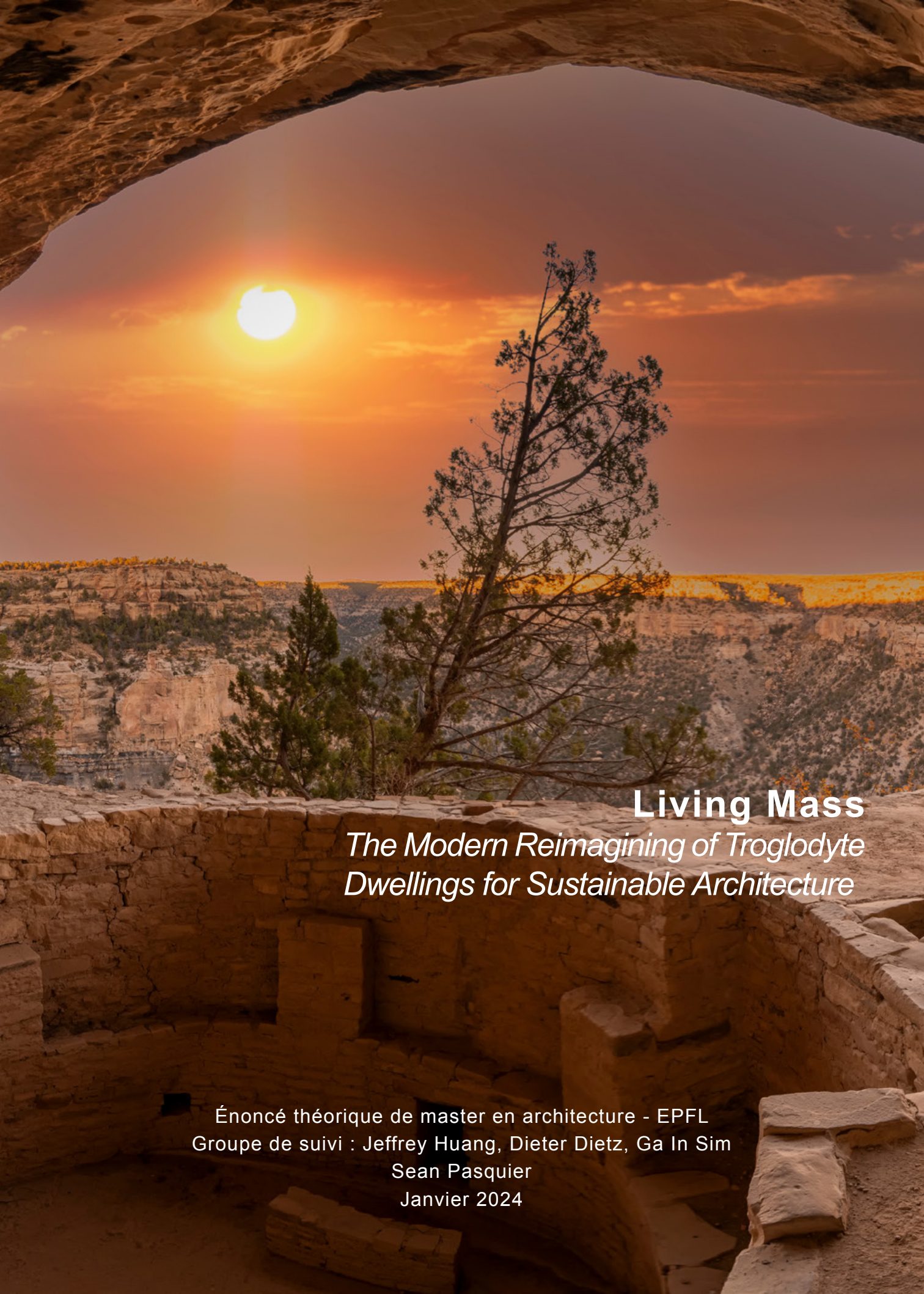




Living Mass

*The Modern Reimagining of Troglodyte
Dwellings for Sustainable Architecture*

Énoncé théorique de master en architecture - EPFL
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Abstract

Abstract

To meet the energy performance requirements for new buildings, we have returned to collective housing to reduce our energy consumption. Facades are increasingly being thickened with a layer of external insulation. The thickness varies from a few centimetres to almost a metre, reminiscent of old stone or earth facades.

Don't we need to update the way we build and develop space?

One such proposal would be to create architecture simply by digging to form habitable spaces in the mass.

The sculptural quality of traditional work brings out the best in hand-hewn stone or hand-dug earth, where you can feel the human hand. There's nothing dry or hard: no right angles or horizontal or vertical lines in the «machine à habiter» (as Le Corbusier put it), just softness and curves.

Today, fallout shelters, tunnels, bunkers and logistics centres can benefit from this art of hollowing out the mountain, of shaping the mass. But is it possible to rebuild modern cave dwellings to avoid the constant shifting of the earth? Is it possible to return to this primitive habitat?

As architects, we should learn about vernacular techniques so that we can bring them into our contemporary era.

Introduction

Introduction

As a holistic discipline, architecture interprets words into images. As architects, we are able to translate these ideas into projects that are open to interpretation.

The traditional definition of an architect is that we skilfully combine art and technical skills to design different structures that meet the needs of our clients. In a sense, we are artistic, technical and scientific translators.

We design an artificial landscape that emerges from a client's abstract thought. We create sculptures, forms in the landscape. It is very easy to want to give abstract forms, to make the client dream with these images, forgetting that architecture has a social impact on everything around it. But our role goes beyond that: we are the producers of society, we are building the world of tomorrow, we are planning the social landscape. Through its form, materiality and function, architecture represents the culture and social functioning of society. We are connected to all this and must plan responsibly.

Architecture, as mentioned earlier, is the creator of the spaces in which we live and is the result of the dominant ideas of a given period. It reflects the issues of the day and the social dynamics at play. Housing, in particular, is an expression of architectural styles, but above all it is a major political issue. The spatial configurations that surround us influence our social interactions and perpetuate certain lifestyles.

Since the Industrial Revolution, rapid urbanisation has led to a massive migration of rural populations to urban centres, creating a strong demand for housing.

Since the era of the Modern Movement, housing has been at the centre of architectural debates, with questions of scale, relationship to the land, urban structure, comfort and progress. Although the Modern Movement placed functionality at the heart of housing design. By optimising space and experimenting with new forms and types of housing. The fact remains that housing today remains one of the most heavily built programmes, with a major impact on landscape and resources.

We are now in an era of energy transition, and although it is taking too long and has not yet been adopted by some countries, we need to stop building in a way that is not responsible for the climate. This includes reviving old, forgotten techniques, developing new types of communal housing, revaluing the thickness of walls and returning to raw materials such as stone and earth.

One of these proposals would be to create architecture by digging to form habitable spaces in the mass, to return to a negative architecture, as in cave houses or troglodytic dwellings. The subsoil has always welcomed mankind into its bosom, offering effective thermal insulation, maintaining stable temperatures throughout the year and providing protection from the elements. In today's western society, the underground is mainly used as a means of defence, with bomb shelters, storage, transport and logistics centres. In Switzerland, due to the topography of the terrain, we have continued to improve the art of digging through rock and shaping the mass, but only the above-mentioned programmes have benefited from this. Housing has lost this know-how because houses are built upwards, becoming objects above the ground.

Having noticed that the topological context of projects is less and less taken into account because it has become so easy to build above ground, I wonder if it's possible to rebuild modern cave dwellings to avoid the constant shifting of the earth, and if a return to this primitive habitat is conceivable. In making this analysis, I'm wondering what lessons can be learned from this specific architecture for the creation of contemporary architecture that is more connected to its environment.

Methode

In this thesis I would like to explore my interest in troglodyte architecture and dwellings in order to better understand this type of architecture and to adapt its characteristics to contemporary architecture and to design such architecture today.

In the first part, in order to better understand what a troglodyte dwelling is, I will break it down into three essential criteria: mass, compactness and excavation. The aim of this approach is to define the fundamental characteristics of troglodytic dwellings and to identify the parameters that are relevant to the design of contemporary dwellings.

The second part of my thesis consists of an analysis of three case studies from around the world.

Finally, the comparison of these case studies and the definition of cave dwellings resulting from this analysis will enable me to formulate ideas for future architectural proposals.

The statement formulates a historical definition of cave dwellings and critically analyses it, incorporating parameters related to our present and future problems, in order to provide an opening to possible concrete strategies aimed at redefining our way of building and living.

Mass

By definition, the term mass refers to «a large quantity of matter, of a substance without precise form, a volume of an object important by its dimensions, a compact block of which one does not distinguish the parts».¹

In architecture, mass is staged through the excavation and extraction of material, often combined with work on the creation of fullness and emptiness, representing the programme spaces and circulation respectively.

Mass, or thickness, in architecture is a concept that shapes the way we perceive and experience built spaces. Beyond its physical dimension, thickness represents the depth, density and sensory quality of the spaces that surround us, adding a poetic and functional dimension to the design of buildings.²

Architectural mass is visually manifested by the appearance of compact volumes, imposing in size and generally composed of a single material that best expresses the massive aspect.³ Thickness is also essential for stability and strength, which play a crucial role in the functionality of spaces. Thick walls can provide acoustic or thermal insulation, while thick floors or ceilings can incorporate ventilation, lighting or even storage systems. In design terms, mass implies a process

that revolves around the use of material, aiming to create both full elements and voids by extracting it. We could then speak of an «inhabited mass» in which the walls are expressed as a single element. The expression of a building in which spaces are excavated.⁴

Architectural mass has sensory qualities beyond its physical dimension. The way we perceive and feel the thickness of a wall, cladding or surface can influence our spatial experience. Textured materials, sculptural details or variations in depth can create tactile and visual sensations that enrich our interaction with the built space. Spatiality thus becomes a multi-dimensional experience that combines the physical elements of a space, such as form, light, texture and scale, with the sensory and emotional responses of the individual.

Mass architecture projects focus on empty and full spaces, often made of a single material. As Peter Zumthor said: "Atmosphere acts on our emotional perception. It is a perception of unprecedented speed and one that we human beings use, apparently, to survive. (...). There's something inside us that instantly tells us a lot of things. Immediate understanding, immediate

¹Définition de Le Petit Robert de la Langue Française 2020

² J. Parker, *What is mass in architecture?*, Design your world, Explore Architecture, 2023, [en ligne], consulté le 25 octobre 2023 https://www.architecturemaker.com/what-is-mass-in-architecture/#What_is_mass_and_space_in_architecture

³ P. Collins, *Architecture - Space, Mass, Design*, Encyclopedia Britannica, 2000, [en ligne], consulté le 13 novembre 2023 <https://www.britannica.com/topic/architecture/Space-and-mass>

⁴J. Lucan, *Généalogie du poché. De l'espace au vide*, matières, numéro 7, PFL, 2004, pp. 41-54 <https://www.e-periodica.ch/digbib/view?pid=-mat-001:2004:7::150#46>

emotion, immediate rejection.”⁵

Massive architecture can be overwhelming because of the thickness of the structure. It is therefore essential to give real thought to the shape and layout of the programmes and the use of light to avoid aggressive architecture that does not create a sense of calm. These principles can be used to accentuate or reduce the desired effect of the mass and massing of the project. In this way, the openings, voids, heights, geometry and lighting devices will help to create a particular atmosphere that will help to control the heavy effect of the hollow spaces. Consequently, in order to create positive sensations and emotions of comfort, security and peace of mind, it is necessary to develop an architecture that is oriented towards an atmosphere of security.

Ultimately, this approach aims to change our primal instincts and allow us to live harmoniously in such buildings.

In conclusion, mass in architecture goes far beyond its physical dimension to become a complex, multidimensional element. It influences not only the structure and function of buildings, but also our sensory, emotional and aesthetic experience of built space.

⁵P. Zumthor, *Atmosphère*, Birkhauser, Bâle, 2018, p. 13

Troglodyte

Definition

The culture of the troglodyte housing has tended to disappear in our western society, but this culture has survived through time and around the world: China currently has more than 40 million troglodyte dwellings; in Tunisia, hotel complexes are being built on ancient sites; in France, especially in Lorraine, there were around 15,000 troglodyte dwellings until the beginning of the 20th century.⁶

In the Neolithic period, when humans settled down and abandoned the nomadic life of hunting and gathering in favor of agriculture and animal husbandry, a type of dwelling emerged: the troglodyte. The term comes from Greek, where "troglodyte" is derived from τρώγλη (tróglê), meaning "cave", and δύνειν (dýeiê), meaning "to penetrate into". Troglodytes dug caves to live in.⁷

These habitats are defined as architectural structures built into natural cavities or carved into rock formations. These subterranean dwellings have been used across different eras and cultures and offer unique environmental and structural advantages.

It is really interesting to understand the several reasons why humans have developed such habitats. Firstly, they do not require the transport of materials. This is why

we find this type of dwelling in arid regions, where weather conditions are particularly harsh and building materials such as wood are particularly scarce.

They also provided effective thermal insulation, maintaining stable temperatures throughout the year and offering protection from the elements. The use of troglodytic structures varied according to cultural needs, ranging from simple shelters to complex installations integrating residential, agricultural and ceremonial spaces.⁸

The construction of these habitats required a precise understanding of the local geology, as well as sophisticated techniques for excavating and shaping the spaces. They were intrinsically adapted to natural conditions and required little maintenance. What's more, their environmental impact was minimal, blending harmoniously into the surrounding landscape.⁹

There are several examples of cave dwellings in the Mediterranean, in Tunisia, Cappadocia and southern Italy, which we will discuss later.

These dwellings can be divided into two sub-categories: hypogean dwellings and

⁶ M.-E. Scheffer, *Habitat troglodytique et souterrains aménagés*, Atlas Archéologique de Touraine, FERACF, Tours, 2014

⁷ G. Pitiot, C. Desodt, H. Horsin Molinaro, *Les habitations troglodytes*, Culture science de l'ingénieur, école normale supérieure Paris-Saclay, 2023
<https://eduscol.education.fr/sti/sites/eduscol.education.fr/sti/files/ressources/pedagogiques/14301/14301-les-habitations-troglodytiques-ensps.pdf>

⁸ L. El-Wakil, *Architecture troglodyte : théories, réalités, sauvegarde*, UNIGE, 2012, [en ligne], consulté le 13 novembre 2023

https://www.academia.edu/9302967/Architecture_troglodyte_théories_réalités_sauvegarde

⁹ J.-C. Trebbi & P. Bertholon, *Habiter le paysage, maisons creusées, maisons végétales*, Collection architecture, Editions Alternatives, France, 2007, pp. 31-55

semi-hypogean dwellings.¹⁰

The first of these categories is characterized by the fact that it is built entirely underground, like at Matmata in Tunisia. The thermal characteristics of the dwellings in question are similar to those of a cave, so the daily and annual temperature variations are very small compared to the outside variations. (Fig. 1)

The second, as the name suggests, is to build the hypogaeum first, and then to use the same material excavated to create new hypogaeum spaces and cisterns to build outdoor structures. (Fig. 2)

The excavations for the underground rooms are always directed downwards, according to the inclination of the sun's rays in winter, in order to provide the perfect amount of light and warmth in every season. Semi-hypogynous dwellings are characterized by parts of the cave dwelling and parts built outside. These types of dwellings make use of the thermal mass of the land, while creating real outdoor spaces for greater comfort. In Italy, the most famous example is the Sassi in Matera.



Fig. 1
Hypogean house in Matmata



Fig. 2
Model of the Semi-Hypogean village of Matera

¹⁰ G. Cadoni, *Les systèmes de rafraîchissement passifs dans l'architecture contemporaine et la conception bioclimatique du bâtiment. Méthodologie d'analyse et évaluation de réalisations à travers le monde*, École Nationale Supérieure d'Architecture de Marseille École Doctorale 355 «Espaces, Cultures, Sociétés», 2012

The troglodytic dwelling, located between the surface and the depths, represents a tangible link between architecture and the natural environment, and between man and nature. By going underground, it seeks on the one hand to preserve the panorama and on the other to guarantee individual safety. The remarkable variety of its structures demonstrates mankind's ability to adapt to different environments. In general, these dwellings are built around a basic unit consisting of a single room forming a single corridor, dug either perpendicular or parallel to the slope of the land. Over time, the needs of the dwellings evolve and new rooms are added. These rooms can be dug out of the rock or stacked on top of each other on several levels.

These rooms, arranged in rows or on top of each other along the rock face, are used to let daylight into each room and are characterized by openings of different sizes. Alternatively, the rock face is completely excavated and a façade is built to close off the originally wide open cavity.

This type of dwelling needs to allow air to circulate to combat the natural dampness of the rock, so the rooms are often fitted with a wooden door that does not touch the ground,

or a door with holes in it, and a fireplace. What is most interesting about these traditional dwellings is the instinctive knowledge or understanding of building physics. In fact, in order to minimize this type of device, the geometry, the orientation of the excavations and the size of the openings are designed to let in natural light and air, facing south or following the path of the sun, using the rock face as a natural solar oven to dehumidify the rock and the thermal inertia of the land to keep the house cool inside.¹¹

¹¹ M.-E. Scheffer, *Habitat troglodytique et souterrains aménagés*, Atlas Archéologique de Touraine, FE-RACF, Tours, 2014



Fig. 3
Archaeological site of Vardzia in Georgia

Knowledge of the soil

Knowledge of the ground is essential for troglodyte dwellings. Despite research by archaeologists and historians, no written records have been found. Several hypotheses have been put forward as to how troglodytic dwellers chose their sites. They were often located in old quarries, in places that had features in common with old quarries, in places that already had natural caves, or simply in strategic locations for defense. All these clues are true, but they still don't tell us how the troglodytes knew their ground and the different techniques and skills they used to dig. What is certain, however, is that this knowledge was passed down from generation to generation among the inhabitants of these places, and although mistakes could be made in their construction, there was a basic knowledge that the builders / inhabitants had to possess. They perfected their building techniques on the basis of observations and knowledge passed down from previous generations. This knowledge, rooted in an understanding of the environment, enabled them to develop appropriate solutions that made the most of the natural resources available. Their architecture is built in harmony with the sun, wind, water, vegetation, minerals and the

earth. By carefully observing the natural elements of the land, these peoples have created architectural structures that interact like ecosystems.

This monolithic architecture, carved out of the ground, is the only way to ensure structural stability and impermeability inside the dwelling. In most cases, troglodyte houses are dug into soft ground to facilitate construction. For example, sedimentary rock such as limestone, molasse, sandstone, travertine or earth.¹² And despite appearances, the cavities are not necessarily made up of homogeneous material. As a result, these habitats have to be maintained by their inhabitants in order to keep the rock stable, the relative humidity viable and the temperature low.

They understood the three stages of the natural process of cave formation in order to counteract natural erosion when designing troglodytic architecture. Corrosion, which occurs when carbonic acid rainwater dissolves the surrounding rock. Erosion, caused by water carrying clay, sand or gravel, hollows out the walls and erodes the rock. Finally, incision, which is when the rock

¹² G. Pitiot, C. Desodt, H. Horsin Molinaro, *Les habitations troglodytes*, Culture science de l'ingénieur, école normale supérieure Paris-Saclay, 2023
<https://eduscol.education.fr/sti/sites/eduscol.education.fr.sti/files/ressources/pedagogiques/14301/14301-les-habitations-troglodytiques-ensps.pdf>

breaks away from the ceiling or walls.¹³

To avoid this, it was necessary to think about the context of the site, the shape of the excavations to channel the water and the construction of ashlar retaining walls where necessary.¹⁴ It is therefore a living environment that evolves over time and whose users must be attentive, connected to their environment and collaborate with nature and the soil.

