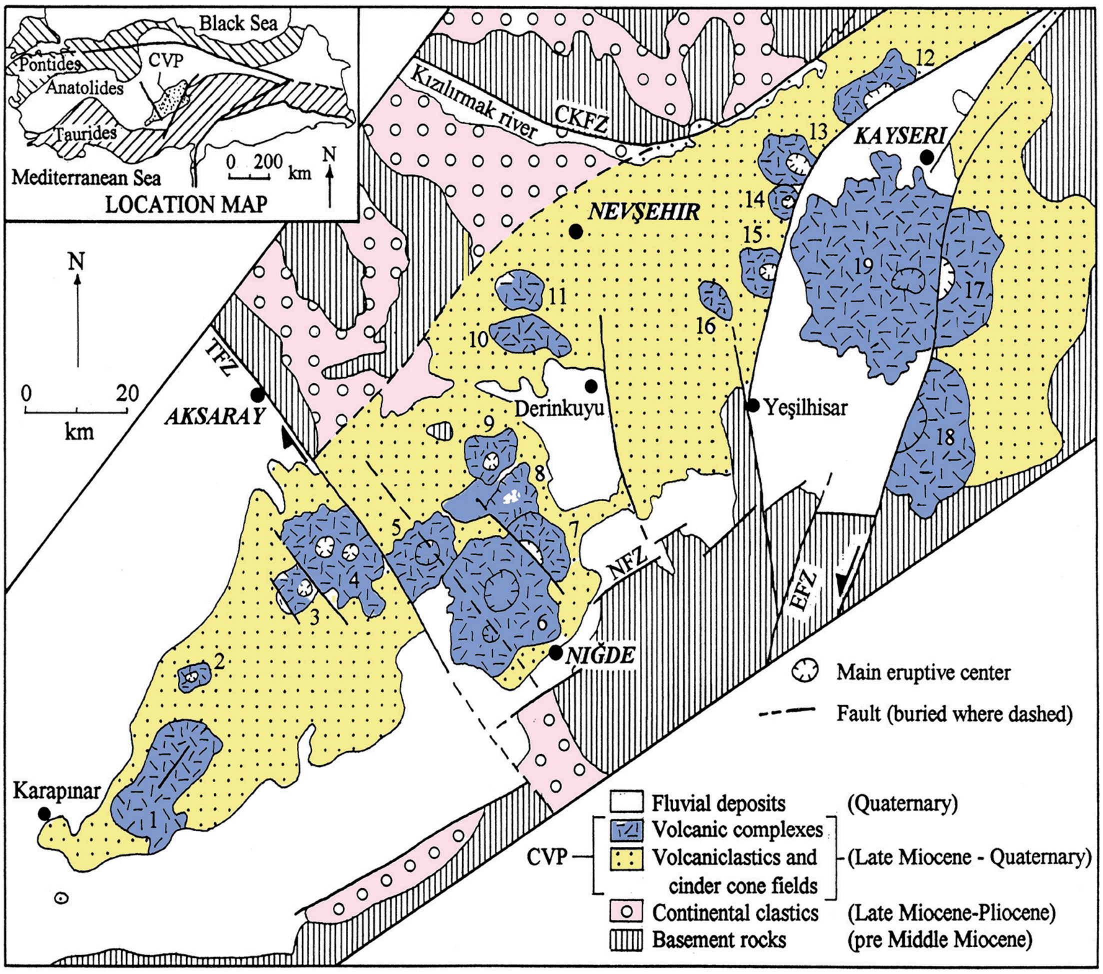


Fig. 1 Geological map of Cappadocia (Toprak 1998, 56)

Fig. 2 Geological landscape of Cappadocia

Fig. 3 General view of Cappadocia

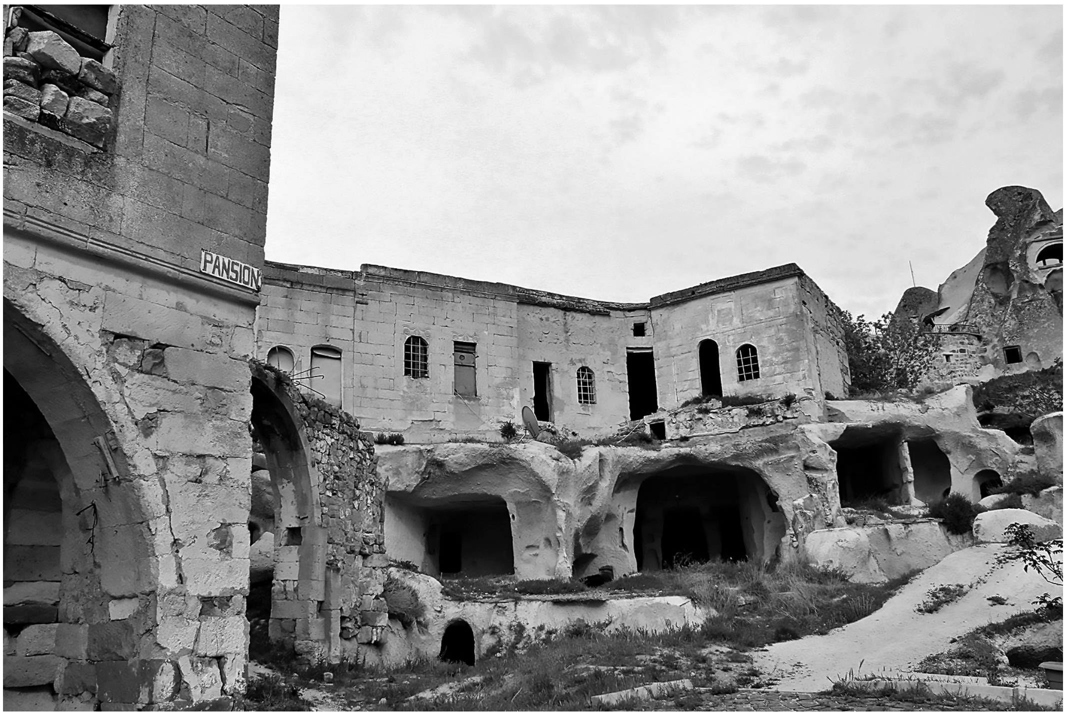


Fig. 4 Using rock-carved and masonry techniques together

Fig. 5 Stone-carved ornaments on the facade of a traditional house

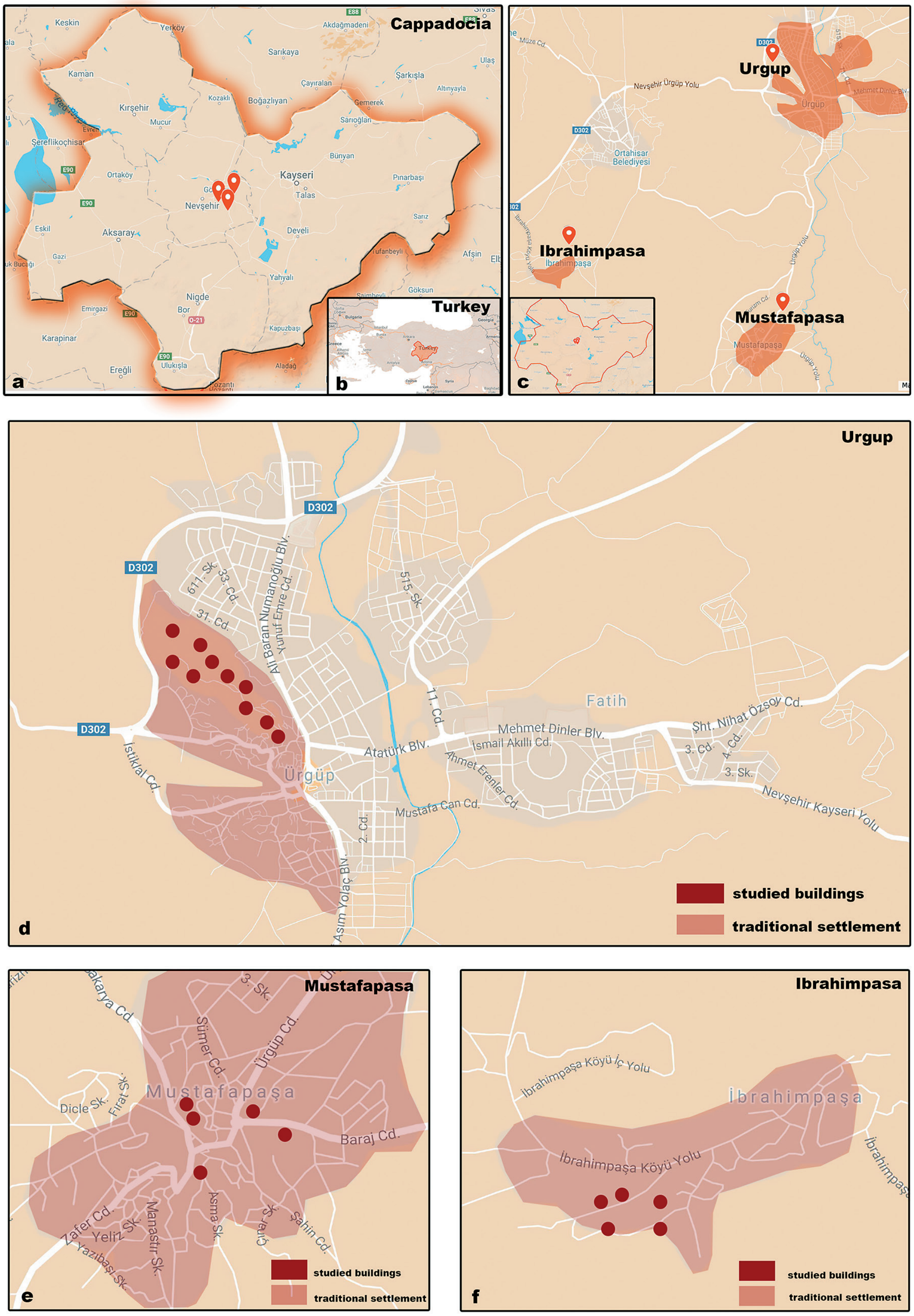
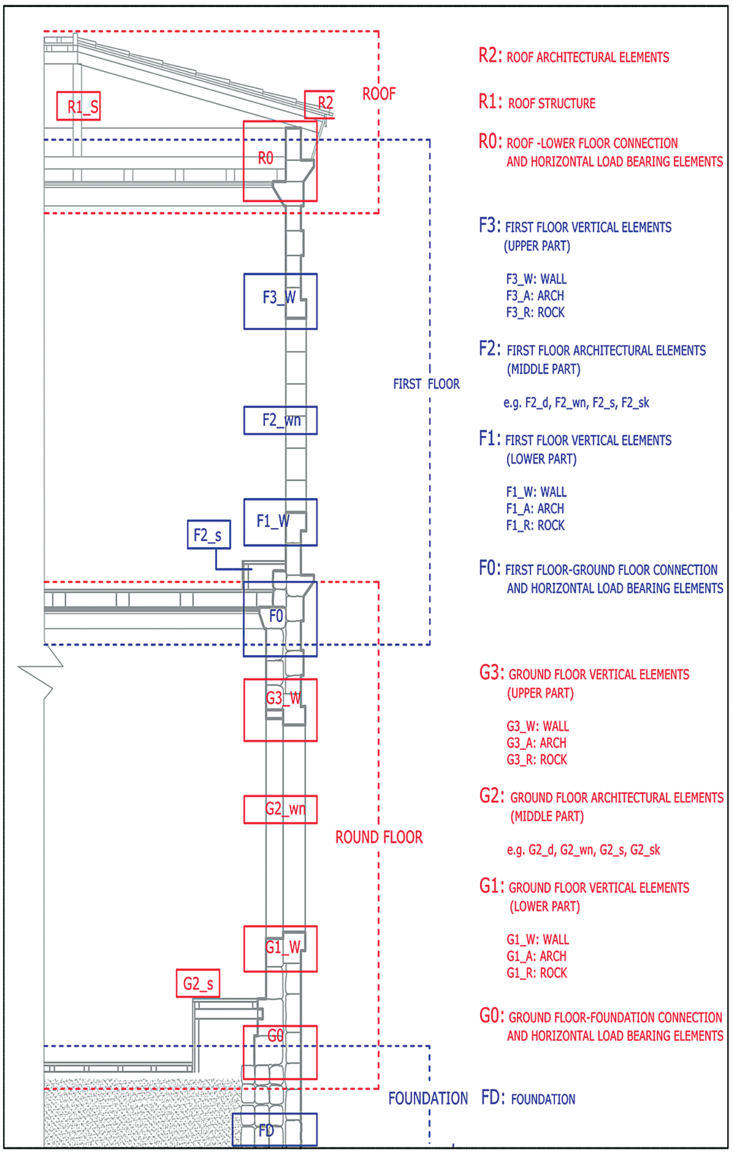
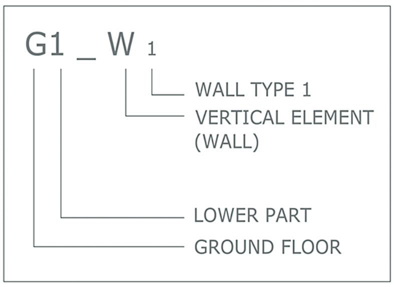