¹³Club spéléologique de Bâle, Genèse d'une grotte, Karstlehrpfad, 2021, [en ligne], consulté le 20 décembre 2023

https://www.karstlehrpfad.ch/tafel_04/index_F.html

¹⁴J.-C. Trebbi & P. Bertholon, *Habiter le paysage, maisons creusées, maisons végétales*, Collection architecture, Editions Alternatives, France, 2007, pp. 93-111

Parameters of troglodyte Housing

The urban planning concepts of troglodyte villages are very similar, despite differences in culture and location, as in Matmata in Tunisia and Sanmenxia in China. The houses are laid out according to the topography of the land. They are built around a central courtyard where they are aligned along the rock faces and arranged in superimposed storeys to maximize the use of space. The dwellings are grouped together to make efficient use of the land and the natural heat of the ground. Villages include communal spaces or courtyards to take advantage of natural thermal changes, but also to encourage social interaction like in the Sissi of Matera.

The dwellings are separated by family, but the square or courtyard acts as a place for synergy between the inhabitants. (Fig.5) Access to the cave villages is designed to be both safe and practical. Stairs, ramps and paths are designed to facilitate the movement of the inhabitants and to adapt to the topography.¹⁵

This type of habitat, as mentioned above, has certain peculiarities that it has to deal with in order to adapt to its specific environment, and these will dictate the design of the spaces.

¹⁵J.-P. Loubes, P. Clément, *Maisons creusées du fleuve jaune : l'architecture trogloditique en Chine*, Editions Creaphis, 1998, pp. 106-109



Fig. 4
Troglodyte village of Sanmenxia in Central China

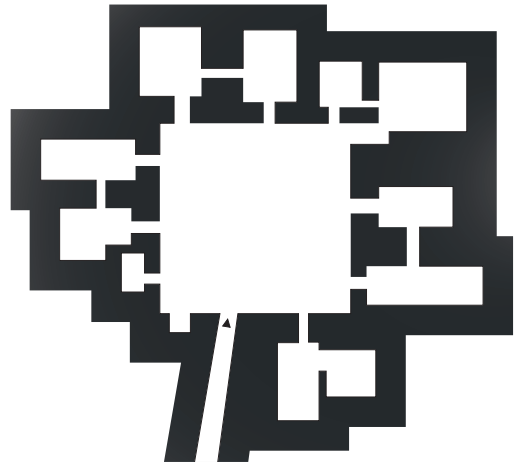


Fig. 5
Schematic plan of a cave dwelling around a courtyard for 3 families



Fig.6
Circulation sytem of Iranian village Kandovan



Fig 7. & Fig 8.
Wall holes installed in Matmata houses to reach upper rooms



Fig 9
Circulation sytem adapted to the topography of the village of Hasankeyf in Turkey

The management of relative humidity, which, if not taken into account, can not only alter the stability of the cavity, but also render it unprofitable.

A ventilation system is installed to prevent excessive relative humidity in the air coming from the rock and also from the water spaces in the house.

Two types of system were made. One directly connected with the door and an opening in the back of the cavity, because of the heat of the oven a natural airflow is created, Like in Cappadocia or Matera (Fig.10). A second one was a system of a heated floor, a cavity connected with the courtyard and heated by the oven of the kitchen permit to distribute warm air in all caves, like in Matmata, in Tunisia or in China with the system of kang (Fig. 11).¹⁶

The thermal inertia of the ground above the caves influences the thermal capacity of the cave dwellings. The rooms furthest from the façade will have the smallest changes in temperature, as will the rooms on the façade. This physical phenomenon allows the shape of the caves and the punctual ovens close to the façade to create a flow of hot and cold air that prevents the air from becoming too dry and keeps the temperature around

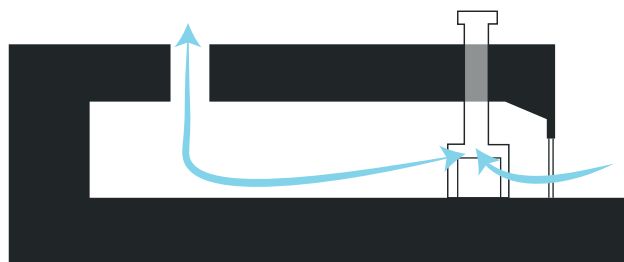


Fig. 10
Diagram of a ventilation system with chimney



Fig. 11
Diagram of a ventilation system with heated floor

¹⁶S. Feifei, Chinese Climate and Vernacular Dwellings, University of Hull, UK, 2013, [en ligne], consulté le 2 janvier 2024, pp. 146-156
https://www.researchgate.net/publication/269966756_Chinese_Climate_and_Vernacular_Dwellings

20 degrees Celsius, with plus or minus 4 degrees, which allows the rock to remain stable.¹⁷

The light inside this architecture is also a key feature. With only one façade, these cavities are destined to be in darkness. However, the relationship between human well-being and natural light is significant. Daylight acts as a natural regulator of our biological rhythms, influencing our mood, sleep cycles and productivity. Access to it has a strong impact on our mental wellbeing, as natural light stimulates the release of serotonin, a hormone associated with happiness, which can help reduce stress and anxiety.¹⁸

A number of ingenious devices are used to ensure that the architecture is well lit. Orientation will play a major role in maximizing the amount of natural light. (Fig. 12) The size of the openings will also influence this, often opening onto a courtyard with a hollowed-out area forming a zenithal window to prevent heat loss. The rooms have also been hollowed out into staircases to allow light to penetrate deep into the voids (Fig. 14), the height of the ceilings has also been increased to intensify the lighting in the rooms, and finally the walls have been treated to allow light to be reflected in this architecture.¹⁹

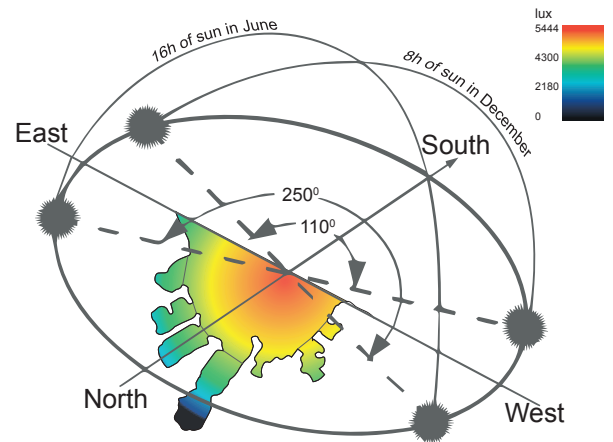


Fig. 12
Diagram of the disposition of cavities to follow the sun courses



Fig. 13
Exemple of openings and orientation in an old troglodyte complex in Guyaju in China

¹⁷G. Pitiot, C. Desodt, H. Horsin Molinaro, *Les habitations troglodytes*, Culture science de l'ingénieur, École normale supérieure Paris-Saclay, 2023, pp. 7-13

¹⁸C. van der Poel, *La lumière, une matière à émotions*, Espazium. Espazium, 2020, [en ligne], consulté le 20 décembre 2023 <https://www.espazium.ch/fr/actualites/la-lumiere-une-matiere-emotions>

¹⁹H. Asma, *Le soleil en sous sol*, Thèse de master, Ecole Nationale Supérieure d'Architecture de Paris-la-Villette, La fabrique spatiale et culturelle des territoires durables, Paris, 2019, [en ligne], consulté le 20 décembre 2023, pp. 16-17 https://issuu.com/halfaouiasma/docs/memoire_paris_la_villette

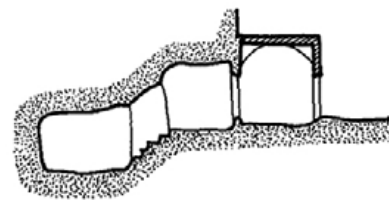


Fig. 14
Exemple of a room hollowed out into Staircase in Matera

Modern Troglodyte

A revival of this architectural style is now beginning to emerge. Contemporary troglodyte architecture combines the ancient principles of rock-cut dwellings with modern innovations. These designs take inspiration from traditional dwellings while incorporating modern technologies. Renovation projects and studies carried out in Europe and China in the 1980s have enabled us to learn more about and improve these habitats from the past. Adapting these caves to modern needs starts with reducing the risk of damp and all that goes with it by applying lime to the walls and ceilings. By introducing mining technologies and tunnels to increase the stability of the caves, and also, as in Lanzhou, China, by experimenting with new communal habitats.²⁰ (Fig. 15)

These experiments perfected the traditional forms and typologies, attempting to break the austerity of the lateral troglodyte, enlarging the spaces and allowing communication between rooms and floors from the inside, as opposed to the original circulation systems from outside. (Fig. 16)



Fig. 15
Experimental cave dwelling at the Energy Research Centre in Lanzhou (Gansu)



Fig. 16
Plan of a contemporary cave dwelling proposal in Lanzhou

²⁰J.-P. Loubes, P. Clément, *Maisons creusées du fleuve jaune : l'architecture trogloditique en Chine*, Editions Creaphis, 1998, pp. 119-137

The openings in the façade have been replaced by large orioles and blinds have been installed to allow the user to block out the light. Skylights with a play of mirrors allow natural light to reach the deepest rooms. Ventilation systems have been made more complex, with air intakes on the façade and air ducts at the rear, allowing air to circulate internally from one level to another like we can see on the section on the right (Fig. 17), a mix between traditional and modern technics permit to involve this kind of houses. Façade cladding is protected, and stone cutting and plastering techniques are used to reduce the wear and tear caused by the natural elements. (Fig. 18)

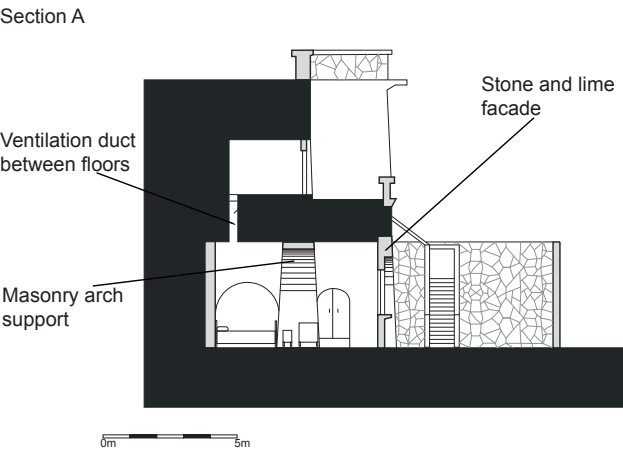


Fig. 17
Section of the contemporary cave dwelling proposal in Lanzhou

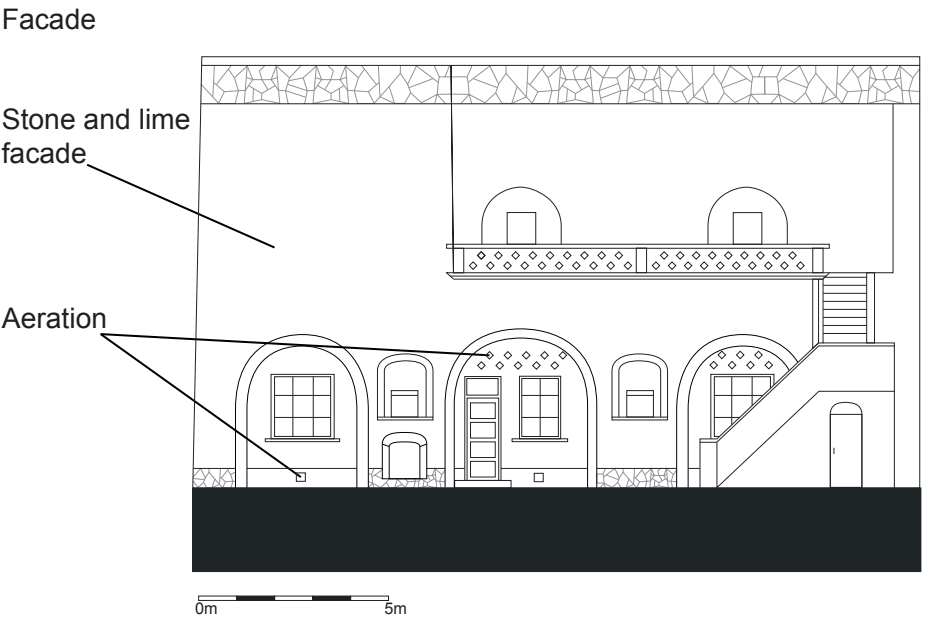


Fig. 18
Facade of the contemporary cave dwelling proposal in Lanzhou

In short, contemporary troglodyte architecture is a fascinating fusion of past and present, combining ancestral traditions with modernity to create sustainable places. Although modern techniques make it possible to create troglodyte architecture directly from the ground, there is still a lack of confidence and knowledge when it comes to carrying out such projects. As a result, projects such as troglodyte houses in kit form are being sold²¹ (Fig.19 &20).

Or the addition of a concrete structure that looks like a cave dwelling but is ultimately 100% artificial, as in the Villa Vals project by B. Maestenbroek and C. Müller in Vals²², in Switzerland, which consists of a concrete structure buried in the ground. (Fig. 21 & 22) This shows the interest in this alternative form of housing, but also the lack of knowledge and confidence in traditional building systems.

We can see that architecturally, this type of house fits in well with its context.

What's more, they demonstrate that the thermal inertia of the earth or rock is the only way to insulate these structures. However, the ancestral knowledge of understanding the environment is no longer relevant, and modern techniques have completely

replaced the natural structural elements, leaving the context as nothing more than insulation.

²¹B. Peyrat, Conçue pour se fondre dans le paysage la maison troglodyte en kit est désormais en vente, Visite guidée, Domozoom, Idées déco de professionnels pour votre maison, 2017,[en ligne], consulté le 20 décembre 2023 <https://www.domozoom.com/idees-deco/offrez-vous-une-maison-troglodyte-en-kit/508474>

²²B. Mastenbroek, C. Müller, *Villa Vals*, Gutundgut. 2009, [en ligne], consulté le 20 décembre 2023 <https://www.gutundgut.ch/portfolio/villa-vals/>



Fig. 19
Structure of a troglodyte house in prefabricated plastic



Fig. 20
Prefabricated house in USA



Fig. 21
Picture of the facade of Villa Vals

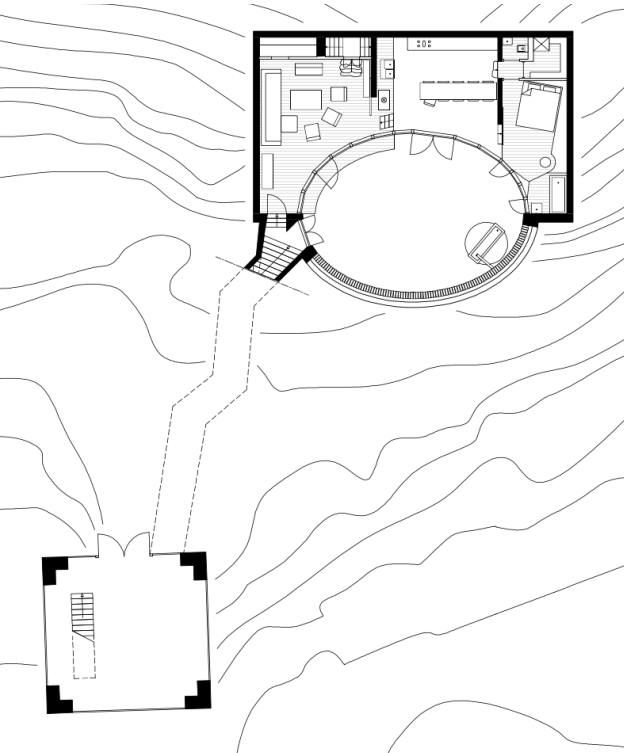


Fig. 22
Plan of villa Vals and its underground entrance

Case Analysis

Parameters of Analysis

As we have seen in previous chapters, troglodyte architecture depends on a precise knowledge of the local soil and geology for its stability and habitability. Adaptation to the specific environment includes managing humidity, ventilation and maximizing natural light to promote the well-being of the occupants. The architectural mass, a symbol of solidity and density, is shaped by voids to create a dialogue between full and empty spaces. This density has an impact on the sensory perception of the occupants, requiring thought to be given to form, light and spatial arrangements to avoid any feeling of suffocation.

To illustrate this research, I will analyze three case studies: The village of Matmata in Tunisia, the village of Matera in Italy, and the region of Cappadocia in Turkey.

I will begin with a brief historical analysis of each place and then, through drawing, analyze the typologies, forms, management of light, urban tissue, and water.

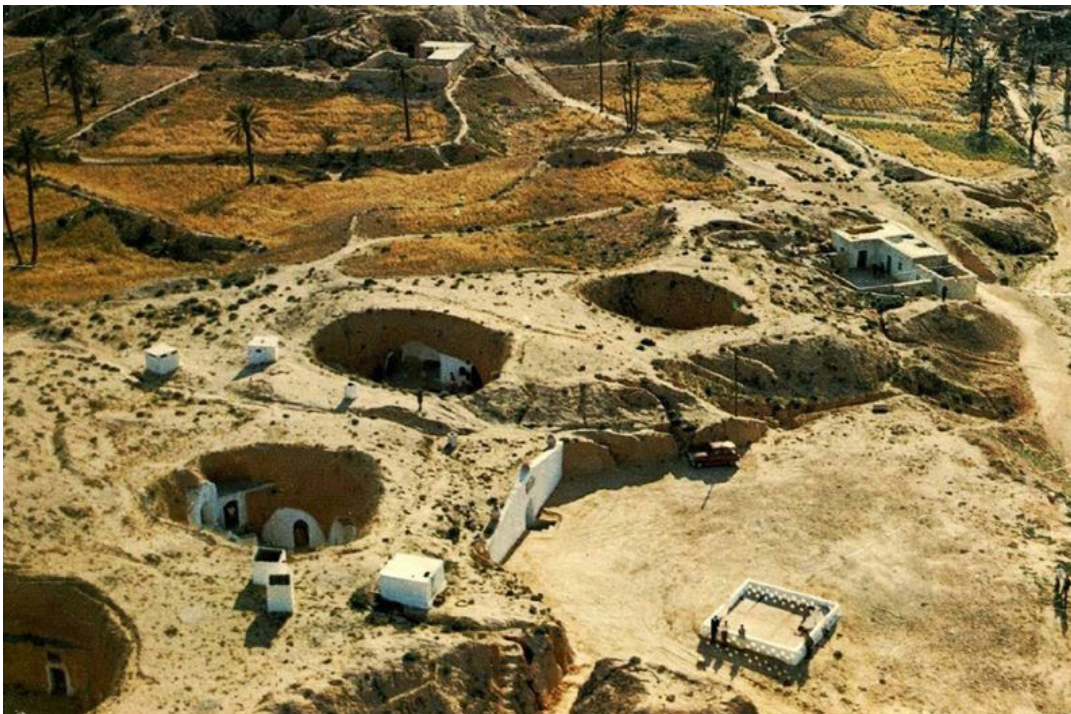


Fig. 23
Village of Matmata in Tunisia



Fig. 24
Village of Matera in Italy



Fig. 25
Stone formations and cave city in Cappadocia

Village of Matmata in Tunisa

The influence of the Berbers is deeply rooted in certain areas of Tunisia, in particular Matmata, located in the northern part of a mountain range that stretches from the Matmata Nouvelle delegation to the Tunisian-Libyan border. The history of this place is unknown, apart from the stories and legends passed down from generation to generation. The most likely story is that the underground caves were first built in ancient times, during the Roman era. The story goes that after one of the Punic wars, the Roman emperor sent two tribes to settle in the Matmata region, with permission to kill anyone in their path. The inhabitants of the region had to abandon their villages and dug caves in the ground to hide from the invaders. Other sources claim that these caves were dug in response to the Arab invasion.