Fig. 6 a) Settlements having common geological formations named Cappadocia + selected settlements, b) General location of Cappadocia in Turkey, c) Selected settlements within Cappadocia, d) Traditional settlement and studied buildings in Ürgüp, e) Traditional settlement and studied buildings in Mustafapaşa, f) Traditional settlement and studied buildings in Ibrahimpaşa



a



b

	BUILDING LOT		FOUNDATION FD
ÜRGÜP/ KAYAKAPI	131/14	A	FD1
		B	FD1
		C	FD2
	131/10	A	FD1
		B	FD1
		C	FD1
		D	FD2
	131/23	A	FD3
		B	FD3
		C	FD2
		D	FD2
	131/45		FD4
	132/12	A	FD1
		B	FD1
		C	FD2
	182/10		FD2
	185/12	A	FD1
		B	FD1
	131/21	A	FD6
		B	FD2
	184/29		FD5
MUSTAFAPAŞA	44/4668		FD1
	/4731		FD2
	/652		--
	/4821		--
	/5112	A	--
		B	--
	5112-2	A	--
		B	--
İBRAHİMPAŞA	NO:39		FD1
	NO:26B		FD2
	NO:108		FD1
	NO:93		FD2
	NO:87		FD2

(diagonal mark) same space — — cannot survey

c

Fig. 7 a) Code system of the research, b) Detail of the coding, c) Table portion showing all variations of foundation