Whatever the real reason, these underground settlements remained hidden for centuries in a very hostile region and were only discovered in 1976. When heavy rains flooded the caves, the inhabitants sought help from the authorities in the nearby town of Gabès. Thus the secret of Matmata was revealed to the world and the Tunisian government. Following this cry for help from the inhabitants, modernist politics, led by

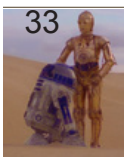
Tunisia's first president, decreed that this village was a «sign of animal life» and that it had to be changed.²³

So it was decided to move the population closer to the mountains to build the «new city». This heritage strategy, initiated by the Tunisian government, applies to the whole country. It is based on questioning traditional forms of housing as part of a modernisation drive that is seen as essential to improving the living conditions of Tunisians, according to the vision of the national leader. Despite this new political impetus, only a few families have moved into the new above-ground housing, with most residents continuing to live underground.²⁴

The region was revitalised by the increased tourist interest generated by George Lucas' wise Star Wars film, and Matmata is now part of the Star Wars universe thanks to the fact that it was one of the locations for the village of Tatooine.

²³Z. Hammami. *L'architecture troglodytique verticale et la mise en valeur touristique aux Matmata (Sud-Est tunisien). Fabrique du tourisme et expériences patrimoniales au Maghreb, XIXe-XXIe siècles*, Rabat : Centre Jacques-Berque, 2018, [en ligne], consulté le 30 décembre 2023, p. 5
<http://books.openedition.org/cjb/1568>

²⁴M. M. Sakr, *Learning lesson from Matmata*, The Prince 's School of Traditional Arts, Egypt, 2016
https://www.academia.edu/37312834/Learning_Lessons_From_Matmata



As Matmata is an arid region where temperatures regularly exceed 50 degrees in summer, these dwellings were the inhabitants' means of escaping the harsh climatic conditions, and their abundance was due to the favorable soil conditions. The terrain of Matmata is hilly and the small valleys between the limestone mountains contain silt deposits (almost 20 meters deep) made up of clay with enough gypsum to act as a binder. These deposits provide a firm, stable material that is easy to work with when excavating the rooms. The softness of the soil is also the reason why troglodyte dwellings are possible. The troglodyte dwellings of Matmata are underground structures of the same design as the above-ground courtyard buildings. The houses are characterized by the absence of external facades; they are manifested by their access corridors and central voids. They escape into the belly of the earth so as to be less visible. Subterranean houses have a fusional relationship with the natural landscape in which they are located. It is a vertical concept of a deep courtyard open to the sky and surrounded by walls and rooms.²⁵



Fig. 26
Map of Tunisia

²⁵S. Habouria, *Relecture d'un habitat troglodyte à Matmata, une agora physique, pour l'agora artistique*, issu, 2016, [en ligne], consulté le 30 décembre 2023 https://issuu.com/souhirhabouria/docs/rapport_m__moire



Fig. 27
Aerial view of Matmata



Courtyard

From an aerial perspective, the village is characterized by a play of fullness and emptiness. The upper level corresponds to the village space, while the lower level represents the domestic space. In addition, the central courtyard structures the troglodytic architectural space.

As we can see on Fig. 28., Troglodyte dwellings were designed with a courtyard as their nerve center, around which all the rooms and living areas were built. These courtyards were typically semi-circular, between 5 and 10 meters in diameter and set back about 10 meters from the ground, creating an open space at the heart of the dwelling. (Fig. 29) The rooms, carved out of layers of clay and plaster, were arranged in a row around this central courtyard and connected to it at ground level by a winding tunnel known as a 'sguifa'. This layout allowed for specific circulation and organization within these dwellings, with the patio acting as the only opening to the outside world within this subterranean environment.

Most activities took place in the main courtyard, which was designed with a fountain to provide a constant area of shade. This meant that activities could continue throughout the summer despite the intense

heat. The rooms dug into the rock remained warm in winter and cool in summer thanks to their thermal inertia. These spaces were therefore comfortable to live in and offered advantages in terms of animal welfare and food preservation.

Digging began in the courtyard and, after the edges had been sharpened, the door and window openings were cut out as a starting point for excavating the rooms.²⁶

These spaces, conducive to conviviality and social cohesion, played an important role in community life. They were the setting for interactions between neighbors: conversations, exchanges of goods and advice, mutual support and shared moments of conviviality that fostered strong bonds between residents.

These courtyards created a microclimate that was cooler than the ambient temperature, allowing craftsmen to work in the shade in front of the house.

On Fig 30. to Fig. 33 We can observe different types of courtyards in different houses in Matmata, they always follow the same principles, only the layout changes as it is adapted to the needs of its inhabitants.

²⁶M. M. Sakr, *Learning lesson from Matmata*, The Prince 's School of Traditional Arts, Egypt, 2016, [en ligne], consulté le 30 décembre 2023, pp. 7-8 https://www.academia.edu/37312834/Learning_Lessons_From_Matmata

Fig. 28
typical plan of a troglodyte
dwelling

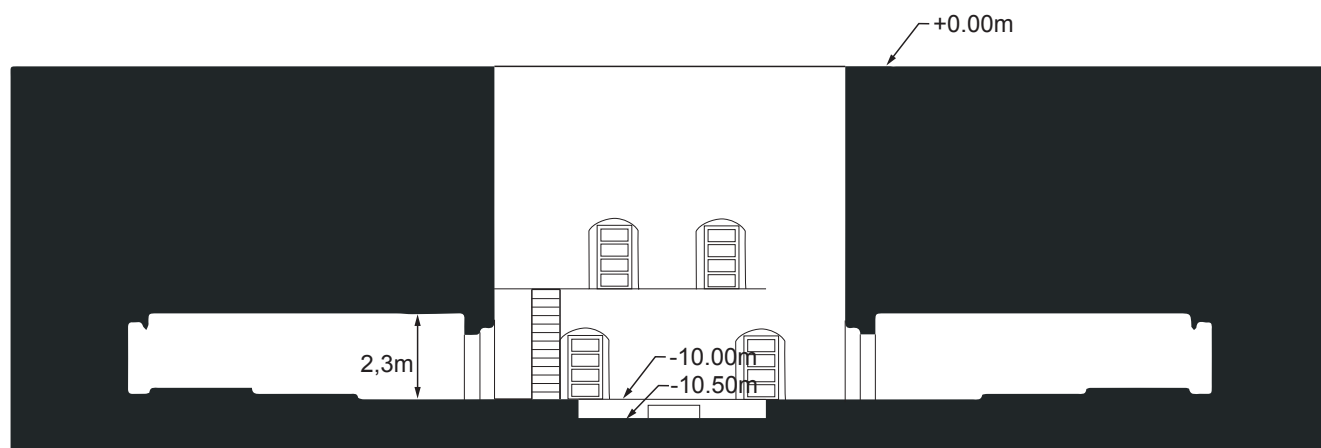
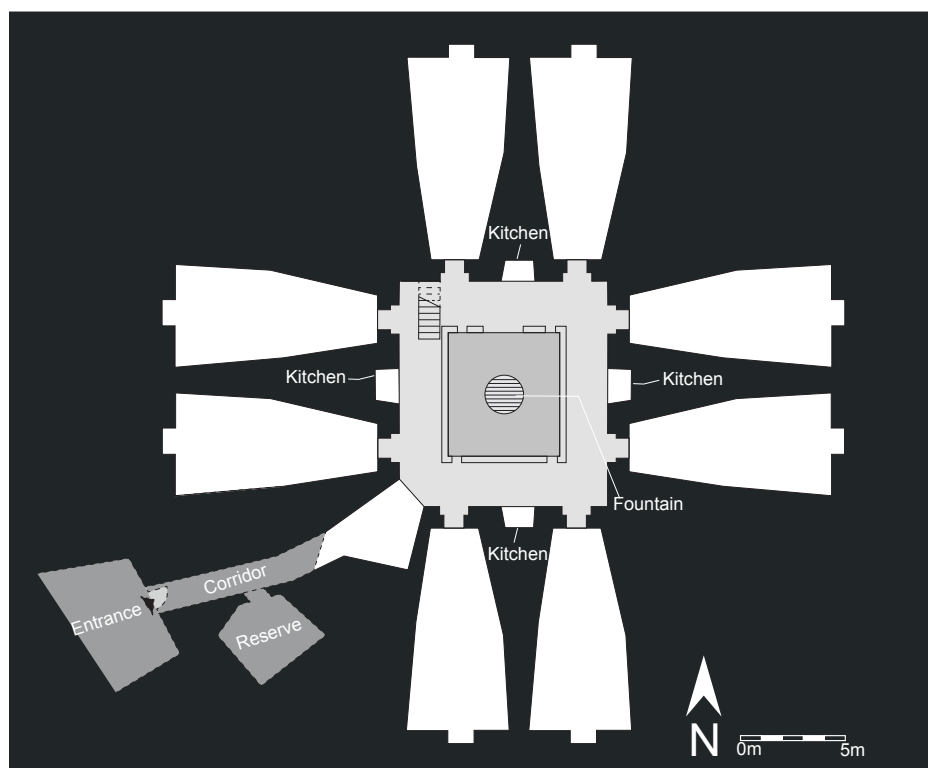


Fig. 29
typical section of a troglodyte
dwelling

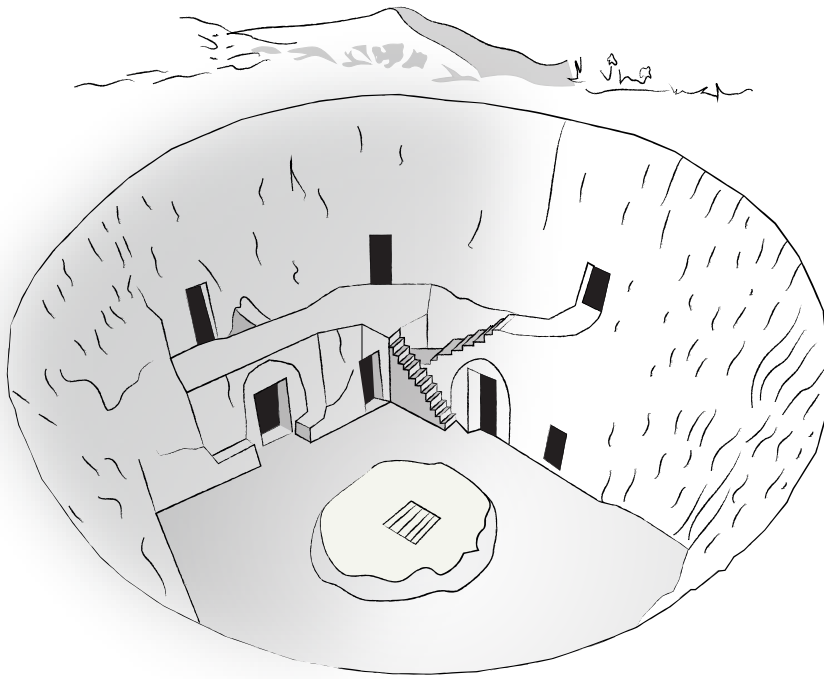


Fig. 30
Aerial perspective of
a courtyard



Fig. 31
Aerial view of a
courtyard with a
fountain



Fig. 32
Aerial view of a courtyard of a traditional house



Fig. 33
Aerial view of a courtyard with a difference of level

These cave dwellings are characterised by this large open central courtyard as already said, which, as can be seen from these different examples, can be used as a private courtyard for a family or for more limited activities (Fig. 32), others are designed for specific functions such as collecting rainwater or storing provisions (Fig. 31), and others are designed from an aesthetic point of view to create a pleasant and attractive space for relaxation (Fig. 33).

Access

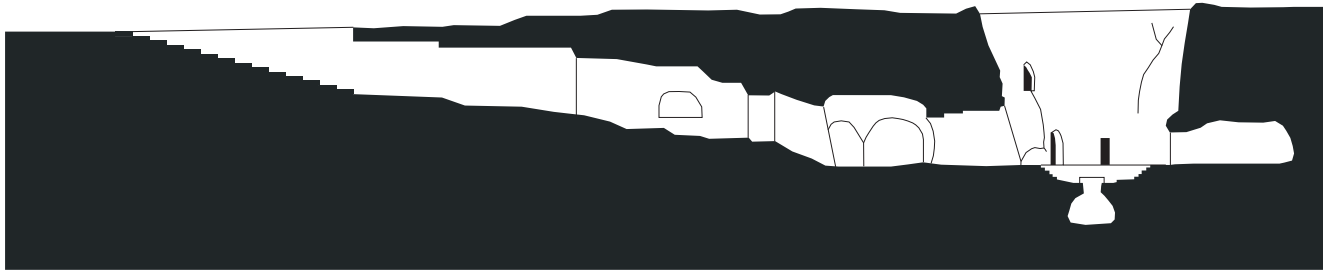
The main entrances to the houses are above ground, at a height of approximately 10 metres, and are reinforced to ensure the safety and protection of the residence. These entrances then descend to the central courtyard through a specially dug tunnel (Fig. 34).

This underground tunnel is designed with a gradual incline and, for added security, the last section changes direction and leads to another curved entrance. Just beyond this curved entrance is a storeroom for agricultural tools, sometimes used to house animals such as sheep and goats. (Fig. 35)

The various rooms of the house are arranged around the central courtyard. Each room is separated from the courtyard by a door. Stairs lead to the upper floors, especially the attic. These staircases can either climb perpendicular to the façade or be cut directly into the rock, ending in a small balcony that acts as an extension of the room below. This layout ensures fluid circulation and practical use of space in this troglodytic environment. The circular façade that surrounds the entire excavated courtyard is the final threshold, the transition between inside and outside. With very little access to the outside world, it is difficult to see inside the houses.

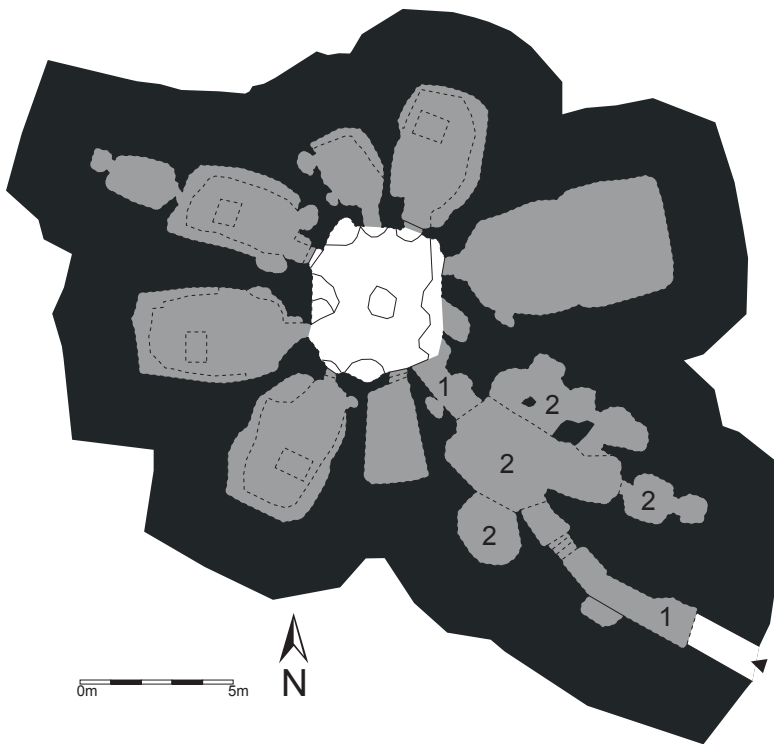
Only a few small windows and doors pierce the courtyard. The passage from public to private space is through the excavated tunnel.²⁷

²⁷S. Habouria, Relecture d'un habitat troglodyte à Matmata, une agora physique, pour l'agora artistique, issu, 2016, [en ligne], consulté le 30 décembre 2023 https://issuu.com/souhirhabouria/docs/rapport_m__moire



0m 10m

Fig. 34
Section of an underground entrance of Matmata



- 1 - Access corridor
- 2 - Storeroom for agricultural tools, and house animals

Fig. 35
Example of a vertico-lateral dwelling at Jebel Matmatata



Fig. 36
View of an access
corridor



Fig. 37
Inside of an access
corridor from the
storerooms



Fig. 38
Stairs to access on
the upperfloor



Fig. 39
Rehabilitated entrance
in a contemporary
way

Plan

The disparity in material resources is also reflected in the number of rooms and units. The greater the number of units or rooms, the richer the owner. We define a spatial unit as all the rooms that have the same function. The traditional house in Matmata has essentially five spatial units: the entrance, the patio, the living rooms, the storage rooms and the kitchen.

The entrance, Sguifa, which is a tunnel dug like a chicane leading to the patio, contains the stables formed by the widening of the patio, the patio, Houch, is the central open space from which the various living and storage rooms open, as well as the kitchen. The living rooms include the bedrooms, which are mainly furnished with a bed and ornaments and can be decorated with niches, the storerooms, which are on the first floor when the house is extended, and the kitchen. The attic, the only room on the upper floor, is used to store food. It is reached either by a staircase cut into the layers of clay and plaster, or by rope. The remarkable thing about this village is the importance attached to the granary. This reflects the fact that, socially, this village put the collective interest of the family before individual interests. The organization of the space and the emphasis placed on the security and preservation of food show that priority was given to the

long-term survival and collective well-being of the community. Unlike other villages in Tunisia, where reserves must be kept out of the hands of women, in Matmata they are primarily responsible for storing the family's wealth.²⁸

The rooms in these dwellings are long and narrow on the lower level and smaller on the upper level. The ceilings are generally vaulted to support the loads and to meet lighting and ventilation requirements. Typical room sizes in Matmata are 4 to 5 meters wide by 8 to 10 meters long and around 3 meters high for the larger rooms, and 3 to 4 meters wide by 4 to 5 meters long and 2.5 meters high for the smaller rooms. The floor between the floor and the ceiling of the room in Matmata varies from 6 to 7 meters. This thickness eliminates any risk of water leakage during heavy rainfall and significantly reduces the rates of heat gain and loss inside and outside the building.²⁹ (Fig. 40)

Depending on the size of the family, two of these sets can be connected by a tunnel through the central courtyards.

On the following pages you can see different types of bedrooms, living rooms, kitchen and storeroom. The concept of the plan does not change, only the number of rooms and their programme are adapted to the needs of the different families.

²⁸Z. Hammami. *L'architecture troglodytique verticale et la mise en valeur touristique aux Matmata (Sud-Est tunisien). Fabrique du tourisme et expériences patrimoniales au Maghreb, XIXe-XXIe siècles*, Rabat : Centre Jacques-Berque, 2018, [en ligne], consulté le 30 décembre 2023, p. 7

<http://books.openedition.org/cjb/1568>

²⁹S. Habouria, *Relecture d'un habitat troglodyte à Matmata, une agora physique, pour l'agora artistique*, issu, 2016, [en ligne], consulté le 30 décembre 2023 https://issuu.com/souhirhabouria/docs/rapport_m__moire

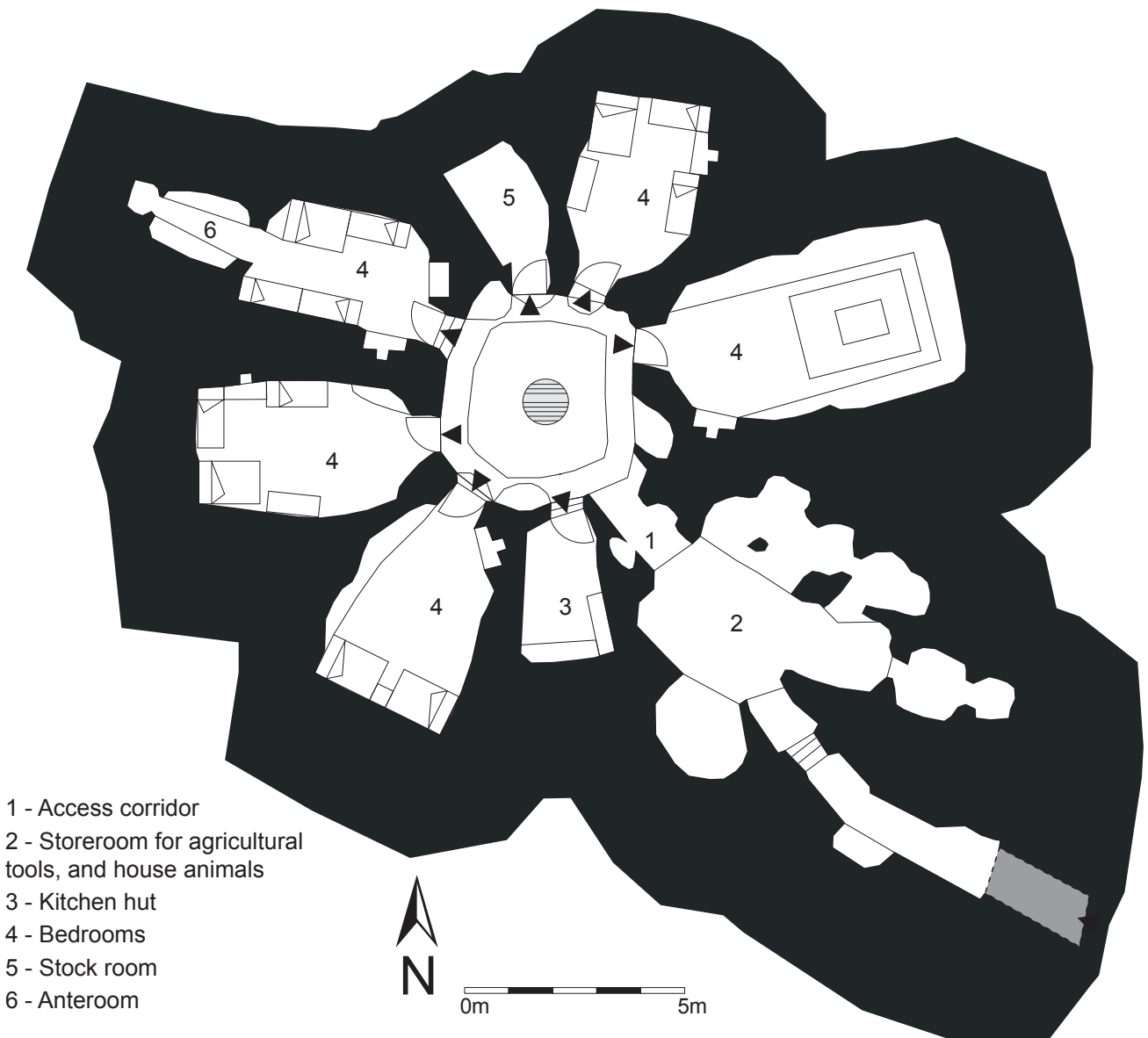


Fig. 40
 Example of a vertico-lateral dwelling at Jebel
 Matmatata



Fig. 41
Berber bedroom in
Matmata



Fig. 42
Berber bedroom in
Matmata



Fig. 43
Bedroom of family in
Matmata



Fig. 44
Parental Bedroom in
Matmata



Fig. 45
Berber living in
Matmata



Fig. 46
Berber living in
Matmata



Fig. 47
Kitchen in Matmata



Fig. 48
Kitchen in Matmata



Fig. 49
Traditionnal cellar with traditionnal ceramic to store food



Sunlight

The homes of Matmata are essentially dependent on the natural cycle of daylight, using sunlight as the main source of interior lighting. As part of the Tunisian desert, Matmata receives a lot of direct sunlight every day. As a result, solar glare was a major problem in Matmata. To remedy this, the sides of the main courtyard benefit from alternating shading due to the depth of the excavation. The shaded sides do not suffer from glare, while the unshaded sides are exposed to direct sunlight. This situation has been resolved by installing small, narrow doors and limited openings in the adjacent rooms, reducing the amount of sunlight entering the living and sleeping areas on the sides.

An analysis carried out in 2019 shows that the rooms do not receive enough daylight throughout the day due to the depth of the rooms, which can exceed 10 meters. To protect against heat and glare.³⁰

As we can see on Fig. 53 & Fig. 54, only the courtyard receive the necessary the daily light factor of light in the entire house, rooms stay in the shadow, walls and ceiling are recovered of white tuff to permit indirect light, only early in the morning and late in afternoon doors are opened for direct light.



Fig. 50
Natural light inside a room in Matmata



Fig. 51
Shadow in a courtyard

³⁰H. M. Raslan, D. S.I Saeed, *Re-evaluating the health performance of historical buildings using well rating system*, Mansoura Higher Institute for Engineering and Technology, Mansoura, Egypt, 2023, [en ligne], consulté le 30 décembre 2023 pp. 7-9 <https://link.springer.com/article/10.1007/s43762-023-00103-z>

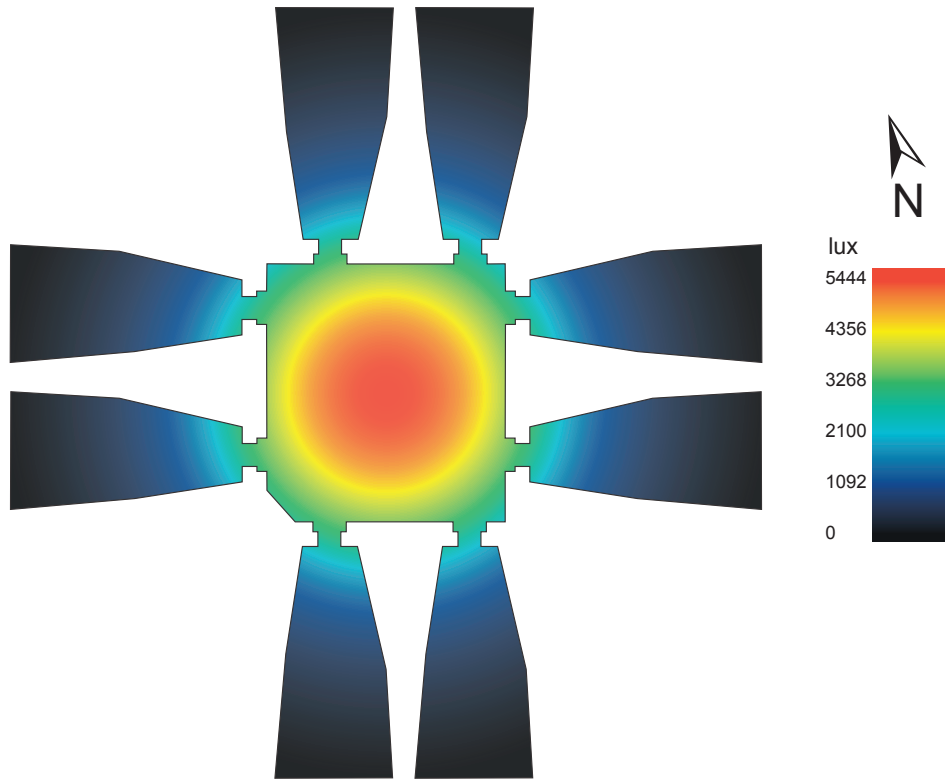


Fig. 52
Day light factor performance in
an entire house

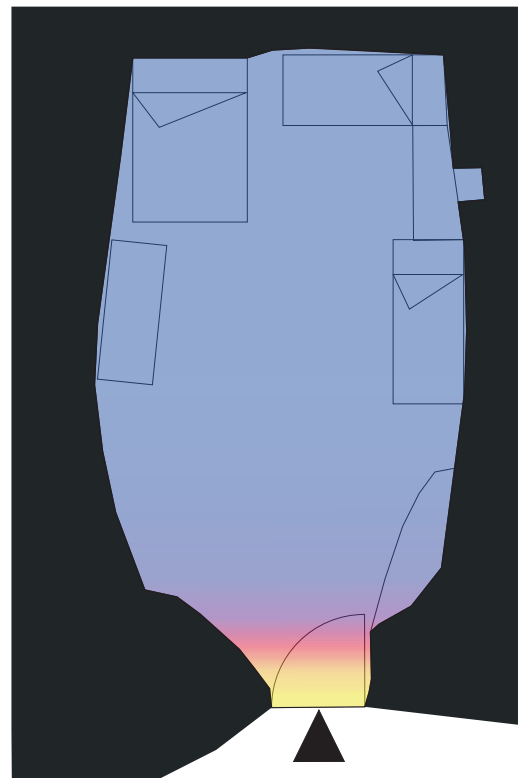


Fig. 53
Day light factor performance in
a room

Water

There is usually a cistern in the center of the courtyard to collect rainwater. A trench is also dug in the tunnel at the entrance. This allows rainwater to be collected further away. The courtyard is protected from the rain by building a short fence around its perimeter with the clay from the excavation, which surrounds the upper ends of the central patio with channels that minimize the penetration of run-off water into the troglodyte and direct it to the cistern. In the center, where the Zoubia is located, the courtyard is slightly inclined, forming a drainage channel for the run-off water.³¹



Fig. 54
Cistern in courtyard



Fig. 55
Trench to collect reain water

³¹Z. Hammami. *L'architecture troglodytique verticale et la mise en valeur touristique aux Matmata (Sud-Est tunisien). Fabrique du tourisme et expériences patrimoniales au Maghreb, XIXe-XXIe siècles*, Rabat : Centre Jacques-Berque, 2018, [en ligne], consulté le 30 décembre 2023, p. 8
<http://books.openedition.org/cjb/1568>



Fig. 56
Trench to collect rain water in the entrance tunnel

Urban Tissue

The urban planning of Matmata is organized around obligations and social relationships between families. As shown on the map on the next page (Fig. 57), four main families share the territory : The «Jemnines» live in the north-eastern part of the city. Thanks to their influence and prestige, they were the first to build permanent structures such as the souk, the mosque and the schools. The Ouled Abdallah family occupies the north-western part. The Touaoua and Dhouaher families settled in the south of Matmata.

These families settled later and, as a result of trade in the region, established links with the local population, acquiring neighboring plots of land and digging cave dwellings side by side.

Some of the houses were connected by rooms or were very close to each other.

As we can see in Fig. 58, some houses had a direct underground connection, a whole system made by families who dug to connect their houses together to be able to have a collective family life.

These families shaped their landscape, taking advantage of the natural relief. They organized whole neighborhoods of individual family dwellings around the closest family members. Thanks to this planning, archaeologists have been able to trace the family trees of these families.³²

³²Z. Hammami, *Tourisme, patrimoine et développement dans la chaîne de Matmata-Demmer*, Thèse de doctorat en science géographique, Université de Sfax, 2014, [en ligne], consulté le 4 janvier 2024, pp. 133-139

https://www.academia.edu/41793162/Tourisme_patrimoine_et_d%C3%A9veloppement_dans_la_cha%C3%A9ne_de_Matmata_Demmer_Sud_Est_tunisien_

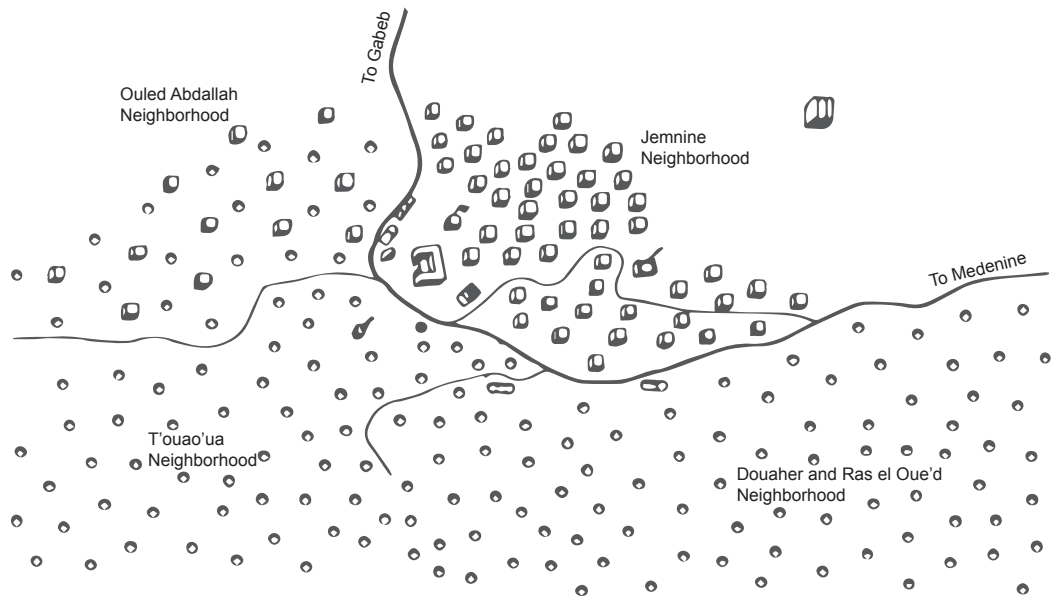


Fig. 57
Family distribution of cave dwellings in the Matmata
commune

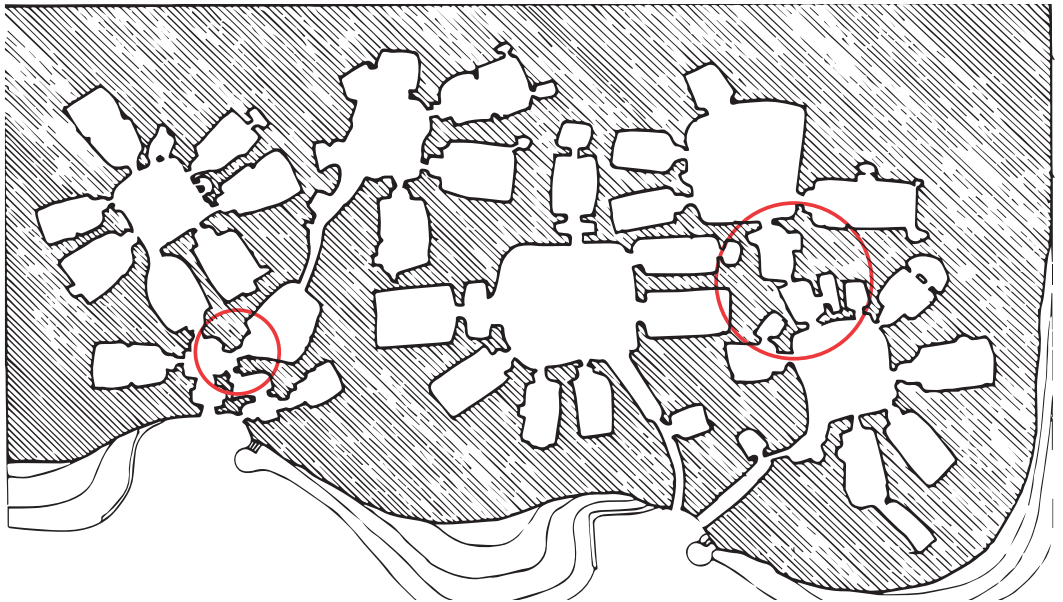


Fig. 58
Interconnecting underground dwellings

Sassi of Matera, Italia

Sassi of Matera are located in the Puglia region of Italy, in the highlands of the Murges, is one of the oldest cities in the world. The first traces of human settlement in Matera date back to the Neolithic period. The natural caves in the surrounding gorges were inhabited by hunter-gatherers at that time. In ancient times the area was inhabited by various civilisations, including the Greeks, Romans and Byzantines, who used the caves as dwellings. During the Middle Ages, the Sassi di Matera underwent a significant expansion. New caves were dug to meet the growing needs of the population. The city prospered despite periods of conflict and political upheaval. During the 18th and 19th centuries, the situation in the Sassi deteriorated sharply and the unhealthy living conditions, marked by extreme poverty and malaria, were considered inhumane and an affront to the new modern Italian Republic of Alcide De Gasperi. In the 1950s, the Italian government forcibly relocated most of the Sassi population to the districts of the modern city. In the second half of the 20th century, Matera was rediscovered by artists, intellectuals and film-makers, attracted by the authenticity of the Sassi. This attention led to conservation and revitalisation efforts

that culminated in the Sassi di Matera being declared a UNESCO World Heritage Site in 1993. Today, Matera is a symbol of urban regeneration in Italy.

The economic development of the stone trade in the region had a significant impact on the development of these areas, influencing the way they were built. The first mines were vertical shafts dug for the extraction of stone, which later evolved into networks of horizontal tunnels for more extensive exploitation. Ventilation and drainage systems were introduced to improve mining productivity, marking the beginning of underground development in the area. Remains of Bronze Age peasant dwellings dug into the rock have been discovered, testifying to man's appropriation of the landscape. The vertically excavated quarries formed large courtyards that were used as an atrium. Around the atrium, rooms were dug horizontally to create hamlets. The complex history of the Sassi of Matera unfolds through various phases, rooted in the traditions of the population, farmers and craftsmen, while always respecting the original purpose of the building.

In this way the village is composed by carved architecture and built architecture, it

represents two different approaches which show the evolution of the architecture and the complexity of the urban planning of Matera, the latter defined by the use of a single, imposing material, limestone or «tufo».³³



Fig. 59
Map of Italie

³³A. Guida, A. Pagliuca, A.G. Loforese, *The Sassi of Matera as the oldest bioclimatic architectural model*, Energy for Sustainability International Conference, Portugal, 2017
https://iris.unibas.it/retrieve/dd9e0b51-27c9-1e84-e053-3a05fe0aa940/The%20Sassi%20di%20Matera%20as%20the%20oldest%20bioclimatic%20architecture%20model_Madeira%202017.pdf



Fig. 60
Aerial view of Matera



Courtyard

The vertically excavated quarries formed large courtyards that were used as an atrium, the first dwellings took place in these courtyard as shown in Fig. 61.

Since that, they keep the spaces and involved them throw centuries to arrive at the present village.

The urban fabric is made up of small courtyards, squares or «campiello», formed by a group of houses that define the space. (Fig. 62.)

These places provided a framework for gathering and collective life, conducive to social interaction. They were the scene of exchanges, the sharing of goods and advice, and of solidarity between neighbors, testimony to the social structure and communal life of the Sassi in the past. Most activities took place in these courtyards. The layout of the courtyards, with a well in the center, always provided a shady spot. This meant that activities could continue throughout the summer, even in the hottest weather. The rooms dug out of the rock, on the other hand, retain heat in winter and coolness in summer thanks to their thermal inertia. This makes them not only pleasant to live in, but also beneficial for the comfort of the animals and the preservation of food.