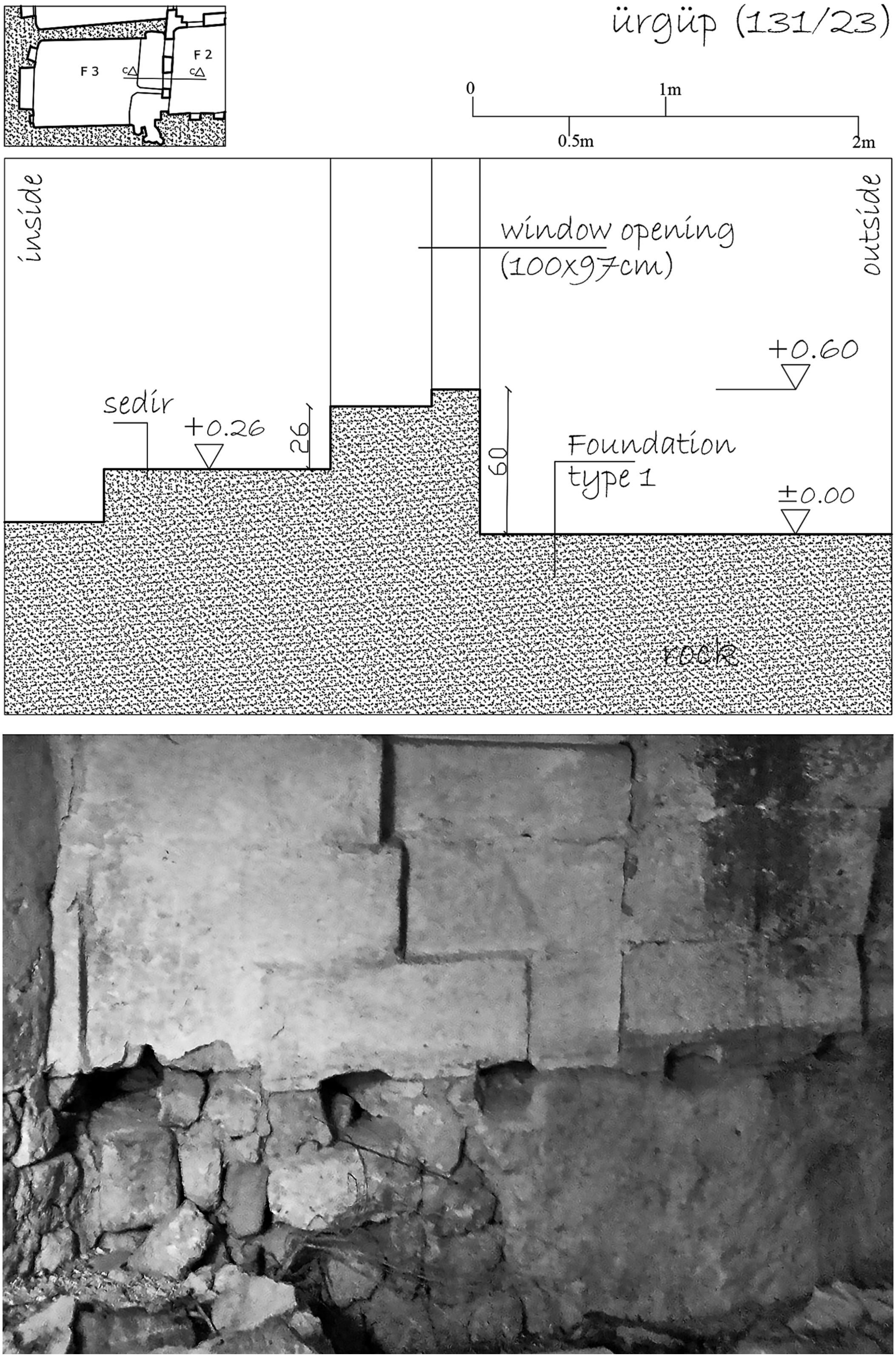


Fig. 8 Foundation type 1: Rock foundation