The «vicinato» (neighborhood) is the name given to these courtyards, which are both social and spatial. It corresponds to the morphology of the communal dwelling, which gave rise to collective rules. These courtyards were shared by the different inhabitants of the vicinato. The craftsmen always worked in front of the house, in the sunlight, because the caves did not allow enough light for this type of work inside, and the inhabitants spent most of their time outdoors. The women, busy with household chores such as sorting vegetables, sewing or preparing meals, would gather in the vicinato to help each other and look after the children. As the families were very large (around 6-10 children per family), it was difficult to stay in the confined space of the basement house. That's why these courtyards welcomed the whole neighborhood every day. A vicinato could accommodate 40 people at a time.³⁴

³⁴C. Ganty, M. Soupe, *Matera ville matière*, Énoncé théorique de master en architecture, EPFL, 2019

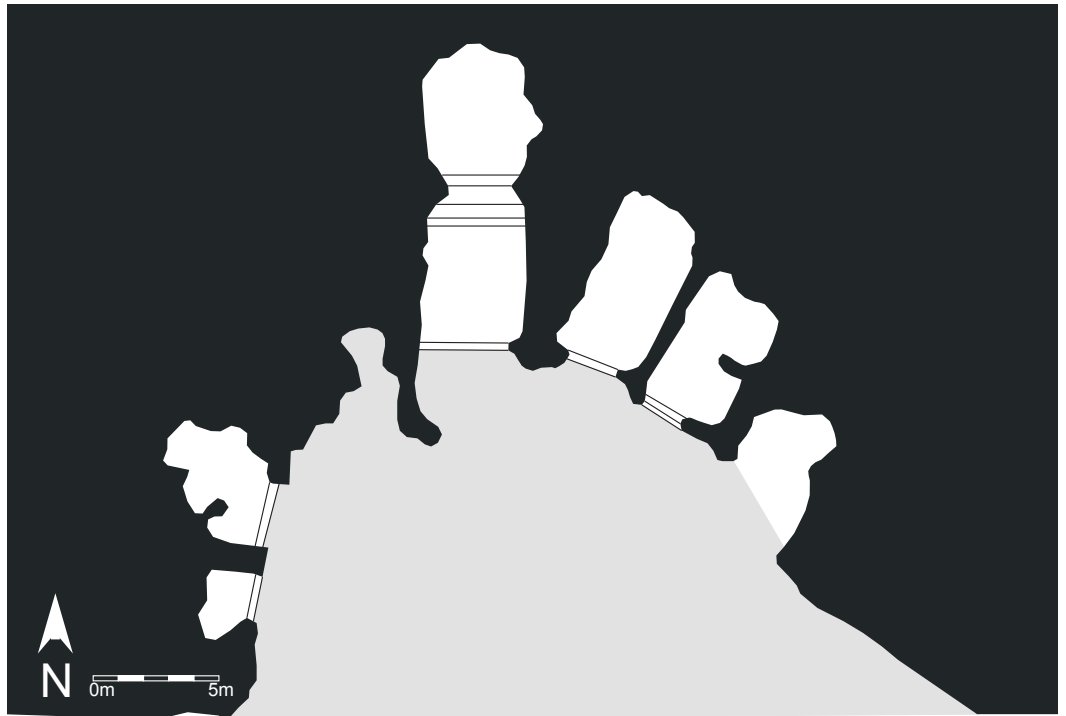


Fig. 61
Origine of the
courtyard



Fig. 62
Courtyard in Matera

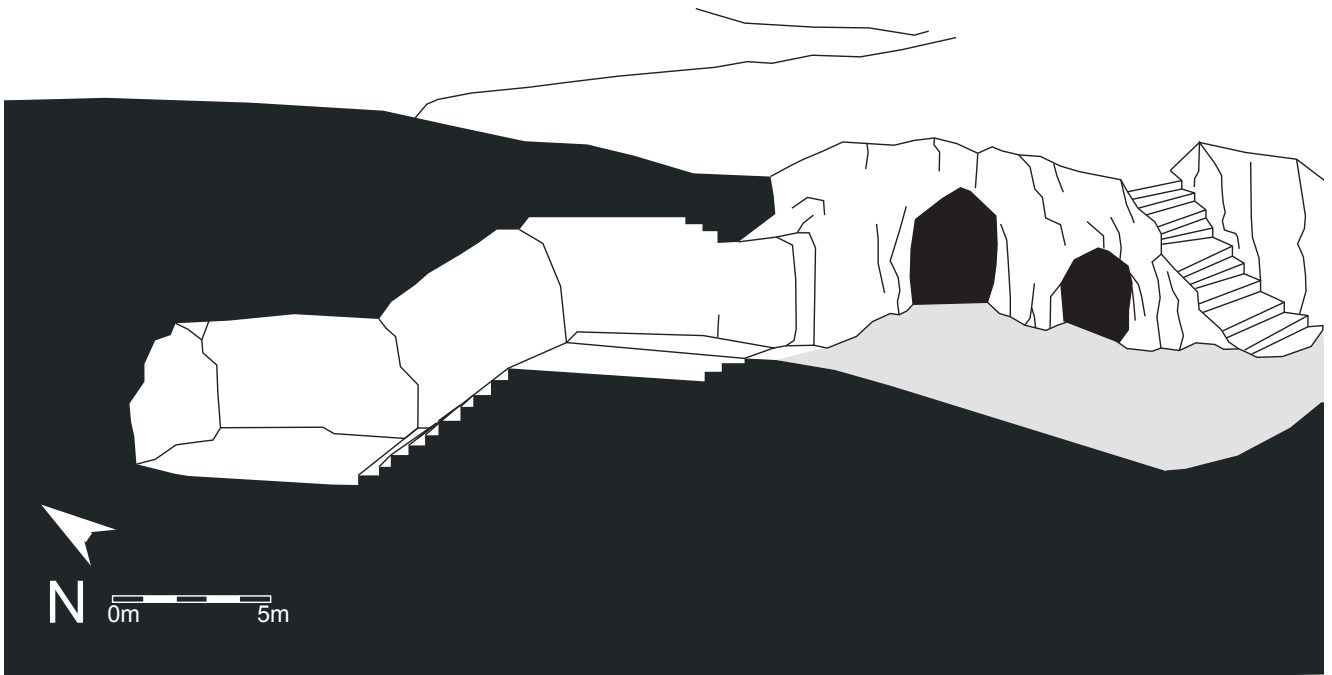


Fig. 63
Section of the original dwellings in Matera

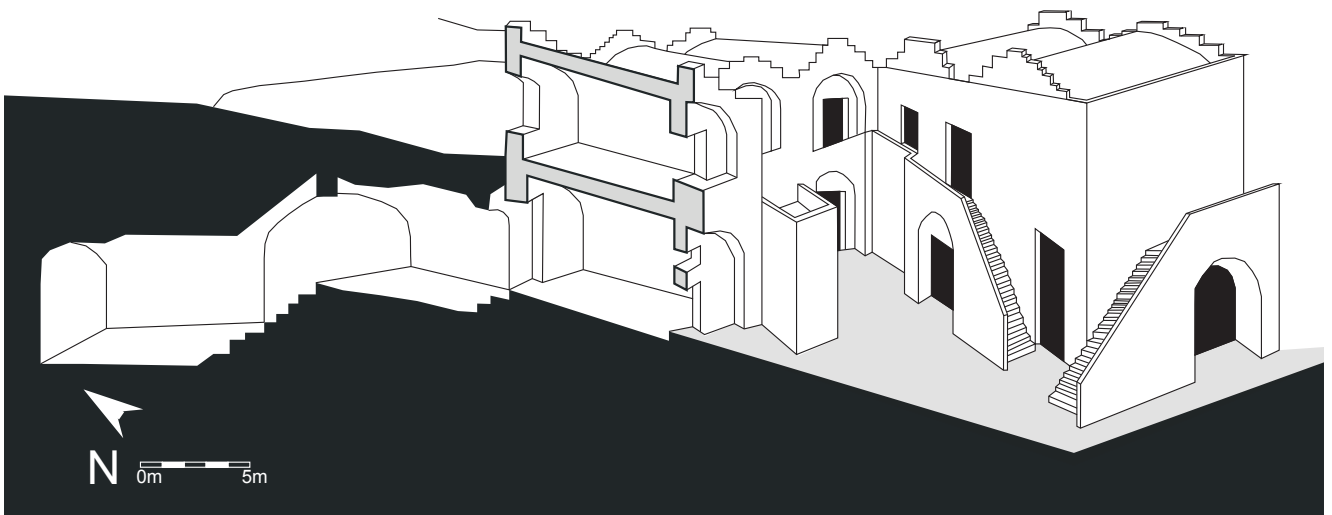


Fig. 64
Section of a courtyard in Matera



Fig. 65
Vicinato dans le
Sasso Barisano



Fig. 66
Vicinato habité

Access

The orientation of the houses in relation to the slope of the valley results in a difference in access from the road downstream compared to the road upstream. The upstream house is accessed directly from the street, while the downstream house is accessed via the courtyard in front of the house. (Fig. 67 & Fig. 68)

In some specific cases, a staircase leads to the upper floor. This depends on the relationship with the rock face. This staircase rises perpendicular to the façade and then turns against it, ending in a balcony supported by a vault. This vault defines a covered space that protects access to the lower level. The entrances to the apartments open onto the courtyard, and those on the upper floors are served by a passageway connected to the courtyard by these staircases. (Fig. 69)



Fig. 68
House with access from the street



Fig. 67
House with access from the courtyard

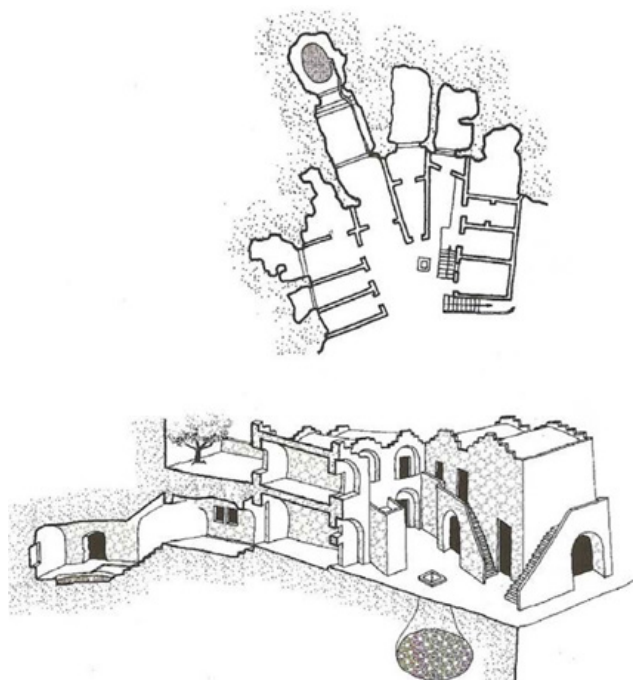


Fig. 69
Plan and axonometry a staircase which leads to the upper floor

On Fig. 70, you can see the importance of the passages in the structure of the Sassi. It underlines the functional division between the lower floor, which is partly excavated and sometimes used as a warehouse, and the upper floor, which is completely built and used for living.

The façade is the last threshold, the transition between inside and outside. With very little exposure to the outside world, it is difficult to see inside the houses. Only a few small windows with shutters penetrate the façade. The transition from public to private space can be felt through these different elements, marking these different thresholds.³⁵

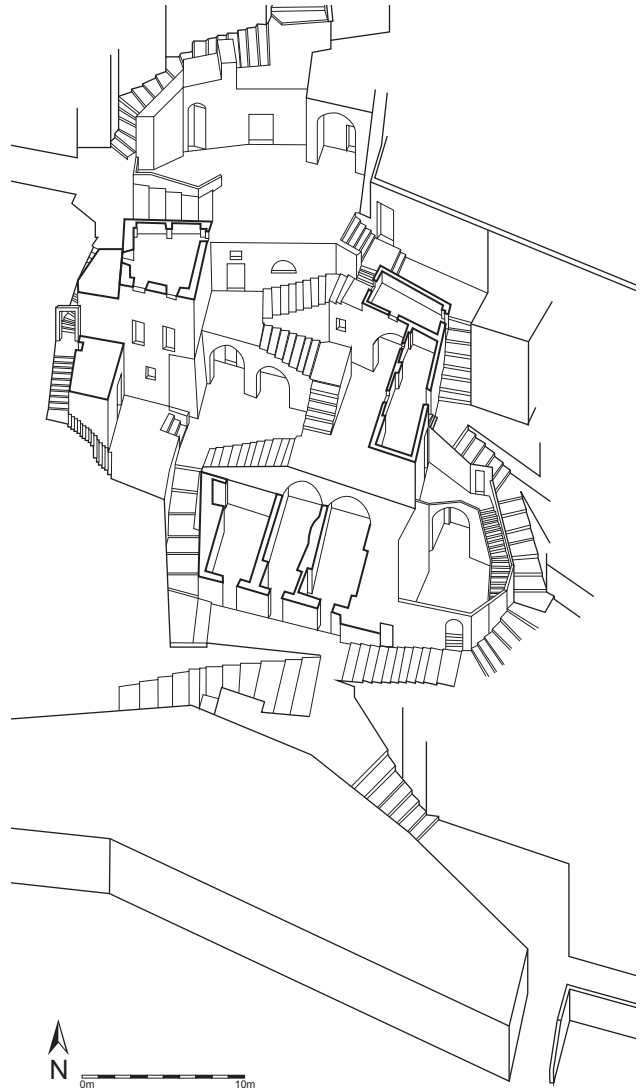


Fig. 70
Plan and axonometry a staircase which leads to the upper floor

³⁵C. Ganty, M. Soupe, *Matera ville matière*, Énoncé théorique de master en architecture, EPFL, 2019, pp. 60-68



Fig. 71
System of pathway limits between public and private



Fig. 72
System of pathway limits between public and private

Plan

The structure is characterized by two parallel walls supporting a vaulted ceiling, enclosed at the front by a wall and at the back by the rock.

The interior layout is largely cave-like. The inhabitants adapted it slightly to meet the basic needs of a family, with separate areas for cooking, eating, washing and sleeping. Spaces at the far end were designed to accommodate animals, as this was where light and oxygen were most scarce.

As mentioned earlier, the courtyard was the preferred location for most activities because of the limited light and space inside. Only the main entrance and small windows above the door on the front wall provided light, allowing both ventilation and illumination of the house. This rudimentary architecture is enriched by functional elements. Notches cut into the rock serve as storage for various objects or candles, while benches, tables and sinks are carved directly into the tuff.

Like we could see on Fig. 73, which is a plan of a project to create a vicinato like in the past with different programs, every cave had a definit program to permit a collective life in the neighborhood.



Fig. 73
Example of vicinato plan in Matera

In the 1940s and 1950s the Sassi were laid out as follows:

The entrance to the apartments had one or two small tables for the crafts that required more light. The kitchen, equipped with a wood-burning stove, sometimes carved into the rock, was near the well, connected to the cistern, dug directly into the stone. In the center was the dining table, while at the back there were separate areas for humans and animals to rest. The toilet was in a corner, also at the back of the cave. In some dwellings, one or two walls divided the interior space to provide a better separation of functions. However, they never completely enclosed a room. The addition of the built part followed the natural vaulted shape of the cave. Although the space was not physically divided by walls, the different treatment of the built part served as the first threshold into the hollowed space. This first space was rigid and straight, with walls of regular stone blocks with an almost smooth surface. The threshold of the second part was marked by the transition between the stone cut into blocks and the sculpted rock face. (Fig. 73)

The excavated area was organic and curved, with a rough rock surface and irregularities caused by physical changes in the limestone. Each dwelling had its own shape and dimensions for this space, unlike the built part where constant dimensions were defined by the size of the vault. The identity of the house was defined by this association between a negative form and its positive counterpart, an essential characteristic of the Sassi.³⁶

Nowadays, the cellars have been converted into more modern accommodation or hotels. With this type of renovation, they want to reinvigorate the village to give this old way of life a modern look, mainly to attract tourists, like in the project of Daniela Amoroso for Corte San Pietro Hotel. (Fig. 77 & Fig. 78) Because the village is a Unesco World Heritage site, they can't make large openings in the facades, so they have to introduce air renewal pumps because modern building methods have made the houses too airtight.

³⁶C. Ganty, M. Soupe, *Matera ville matière*, Énoncé théorique de master en architecture, EPFL, 2019, pp. 70-86

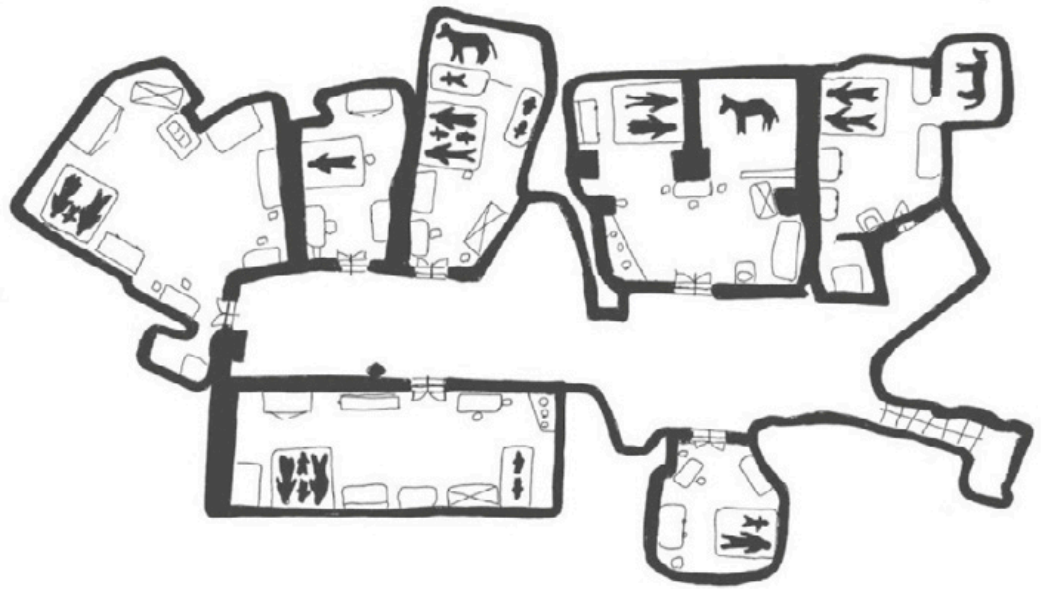


Fig. 74
An example of the
distribution of space
within avicinato in the
1940s-1950s.



Fig. 75
Inside one of the
refurbished cave
dwellings



Fig. 76
Inside one of the
refurbished cave
dwellings



Fig. 77
Inside one of the
refurbished cave
dwellings

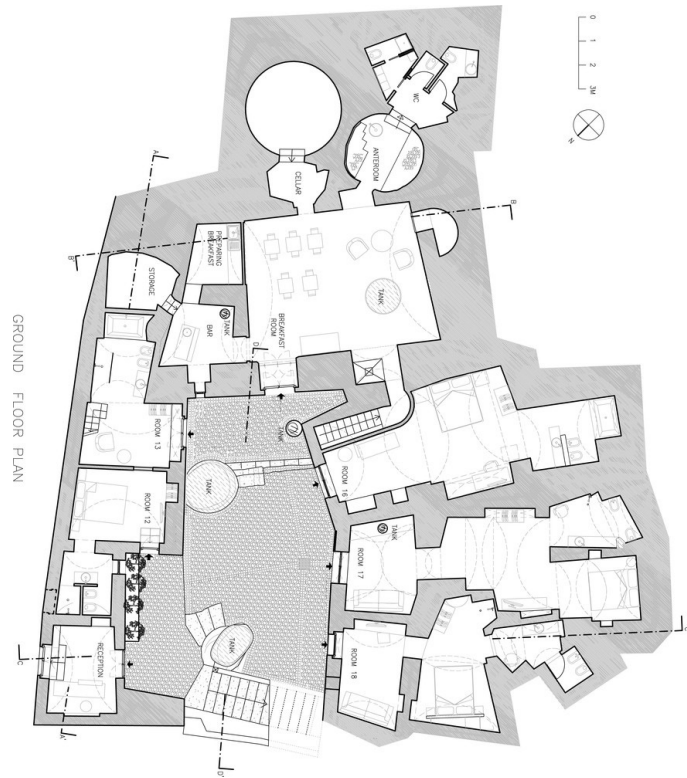


Fig. 78
Plan of Corte San
Pietro Hotel



Fig. 79
Room inside Corte
San Pietro Hotel

Sunlight

The depth of the caves is determined by their exposure to the sun, so that the deepest part receives the maximum amount of light.

(Fig. x)

For example, in a horseshoe layout, the central cave is deeper than the others because its opening, in the center of the semicircle, receives the maximum amount of sunlight. (Fig. x)

The underground chambers are not arranged horizontally, but rather downward. There are one or more steps between each room, depending on the angle of the sun's rays. In winter, when the sun is low, its rays penetrate to the bottom of the cave and heat the walls. This heat, stored in the rock, maintains a pleasant temperature inside. In summer, however, the sun's rays stop at the entrance to the cave, keeping the interior cool. It is possible that the orientation of the caves was calculated to optimize this interaction with the sun.³⁷

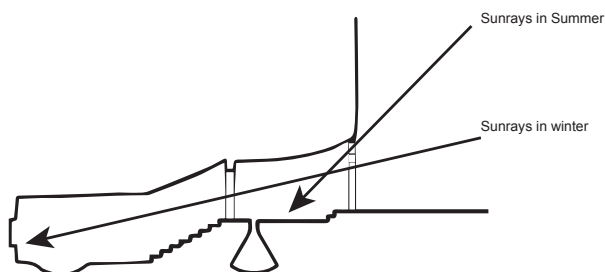


Fig. 80
Sunlight determines the depth and inclination of the cave.

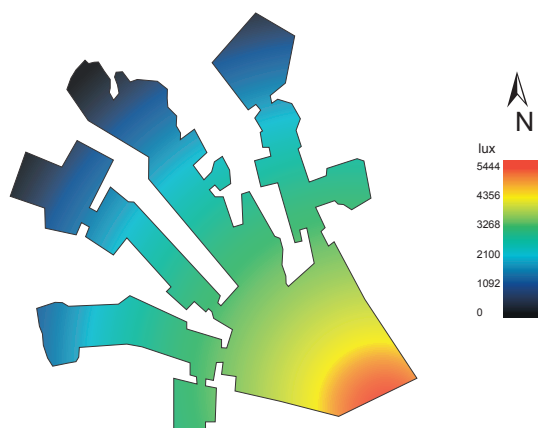


Fig. 81
Day light factor performance in an entire Vicinato

³⁷A. Guida, A. Pagliuca, A.G. Loforese, *The Sassi of Matera as the oldest bioclimatic architectural model*, Energy for Sustainability International Conference, Portugal, 2017, [en ligne], consulté le 27 décembre 2023

https://iris.unibas.it/retrieve/dd9e0b51-27c9-1e84-e053-3a05fe0aa940/The%20Sassi%20di%20Matera%20as%20the%20oldest%20bioclimatic%20architecture%20model_Madeira%202017.pdf

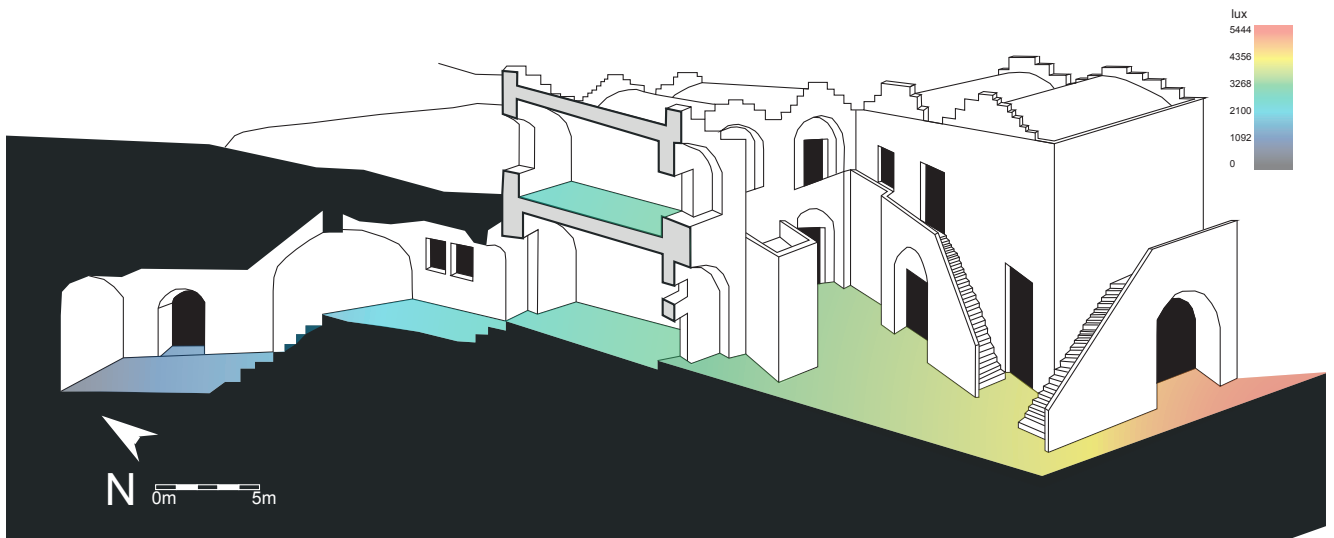


Fig. 82
Day light factor performance in an house



Fig. 83
Daylight inside a cave house

Water

Water management is crucial to the operation of the Sassi. In the Murges region, where rainfall is scarce, the city of Matera suffers from long periods of drought followed by short periods of heavy rain. In order to collect and redistribute the water, the Gravina valley is organized in terraces. Rainfall is collected in channels at the top of the valley and channeled down the slopes. The water is channeled through holes in the rock to the edges of the gorge and to the lower levels.

At the entrance to the caves, vertical pipes carry the water to cisterns or settling basins.

(Fig. x)

These bell-shaped cisterns, sometimes connected to each other, are covered with lime to make them watertight. At the top of the Sassi, a large cistern unites several existing caves and distributes the water to the houses through wells, as shown on Fig. x, the entire village is elaborate with this system.

Dripstones along the walls collect the drops of water from condensation or infiltration, which are then channeled into the settling basins. Canals lining the terraces collect excess water to irrigate the gardens in front of the caves. This system of canals prevents erosion and stabilizes the soil, which is essential as rainfall erodes the clay slopes of the plateau.³⁸

³⁸Matera, *la smart city più antica del mondo*, Geopop, 2022, [en ligne], consulté le 4 janvier 2024 <https://www.geopop.it/matera-la-smart-city-piu-antica-del-mondo/>



Fig. 84
Sketch showing a
idealized section of
a settlement along a
valley cliff at Matera

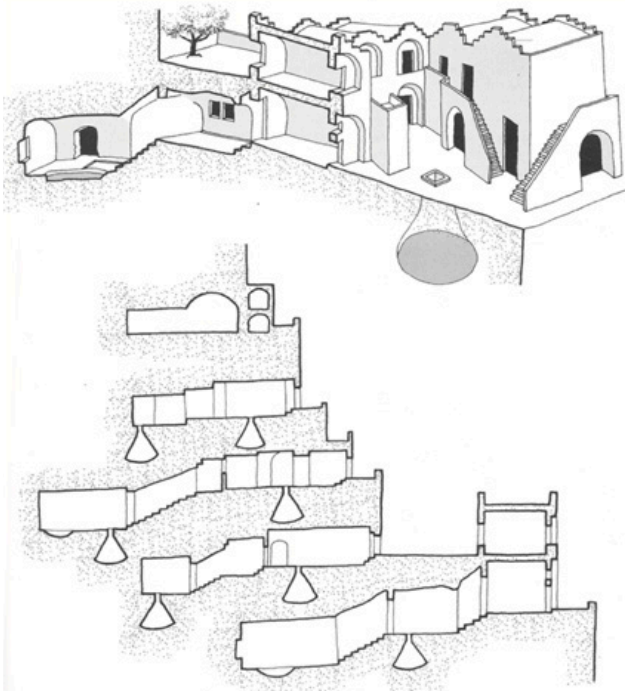


Fig. 85
Axonometric and section drawings illustrating
sloping of cave structures into the hillside and the
managing of water



Fig. 86
Channel in the cliff to transport and collect rainwater

Urban tissue

The city of Matera has grown mainly in an east-north-west direction, along the Gravina valley, which marks the radical boundary of the city. The historic centre, made up of the Civita high on the ridge and the two Sassi below, is characterised by a dense, irregular urban fabric that is more compact in the lower parts. Twentieth-century development, on the other hand, spreads radially to the north, south and west of the historic centre, covering 80% of Matera's territory, with planning that is further removed from vernacular architecture. The industrial area to the west is bordered by farmland, fields, woods and the countryside. The historic centre is separated from the modern districts by pedestrian and road links, with Piazza Vittorio Veneto acting as a symbolic gateway between the historic and modern parts. This square is also the meeting point between the great cistern that supplies the Sassi, the Palazzo and the modern ring roads. Piazza Vittorio Veneto and the Corso define the linear geological boundary of the city with the Gravina.³⁹



Fig. x
Axonometric and section drawings illustrating sloping of cave structures into the hillside and the managing of water

³⁹C. Ganty, M. Soupe, *Matera ville matière*, Énoncé théorique de master en architecture, EPFL, 2019, pp. 70-86

Matera's urban fabric is structured by a network of pathways and its orientation towards the sun. The inhabitants have adapted to the landscape, taking advantage of the natural relief. Excavated material is used to build low walls for the terraces and to extend the caves with buildings. The cascading terraces create small fertile gardens in front of the houses. The buildings are superimposed on the rocky slopes of the Sassi, with the streets acting as «roofs» for the lower dwellings. The main types of dwelling are the houses adapted to the morphology of the rock, of one to three storeys, built directly into the rock face, with terraces and external staircases connecting the levels with independent entrances. (Fig. x)

Different combinations of these basic units give rise to different types of dwellings, such as courtyard houses. The location of the houses is determined by the preferred orientation of the vaults. On the hillside, the dwellings are always perpendicular to the contours and seem to emerge from the rock face.⁴⁰

On the following pages you will be able to use diagrams to understand how an aggregation of cells developed in Matera.

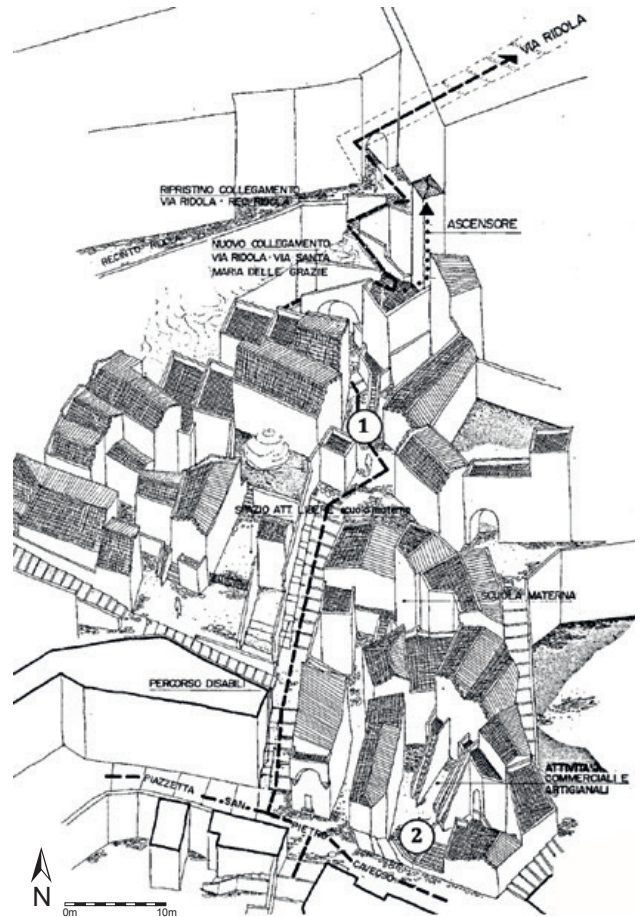


Fig. 87
Urban tissue of a campiello

⁴⁰P. Laureano, *Jardins de pierre Les sassi de Matera et la civilisation méditerranéenne*, Presses Universitaires de Vincennes, Saint-Denis, 2005

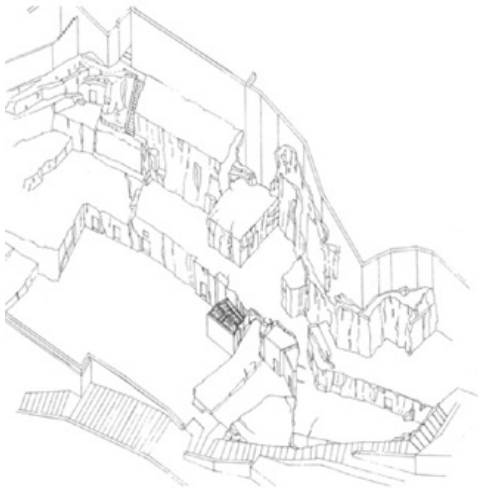


Fig. 88
1st phase: Development of the caves and construction of the first cell leaning against the rocky ridge.

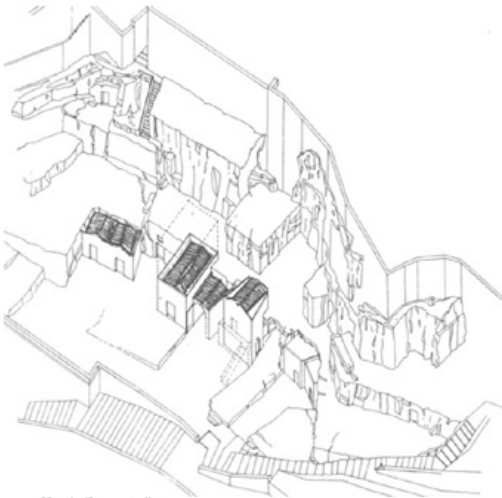


Fig. 89
2nd phase: Construction of cells in the extension of the caves and doubling of the height.



Fig. 90
3rd phase: Progression of the height doublings, with partial occupation of the upper deck.

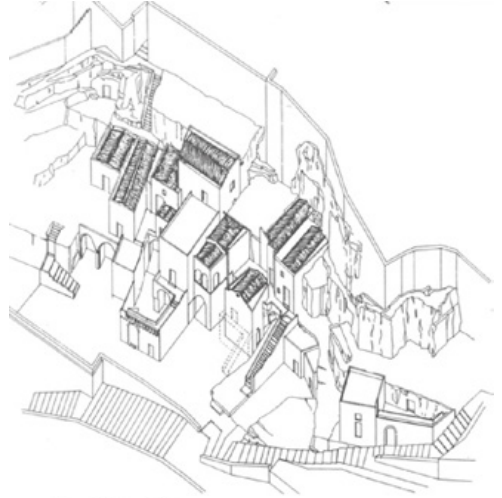


Fig.91
4th phase: expansion of the initial core and formation of new cores.



Fig.92
5th phase: Completion of the occupation of the upper plateau with the construction of cells based on the core already built.



Fig. 93
6th phase: Development ends with the construction of cells to partition off certain courtyards.

Region of Cappadocia, Turkey

Located in the Anatolian region of Turkey, Cappadocia was formed millions of years ago by the eruption of Mount Argaeus, which spewed lava for hundreds of kilometers. The central plain of Anatolia is a landscape of basalt-covered chimneys that resemble giant mushroom-shaped rocks.

The Hittites, who settled here some three millennia ago, began digging caves to keep their possessions at a constant temperature. During times of regional conflict, the inhabitants built underground cities to protect themselves, secret places where they could survive for months at a time. In the first century AD, the first Christians used them to hide from Roman persecution. Some of Cappadocia's troglodyte villages have remained inhabited until recent times.⁴¹

The region is home to cave dwellings, churches and entire underground villages that are still in use today. Today, Cappadocia's reputation is based on its underground structures and its Byzantine-style rock churches decorated with paintings. This subterranean lifestyle is due to a number of factors. The rock is easy to work and solid, making it possible to excavate large rooms with stable ceilings. In the absence of trees for wood, even above-ground dwellings used

tufa for barrel vaults. Typically, houses were carved into the slopes of hills, with rooms arranged around a courtyard on three sides. The underground cities of Cappadocia are remarkable for their size, complexity and diversity. Covering hundreds of square kilometers, different groups carved countless cavities into the rock.

These underground cities were built to withstand attack and to shelter large numbers of people and their domestic animals for long periods of time. Over 40 multi-level underground cities have been identified. In times of peace, the inhabitants of the region went about their business in the open air, cultivating their land. But when faced with invaders, they took refuge in these safe underground locations, which could shelter them for up to six months.⁴²

⁴¹K. Baghum, *Landschaft und Architektur in Kappadokien = Paysage et architecture en Cappadoce = Environment and the architecture in Cappadocia*, E-Periodica, Zurich, 1976, [en ligne], consulté le 2 janvier 2024, pp. 14-15
<https://www.e-periodica.ch/digbib/view?lang=fr&am-p;pid=ant-001:1976:15::293#84>

⁴²P. Yıldız, *Analysis of the 'Cappadocian cave house' in Turkey as the historical aspect of the usage of nature as a basis of design*, Department of Interior Architecture and Environmental Design, Hacettepe University, WIT Press Turkey, 2006, [en ligne], consulté le 30 décembre 2023, pp. 62-69
<https://www.witpress.com/Secure/elibrary/papers/DN06/DN06006FU1.pdf>

These complex underground cities were connected by passages, tunnels and inclined corridors that linked living quarters, communal areas and places of worship. They were equipped with wells, complex ventilation systems, niches for lamps, shops, water tanks, stables and temporary areas for the dead awaiting proper burial above ground. For defense, movable stone gates, similar to millstones, could quickly close off roads in the event of an attack.



Fig. 94
Map of Turkey



Fig. 95
Aerial view of a village in the valley of fairy chimneys



Courtyard

In the architecture of the troglodyte houses of Cappadocia, the courtyard plays a central role in organizing all the living spaces. It is the hub around which all the rooms are arranged, providing a practical focal point.

The size and shape of the courtyard were determined by the available rock and its morphology. The craftsmen did not aim for perfection, but rather for variation and adaptation to a unique topographical environment that had been tested over time. The various bedrooms and living areas are arranged along the sides of this courtyard, providing a practical layout for domestic and social activities. This courtyard allows natural light and air to circulate. In homes that are often dark, it acts as a source of light and ventilation, significantly improving the comfort and livability of the interior spaces. The courtyard is multifunctional. It can be used for a variety of purposes, from everyday life to community or religious gatherings. Sometimes even places of worship have been created in these spaces, underlining their central importance and their adaptability to the different needs of the inhabitants.⁴³

There are five different types of relationship between dwellings and courtyards in the troglodytic architecture of the region.

The first type refers to dwellings without a courtyard, where the main entrance opens directly onto the street, creating a direct link between domestic life and the public space, typical of rock-hewn buildings.

The second type includes dwellings with two separate entrances, one from the courtyard and the other from the street. The courtyard acts as a transition zone between the building and the outdoor space. In some cases, the courtyard is large enough to include green spaces, while in others it is minimal and simply provides a link between the architectural volumes.

The third type includes buildings with a street frontage and courtyards on the other three sides, or those with a rocky rear and a courtyard at the front and sides. A door gives access to the courtyard from the street and the building, where there are spaces for services such as storage, barns and toilets. The fourth type consists of dwellings with courtyards on two sides of the building, often shared with other troglodyte structures nearby.