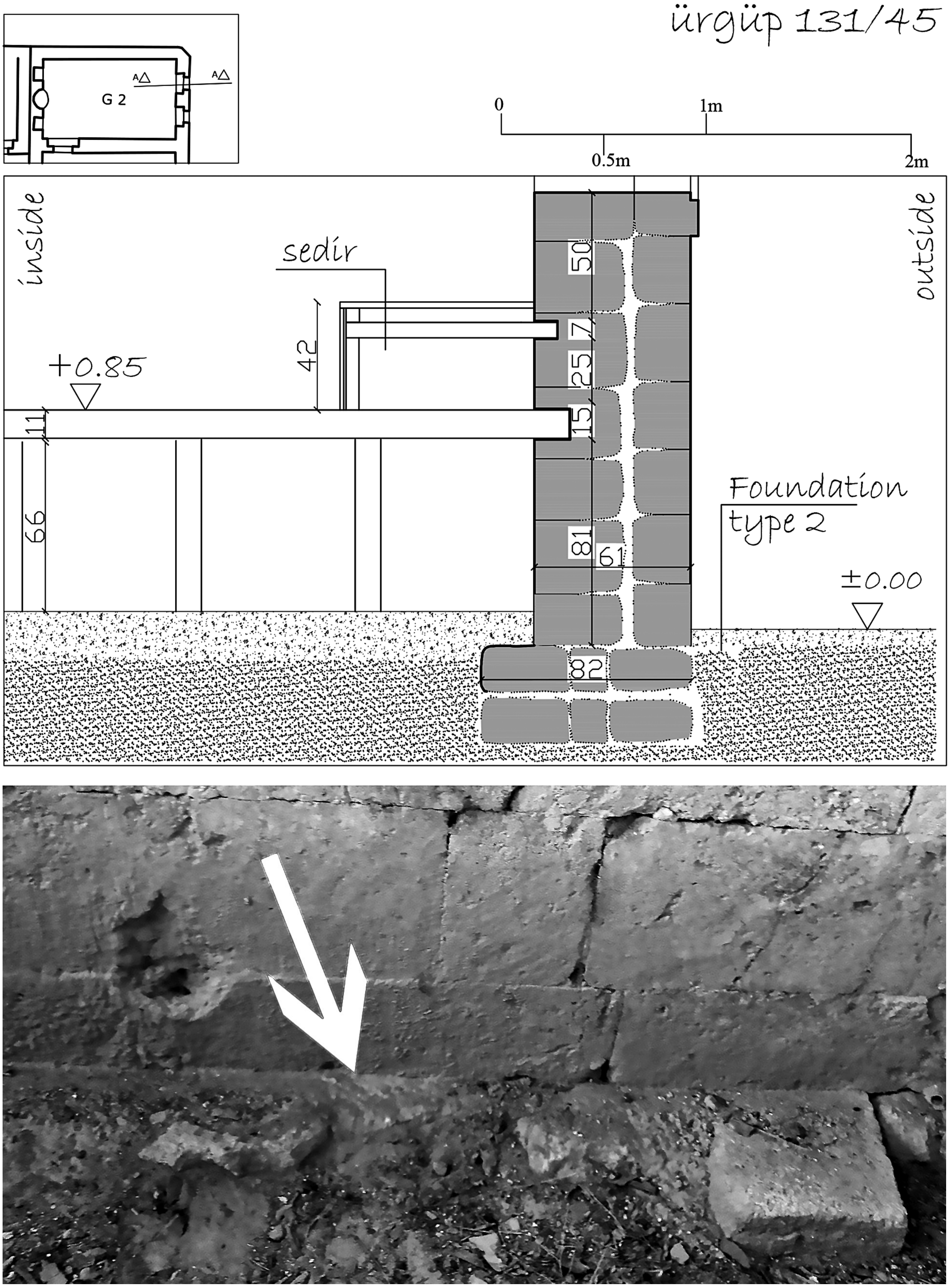
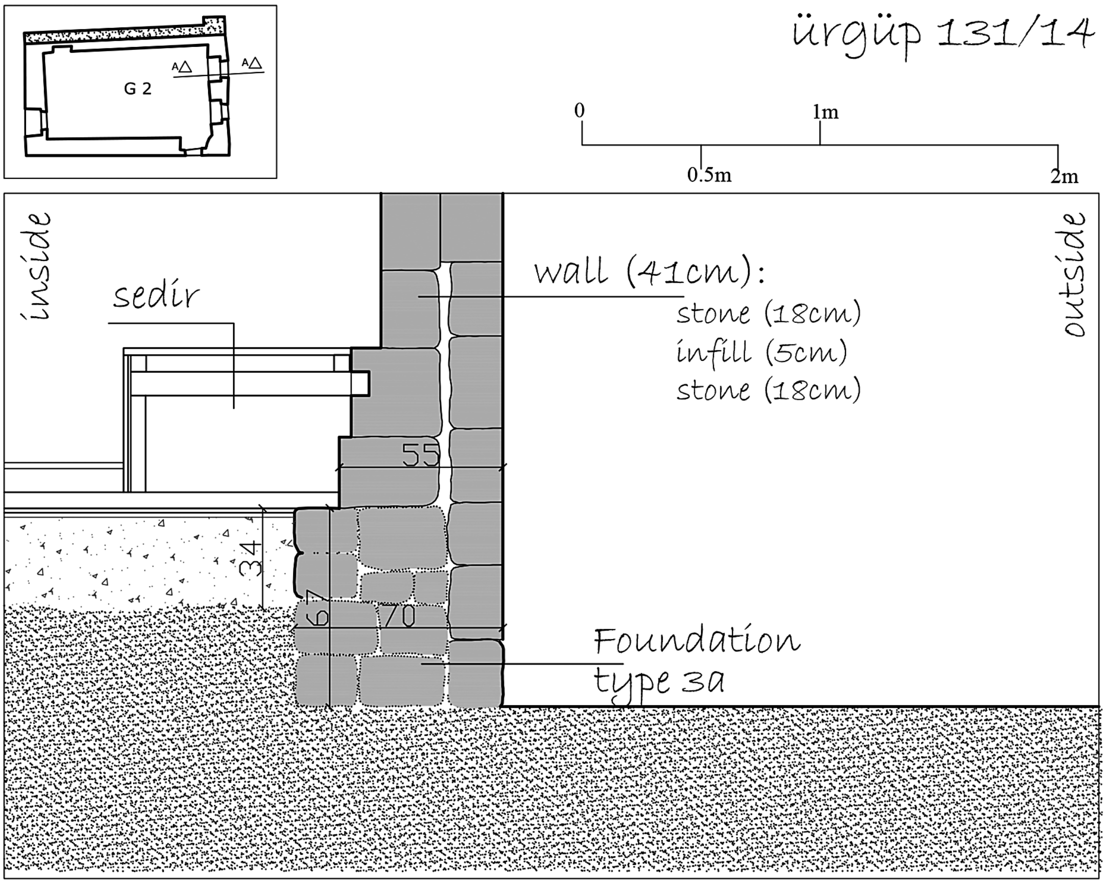


Fig. 9 Foundation type 2: Canal foundation



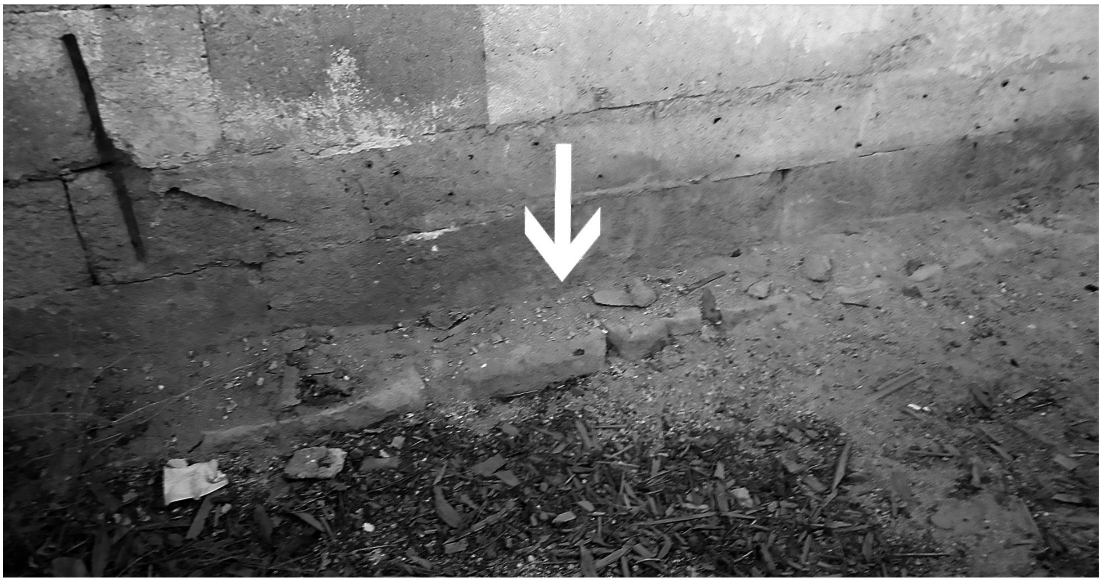


Fig. 10 Foundation type 3a: Shallow foundation

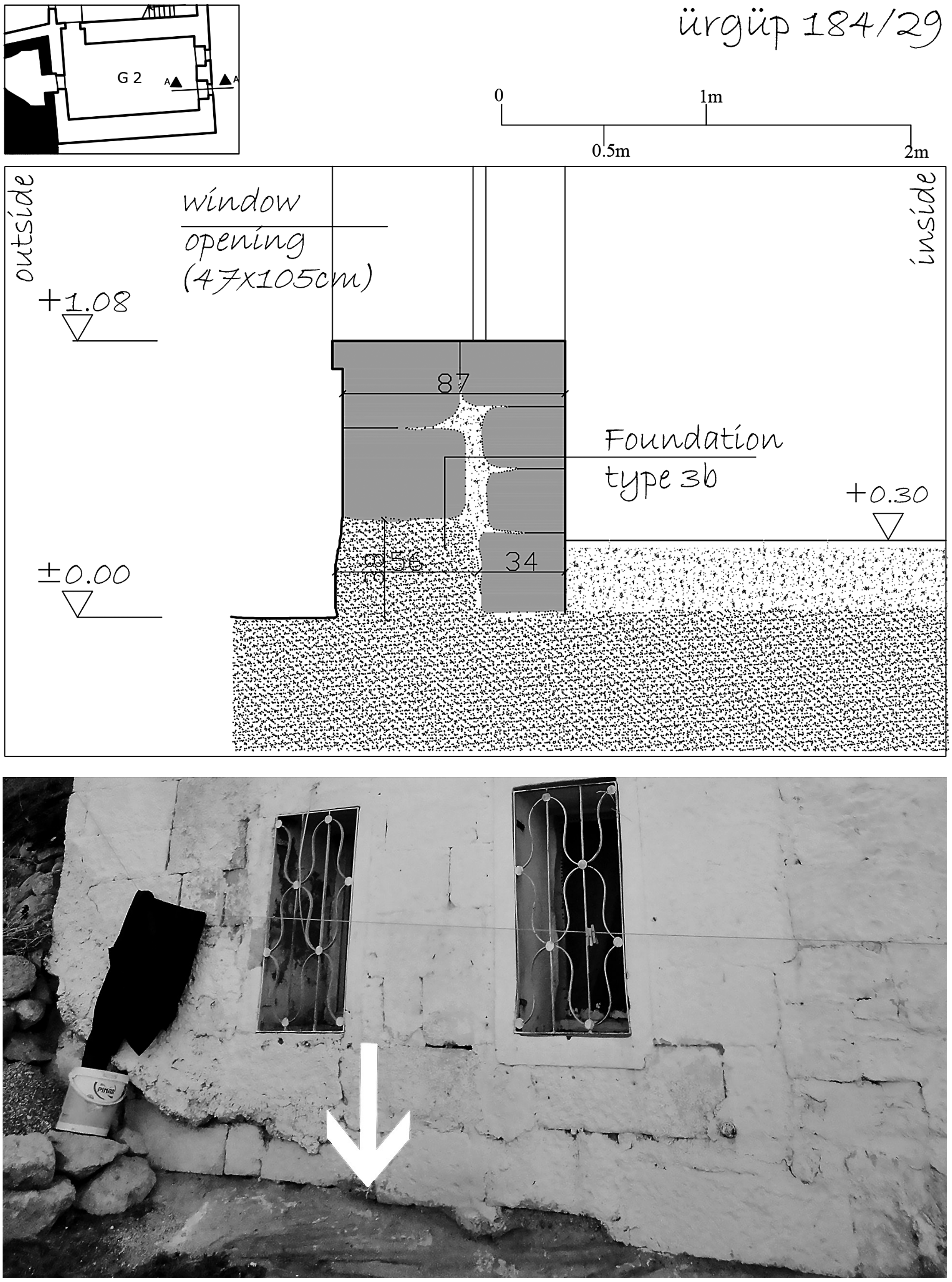


Fig. 11 Foundation type 3b: Shallow-inner foundation

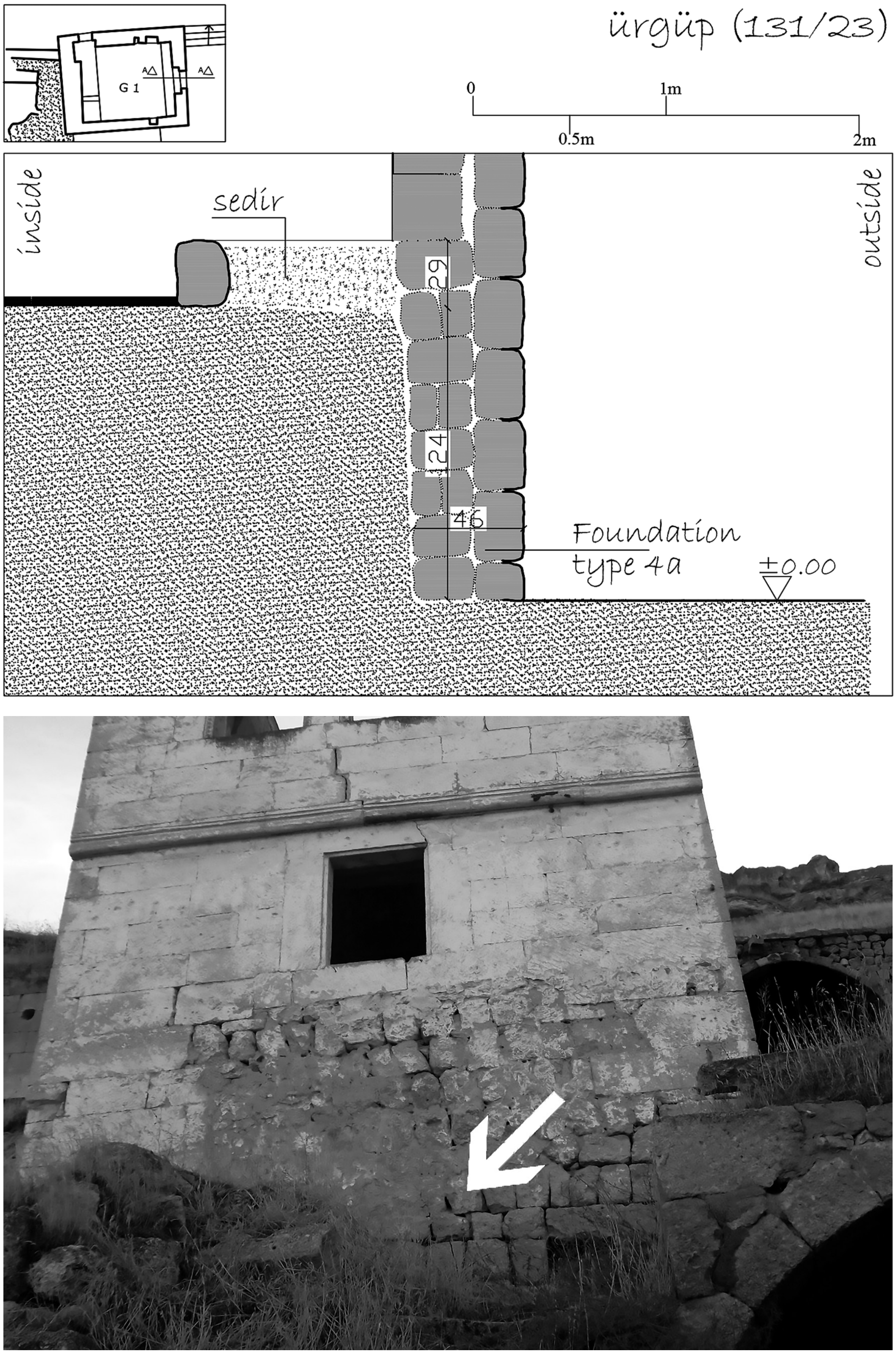


Fig. 12 Foundation type 4a: Deep-slope foundation

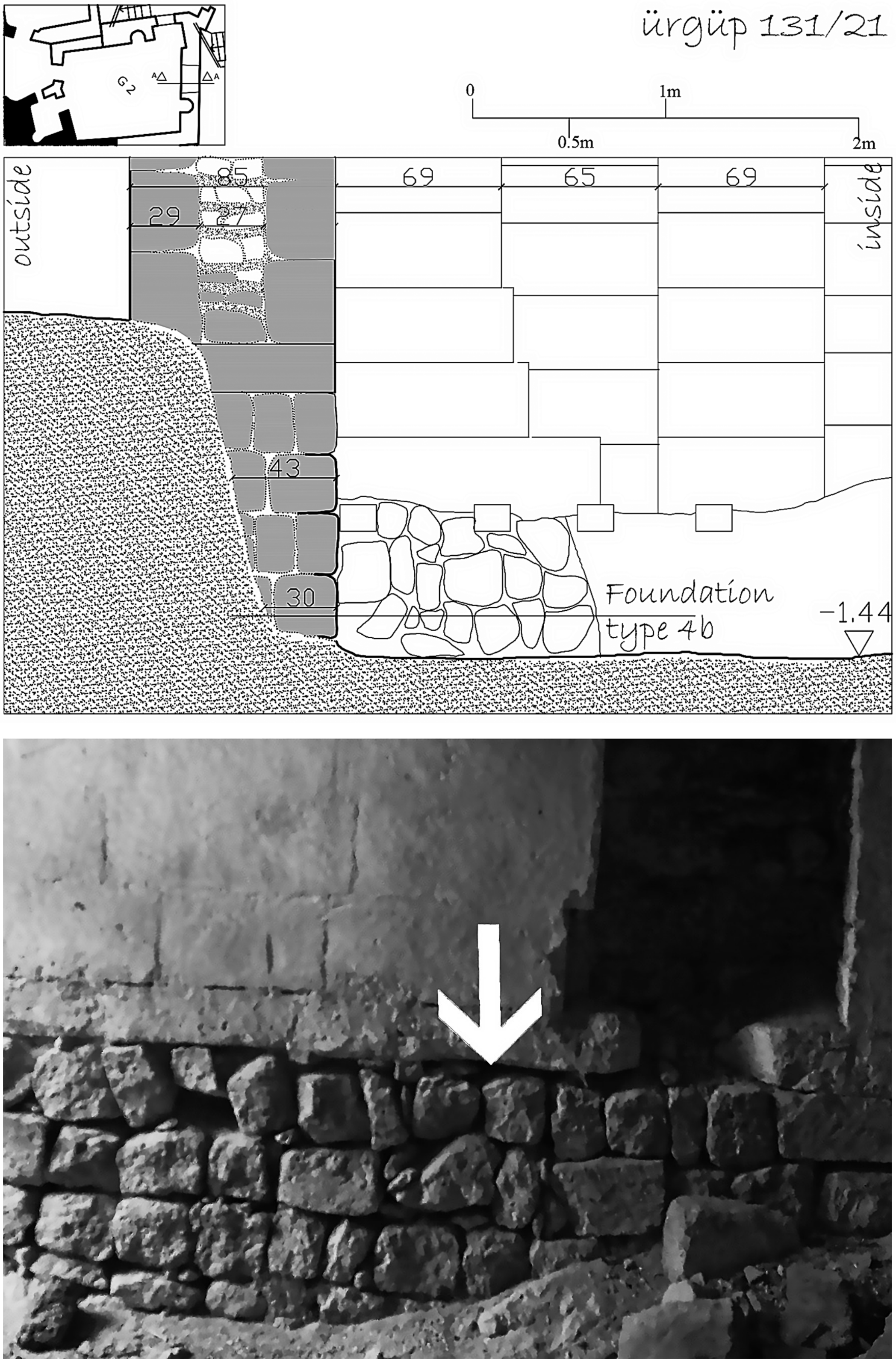