⁴³P. Yıldız, *Analysis of the 'Cappadocian cave house' in Turkey as the historical aspect of the usage of nature as a basis of design*, Department of Interior Architecture and Environmental Design, Hacettepe University, WIT Press Turkey, 2006, [en ligne], consulté le 30 décembre 2023, pp. 65-66
<https://www.witpress.com/Secure/elibrary/papers/DN06/DN06006FU1.pdf>

The last type consists of buildings lined up along the road, with courtyards at the rear, between the dwelling and the rock face. Access to the courtyard is through the lower floor and then through another door. There are also examples where access is first to the courtyard and then to the dwelling, with the back resting on the rock face.⁴⁴

The importance of the courtyard in this region is reflected by the fact that even in the underground cities, courtyards were dug, they looked more like squares due to the fact that they were underground, but a particular intention was made to these places, that of raising the ceiling in order to have this idea of courtyard.



Fig. 96
Old dwelling with its frontside courtyard

44 A. Ercetin, *Background of a History: Cappadocia Houses*, A+ Arch Design International Journal of Architecture and Design, 5(2), 2019, [en ligne], consulté le 2 janvier 2024, pp. 80-83
<https://dergipark.org.tr/en/download/article-file/1135969>

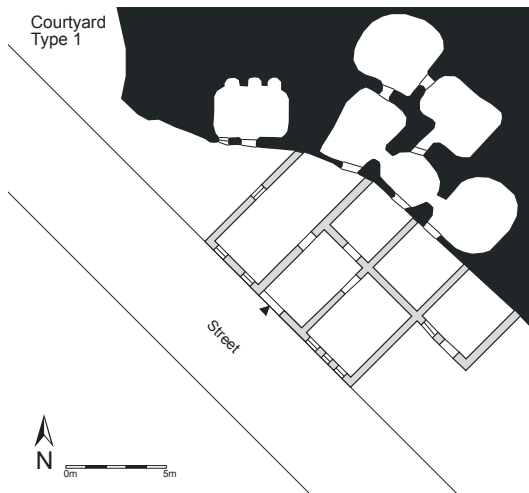


Fig. 97

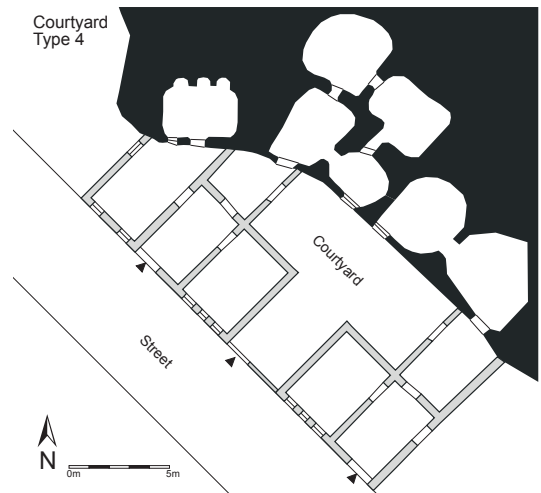


Fig. 100

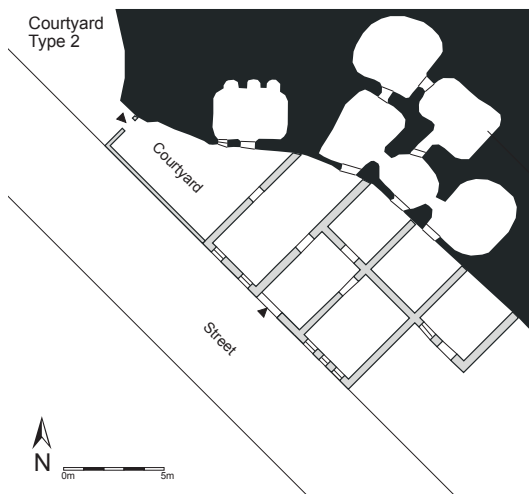


Fig. 98

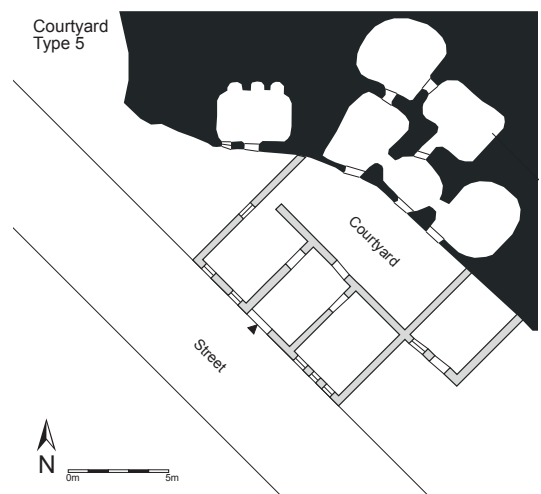


Fig. 101

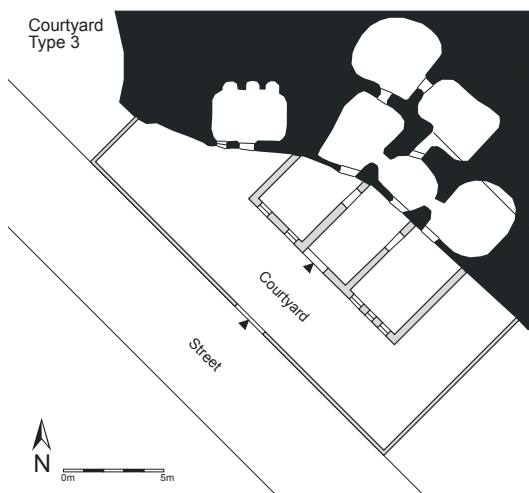


Fig. 99

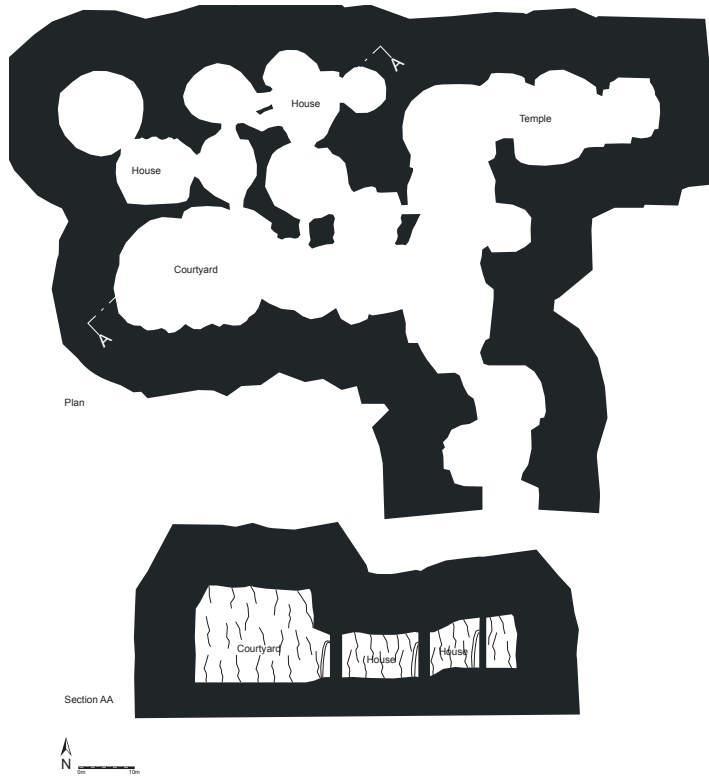


Fig. 102
Underground
courtyard diagram
in the Cappadocia
region



Fig. 103
Underground
courtyard in
Derinkuyu

Access

To provide access to the dwellings and villages, complex features were built into the courtyards, as mentioned above, including rock-cut staircases, rope ladders and open paths along the rock faces. (Fig. 104)

A large part of these villages were not visible. A large underground section was designed to shelter the inhabitants for about six months in case of emergency, so an elaborate circulation system of extensive networks of passages, tunnels, pit stairs and inclined corridors linked family and communal spaces that served as places of assembly, work and worship. These cities were equipped with wells, air ducts, niches for oil lamps, shops, water reservoirs, stables and temporary areas for the dead awaiting suitable conditions for their final burial. Carefully balanced movable stone doors, resembling millstones, were designed to quickly close off passages in the event of an attack.

Derinkuyu, one of these complexes, had eight underground levels reaching a depth of 55 meters and was built around 1300 BC. The city was effectively ventilated by air shafts, some of which were 85 meters deep.⁴⁵

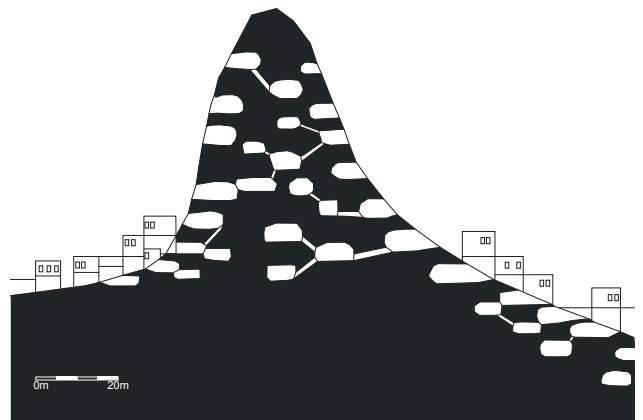


Fig. 104
Section of principle of village in Cappadocia and connection between caves

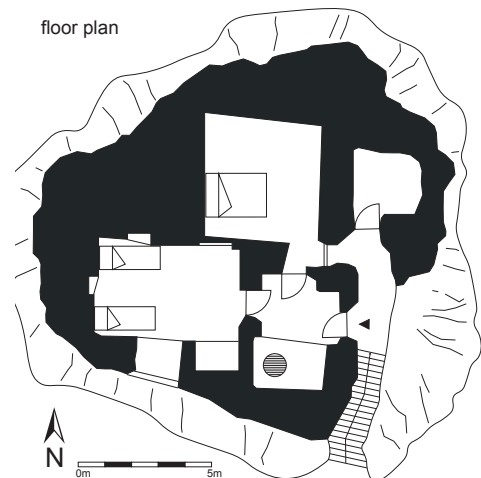


Fig. 105
plan of an house in Cappadocia and its access

⁴⁵P. Yıldız, *Analysis of the 'Cappadocian cave house' in Turkey as the historical aspect of the usage of nature as a basis of design*, Department of Interior Architecture and Environmental Design, Hacettepe University, WIT Press Turkey, 2006, [en ligne], consulté le 30 décembre 2023, pp. 67-68
<https://www.witpress.com/Secure/elibrary/papers/DN06/DN06006FU1.pdf>



Fig. 106
network of paths and
caves through the
cliffs



Fig. 107
part of an above-
ground village with its
traffic system

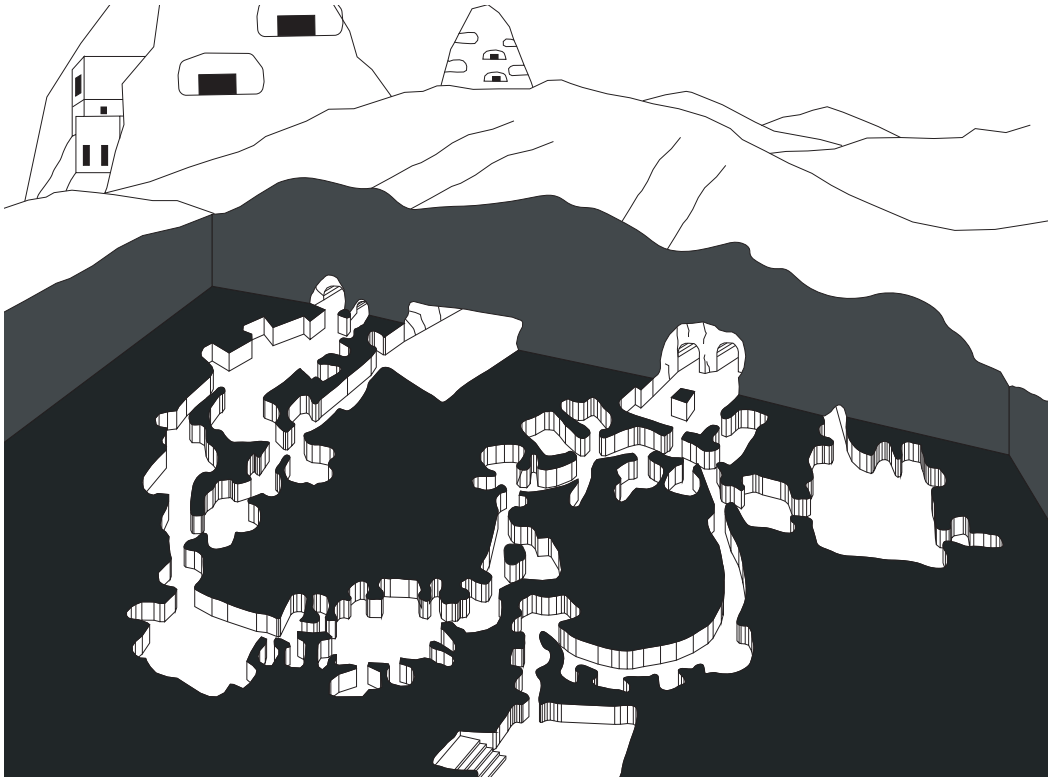


Fig. 108
Inside one of the
refurbished cave
dwellings



Fig. 109
Daily life in
underground city, with
vertical circulation

Fig. 110
Tunnel to acces to
underground city of
Özkonak



Fig. 111
Movable stone doors



Plan

The plan of cave dwellings is generally characterized by two or three different types. The steepness of the terrain and the arrangement of the masses along the slopes have made it difficult to form a standardized layout. These dwellings generally consist of one or two storeys arranged around a central courtyard, with rooms carved out of the surrounding rock. Often the only lower level is the second floor terrace.

The residences were made up of three parts: the dwelling, the living quarters and the stable. They often had a semi-hypogean section for periods when there was no conflict.

The living area is surrounded by walls used for working outside the house. The barn contains shelters for the animals and a hayloft. On the ground floor are the kitchen, dining room and stable. On the upper floor there is a vaulted room accessed by a ladder, with rooms on either side of the open arched section. Typically, the facades facing the courtyard or road have two rectangular windows. This room is usually adjacent to the back wall and is accessed by a ladder.

In the architecture of Cappadocian houses, rooms are arranged around a central platform to form a living unit. These rooms,

which are generally square, are uniform in shape, size and features and are built in proportional modules. Traditionally in this region, the upper floors were used as the main living areas, while the ground floor was used for winter activities, domestic services and storage. The layout of the houses was often influenced by the arrangement of the sofas, the sofa, which we can call the space between the rooms, is variable with every single feature, which determined the number and arrangement of the rooms. In steeply sloping areas, the sofas blended into the rocky relief, influencing the layout of the living spaces and giving rise to specific house plans.⁴⁶

A series of rooms adjacent to the courtyards of the architectural complexes often had less obvious functions. These rooms, which were central to the complex, may have served as additional reception rooms, some of which were dedicated to women. They have been described as multipurpose 'day rooms', allowing more intimate receptions for a limited number of guests, possibly mixed, bringing together men and women.

The kitchens, with their huge conical fireplaces and braziers placed near the front door, formed the kitchen and communicated

⁴⁶A. Ercetin, *Background of a History: Cappadocia Houses*, A+ Arch Design International Journal of Architecture and Design, 5(2), 2019, [en ligne], consulté le 2 janvier 2024, pp. 84-86
<https://dergipark.org.tr/en/download/article-file/1135969>

directly with the courtyard. The kitchens had at least one large, elongated niche and several small, shelf-like niches carved directly into the rock, accompanied by a semicircular niche that served as a fireplace. In addition, these kitchens often had small adjoining rooms that provided additional space for food storage and preparation.⁴⁷

In underground cities such as Derinkuyu and Kaymakli, with multiple levels reaching down to 60 meters below ground, the spaces were designed as a system. The spaces were divided into different quarters with living areas, storage rooms, communal kitchens, places of worship and sophisticated ventilation systems for fresh air. The first floor was reserved for the animals, and each floor was a different quarter, centered around communal kitchens, workshops, places of worship, areas for the dead and water reserves. The underground spaces were designed to suit the life of these cities.⁴⁸

On the following pages you will see different typologies of house that we could find in the region of Cappadocia.

⁴⁷F. G. Öztürk, *A comparative architectural investigation of the Middle Byzantine courtyard complexes in Açıksaray - Cappadocia: questions of monastic and secular settlement*, Ph.D. Doctoral Program, Middle East Technical University, 2010, [en ligne], consulté le 2 janvier 2024, pp. 229-231
<http://etd.lib.metu.edu.tr/upload/3/12611990/index.pdf>

⁴⁸P. Yıldız, *Analysis of the 'Cappadocian cave house' in Turkey as the historical aspect of the usage of nature as a basis of design*, Department of Interior Architecture and Environmental Design, Hacettepe University, WIT Press Turkey, 2006, [en ligne], consulté le 30 décembre 2023, pp. 70
<https://www.witpress.com/Secure/elibrary/papers/DN06/DN06006FU1.pdf>

Section



Fig. 112
section of a Chimney in Goreme

Ground floor Plan

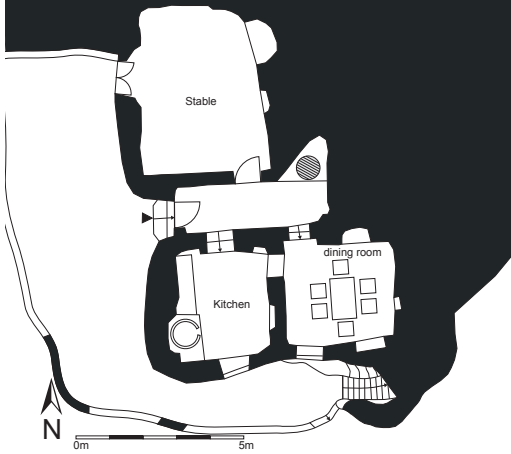


Fig. 113
Ground floor plan of an house in Goreme

First floor Plan

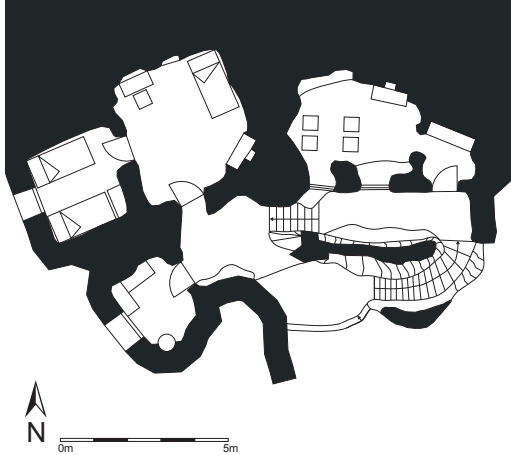


Fig. 114
First floor plan of an house in Goreme

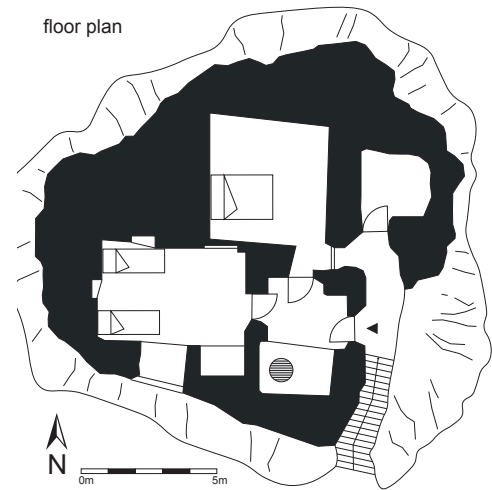


Fig.105
plan of an houses chimney in Goreme



Fig. 115
Village in chimney in Goreme

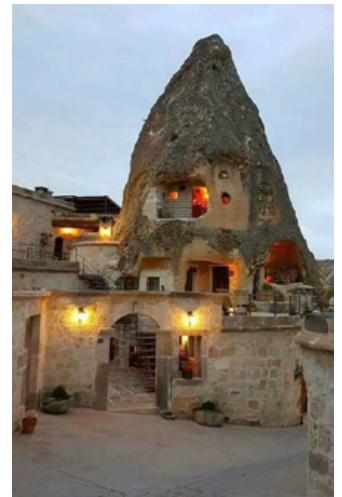


Fig. 116
House with a private courtyard

Sunlight

Natural light is maximized by the layout around a central courtyard. The rooms are arranged to take advantage of the light coming from this open space and to allow for an even distribution of light within the rooms. The openings, generally rectangular windows, are positioned on the facades facing the courtyard or the street. These openings were designed to let in natural light while controlling excessive heat.