Fig. 13 Foundation type 4b: Deep-inner foundation

Fig. 14
Rock-carved
space

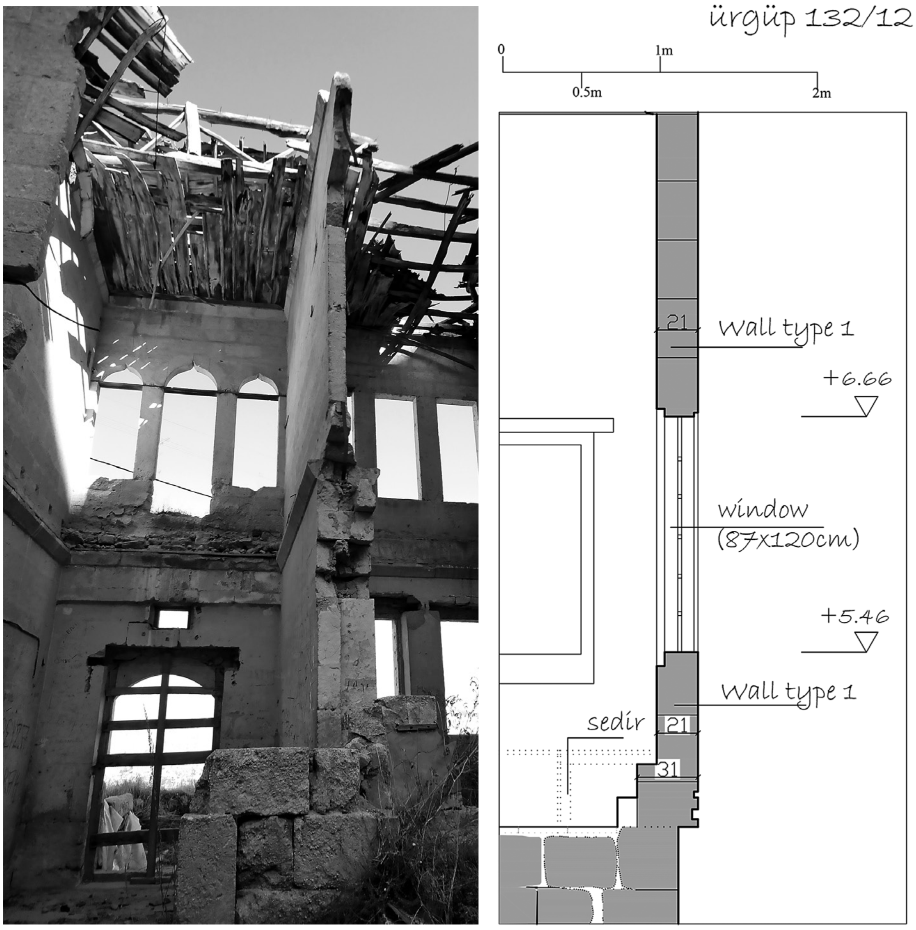


Fig. 15
Wall type 1:
Single-sided wall

Fig. 16
Iron tie bars in first floor walls

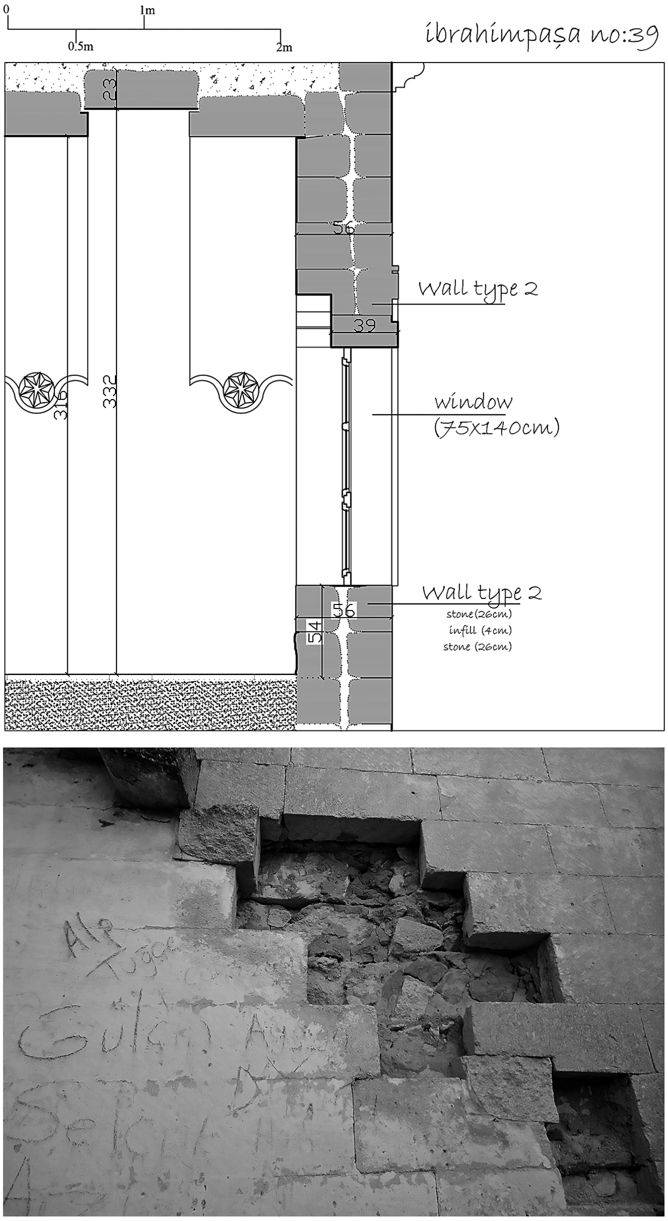


Fig. 17
Wall type 2: Thin, double-sided wall

Fig. 18 Wall type 3: Thick, double-sided wall

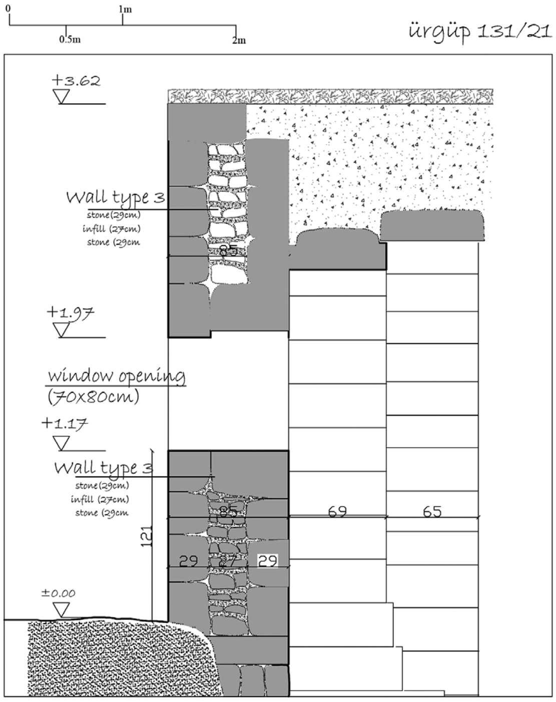


Fig. 19 Wall type 3: Thick, double-sided wall

Fig. 20 a) Stone flooring, b) timber flooring

Fig. 21
Arched vault

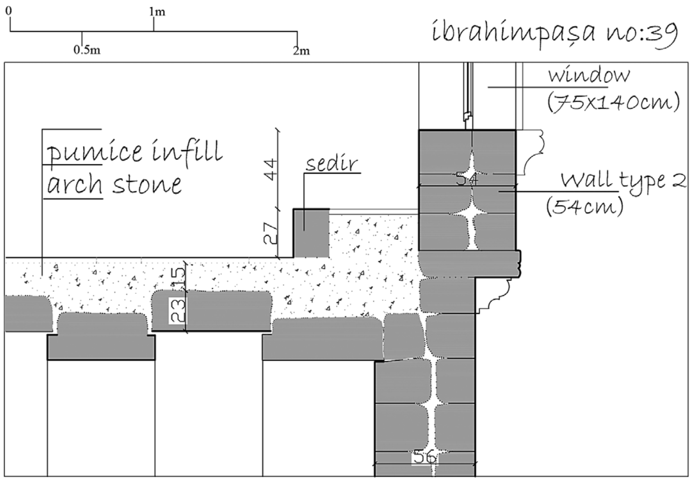


Fig. 22
Detail of arched vault

Fig. 23
Timber beams and ceiling coverings, bottom view

Fig. 24
Hezen of timber logs sitting on inner cornices

Fig. 25 Earth roofs

Fig. 26 Detail of earth roof