Cave dwellings were often designed with rooms arranged around the central courtyard to maximize natural light inside. Niches, shelves and other storage areas were also strategically placed to take advantage of the light.

In addition to rectangular windows, some cave dwellings used special openings, such as vaulted niches, to direct light into specific areas, helping to illuminate darker parts of the rooms. For the deepest parts, the villagers used torches.⁴⁹

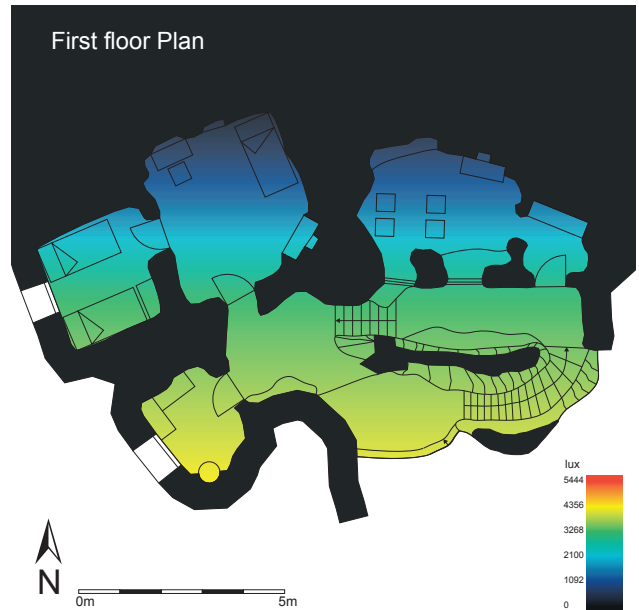


Fig. 117
Day light factor performance in an house in Goreme

⁴⁹F. G. Öztürk, *A comparative architectural investigation of the Middle Byzantine courtyard complexes in Açıksaray - Cappadocia: questions of monastic and secular settlement*, Ph.D. Doctoral Program, Middle East Technical University, 2010, [en ligne], consulté le 2 janvier 2024, pp. 225-231
<http://etd.lib.metu.edu.tr/upload/3/12611990/index.pdf>

Fig. 118
Daylight inside a cave
house in Cappadocia



Fig. 119
Daylight inside a
cave church in
Cappadocia



Water

Irrigation systems in the Cappadocia region appear to have developed as early as the Byzantine period, as a result of the harsh climatic conditions: cold winters with heavy snowfall and limited rainfall in summer. These constraints led to the development of sophisticated techniques for storing and distributing water, drawing on various sources such as snowmelt, rainwater and possibly groundwater. (Fig. 120)

The main water supply system was based on wells dug into the rock, often circular or square in shape with an average diameter of 70 centimeters, which provided access to aquifers. These wells were essential for water self-sufficiency during conflicts such as Arab raids, and were often found in underground shelters. Underground cisterns, fed by different sources, were integrated into different structures for crop irrigation, allowing clever water management.

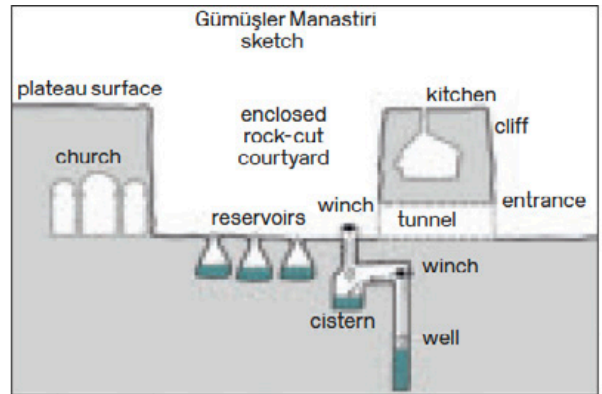
Hydraulic systems were varied and adapted to regional needs. Underground aqueducts, such as those at Uçhisar, used terracotta channels to carry water over long distances. Drainage tunnels protected valleys from erosion by draining excess water, thus promoting agricultural terracing. Cistern tunnels, ingenious reservoirs, were flooded

for irrigation and collected meltwater and rainwater, which was then distributed through canal networks to meet seasonal water needs.

The construction of these systems relied on meticulous excavation methods. Absorption trenches collected run-off water and directed it to the tunnel cisterns. Water pipes were precisely positioned for optimum supply, while cut stone trenches ensured precise gravity collection to the cisterns, demonstrating careful planning.

These systems were designed to store water during periods of snowmelt and heavy rainfall, and to supply water during the dry season. The lithological characteristics of the tufa minimized water dispersion, while losses were reduced by avoiding surface evaporation. These ancient hydraulic systems in Cappadocia reflect the ingenuity of the local people, who cleverly adapted to the climatic conditions to ensure a sustainable water supply.⁵⁰

⁵⁰A. Bixio, R. Bixio, A. De Pascale, *Underground hydraulic systems and anthropogenic cavities in Cappadocia*, Fondazione Benetton Studi Ricerche, Antiga, Treviso, 2020, [en ligne], consulté le 3 janvier 2024, pp. 130-141
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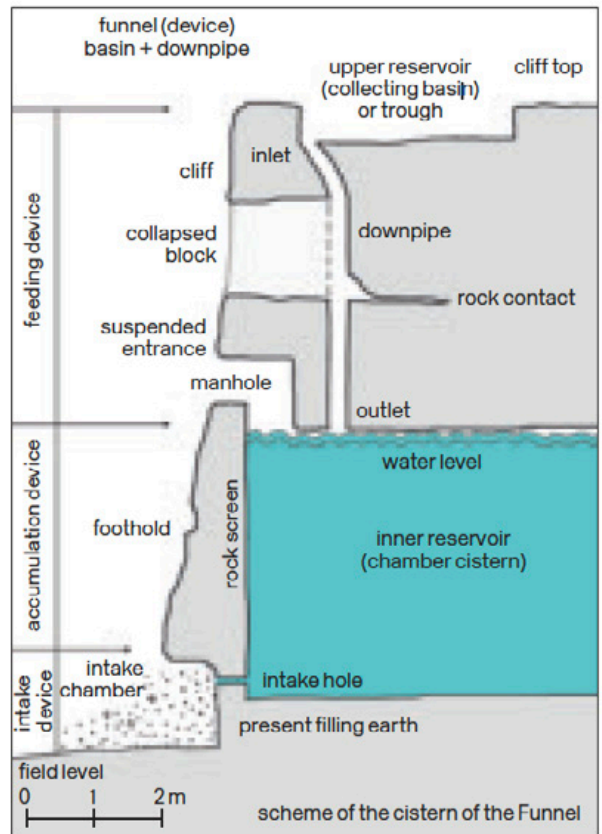


Fig. 120
Cross section of water raising system in Gümüşler Manastırı & Cross section of the cistern of the Funnel situated in the Zemi Valley (Zemi Vadisi)

schematic morphological section
(projection view on the East-West axis)

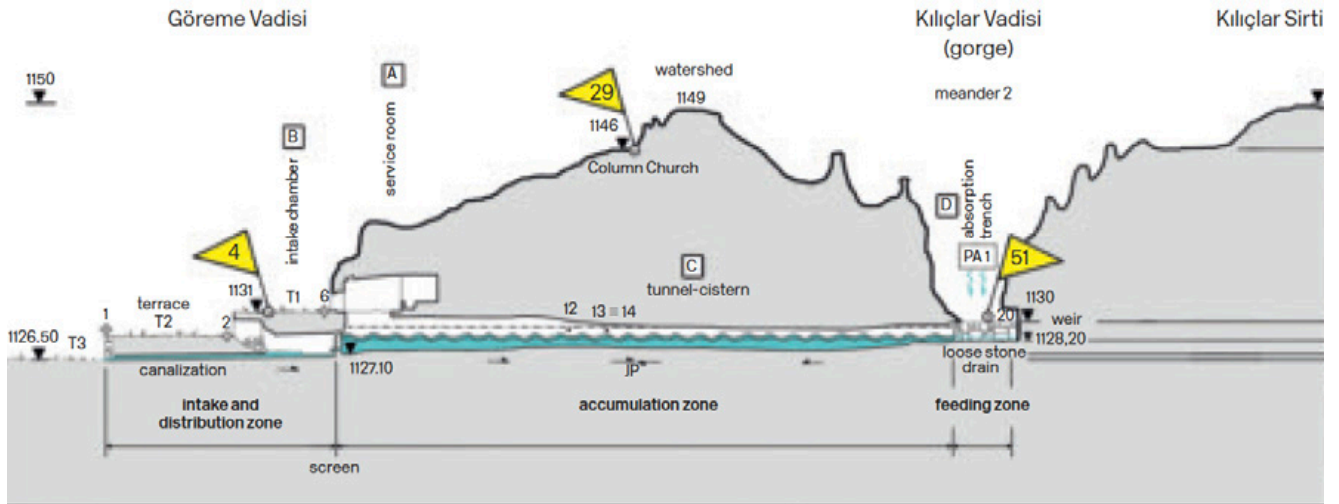
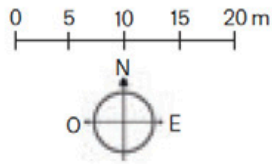


Fig. 121
Longitudinal cross section of Traforo tunnel-cistern cut through ridge between Göreme Valley and Valley of Swords

Fig. 122
Bell-shaped cross
section of
drainage tunnel in
Göreme



Fig. 123
Belvedere tunnel-
cistern, still
flooded in a period of
drought.



Urban tissue

The urban structures and shapes of the villages in the valleys of Cappadocia are determined by the geological features of the place where the villagers chose to settle. Some villages were dug into the ground, clinging to the rock faces of mountain valleys, or spread out along the slopes and even on separate rock formations, each isolated. These settlements were often laid out on different levels, linked by internal or external staircases to allow movement between them. Residential areas were usually close to churches, communal kitchens and storage areas, encouraging an active community life. Narrow, winding streets were often formed leading to central squares where social activities took place, generally following the sloping terrain of the region. An extensive system of underground circulation and spaces connected the surface and underground cities.⁵¹



Fig. 124
Master plan 1st and 2nd floors of St. Mercurius
underground city



Fig. 125
plan of a house in Cappadocia and its access

⁵¹A. Yamaç, E. Tok, B. Filikci, *St. Mercurius underground city of Saratli (Aksaray-Turkey)*, Opera Ipogea, Italia, 2014, [en ligne], consulté le 3 janvier 2024, pp. 37-46
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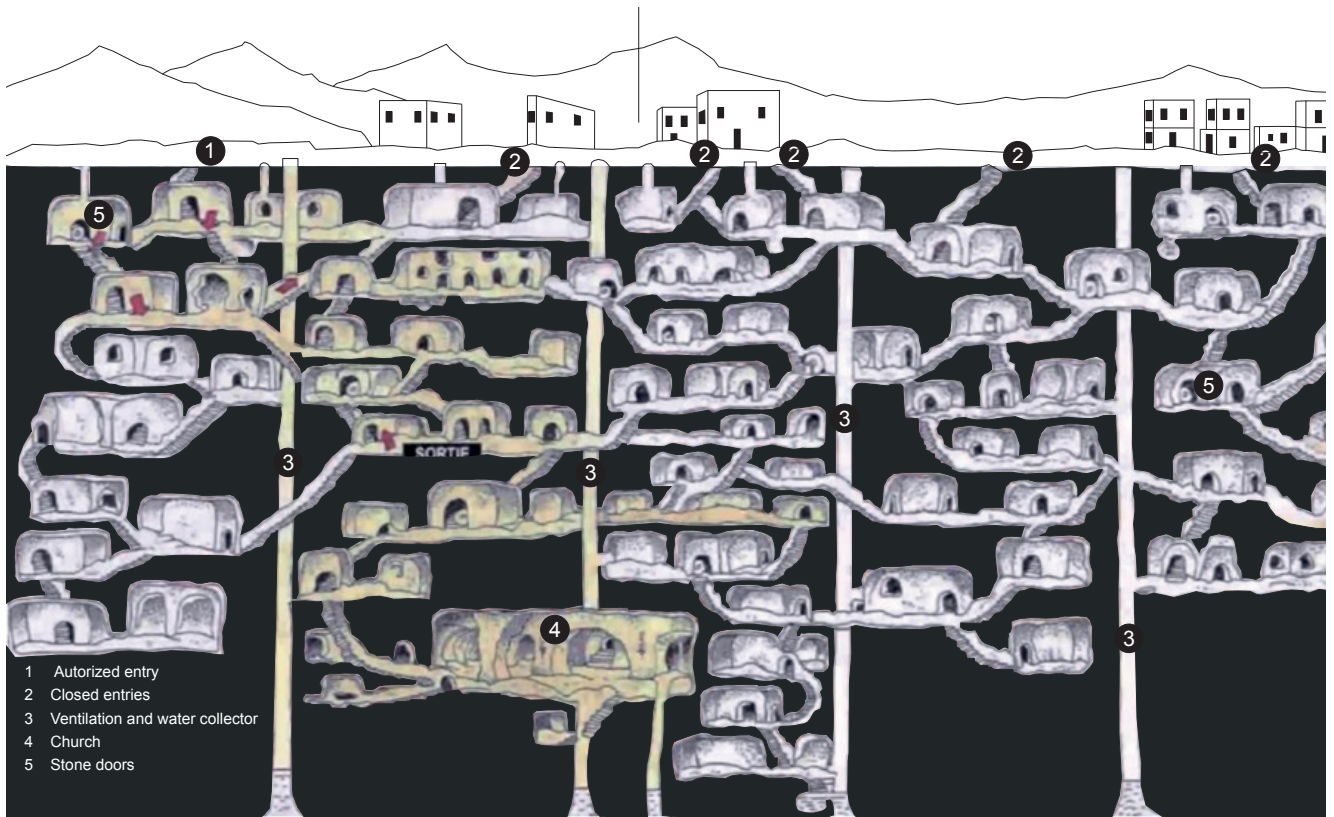


Fig. 126
 Section of the underground city Derinkuyu



Fig. 127
Underground city in Uchisar





Fig. 128
Derinkuyu underground city in Cappadocia



Analysis conclusion

After studying these three different examples of troglodyte architecture, I was able to see that although the appeal of this architecture varies according to individual needs, preferences and geography, it does have a number of advantages.

Built directly into the ground, troglodyte houses benefit from natural insulation. It is relatively cool in summer and retains heat in winter, reducing dependence on heating and air conditioning.

Caves are often built using local resources, minimising the impact on the environment. The use of natural stone as a building material contributes to sustainability and resource conservation. Because cave dwellings are embedded in rock, they offer some protection from extreme weather events such as storms and floods. This makes them more resilient to natural disasters than traditional building methods. Rock architecture often blends naturally into the surrounding landscape, preserving the natural aesthetics of the region.

Because cave dwellings are better insulated, they require less energy to heat and cool, which can lead to significant energy savings in the long term.

Some cultures have used this type of architecture for centuries. Preserving and continuing these architectural practices can contribute to cultural preservation.

However, it is important to note that this type of architecture requires a real understanding of its context. Building these caves can present challenges such as :

Creating openings to let light in without overheating the room can limit the amount of natural light that can be brought into the room, as troglodyte dwellings often have a semi-submerged or buried layout that does not allow light to enter on all four sides.

Adequate ventilation is needed to prevent damp and to allow air exchange. Subterranean environments are prone to moisture build-up, which can lead to problems such as mould and structural deterioration of materials. Adequate ventilation and moisture management measures are therefore necessary. Air circulation in underground spaces is a major challenge, requiring careful design to ensure adequate ventilation and avoid problems associated with air renewal.

Extensions or modifications to cave dwellings can be more complex than traditional structures due to the unique nature of building in rock. The nature of the surrounding rock can limit the usable interior space of a cave dwelling. This can make it difficult to store and arrange functional spaces.

What's interesting about these three case studies is that the architecture is a real living system. In all cases, it has to work with the land, which is constantly changing, and it includes remote systems for water collection and air exchange, using only complex geometric channels dug directly into the mass. In analyzing this type of architecture, we feel that it is the first step towards the 'machine à habiter', a functional architecture that meets the needs of its inhabitants, with spaces optimized in relation to the land. But it is much more than a living machine, it is a living architecture in constant interaction with its inhabitants.

Conclusion

Conclusion

At the beginning of this énoncé, I was thinking about our role as architects and my desire to go back in time and rethink our architecture, because I feel that I am blocked in a system where I cannot be the thinker I should be, but rather an executor of other people's dreams. I felt that it was our duty to create responsible, thoughtful architecture, inspired by ancient techniques, vernacular techniques and examples from around the world, in order to redefine, or rather rethink, our modernity. So I thought about reversing the way we develop architecture, not through the act of creating mass, but through the act of creating void, so I looked at cave dwellings that have been used as homes for centuries.

As my research progressed, I noticed that these dwellings either had a bad reputation because they were considered poor or cave dwellings, or they were perceived in such a poetic way that a kind of tourism developed around them, as in the village of Matera in Italy or the village of Matmata in Tunisia, but only the poor or those truly attached to their tradition still use this type of dwelling.

I also pointed out that there is a revival in France, albeit a very niche one at the moment, and I wanted to show through this

work that another way of thinking about architecture is possible, a 'modern' troglodyte architecture that would be viable in a society like Switzerland because of its topography.

This led me to think about what such a monolithic hypogean or semi-hypogean habitat would look like, so we had to think about the meaning of this mass and how to extract it. Because architecture is not revealed by building, but by subtracting mass, we end up with monolithic constructions. Shape is also very important, because the nature of soil and rock varies from place to place. The geometry of the cavities has to be designed around the physical and structural properties of these elements, and the shapes that emerge cannot be the same as those we know today in our homes, orthogonal spaces with flat ceilings.

This geometry and the visual properties of the ground create an atmosphere, a sensory quality that is very different from the buildings we know, because we don't have to think of the construction in terms of layers, but in terms of a void, it's only the hollowed-out material that appears, in its raw, mineral form.

This allows the construction to give an experience of mass, of thickness, to have sensory and emotional qualities that are very different from our white plastered walls. In addition, as explained in this work, such a habitat requires constant aeration because the soil is alive, it releases moisture, so in order to remain in a place suitable for life, the rock must breathe and be aerated.

Architecture thus becomes a system for supporting life. The openings in the facades, the layout of the rooms and the circulation spaces must all be designed to make the system work. The supply of air, heat and sunlight must all work together to keep the system dry.

Having seen all this, I can confirm that such kind of architecture is possible in Switzerland.

As a result, the work of the architect becomes much more scientific, because he has to develop real geometric thinking and the treatment of textures in order to create a viable atmosphere for the dwelling. Through the planning of their spaces, they must also make architecture a system in order to maintain the comfort standards of our era. It's only through true architectural reflection

that such a project can be realised, because it's no longer possible to hide behind technology to make such buildings possible: the architect will have to be much more than someone's artistic, technical and scientific translator; he or she will have to be a thinker and not just an executor.

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