Virtual and cognitive reconstruction of Roman Imperial Baths in Tunisia

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Abstract

The restoration of the buildings of antiquity from their traces, remnants and stories is the domain of archaeologists and historians. We propose an architecturological reconstruction as an additional method, which is more of a re-conception. A virtual, cognitive and collaborative model is proposed as a generative, dynamic and open model, as a processing system or expert system which involves a set of rules for organizing, training and systematized by the change in architectural analysis, producing variants of the prototype of the building of Imperial Baths from traces or remains only, and to draw their analog model also known as "project".

We analyze a class of imperial Roman baths Type of Tunisia. Hydrotherapy or attendance thermal buildings is a practice perpetuated for thousands of years. This practice has developed from a simple act of bathing to a socio-economic, cultural and even political phenomenon and it is widely used since antiquity on both sides of the Mediterranean. It peaked with the baths where Roman civilization has become true temples of secular life.

The method is to trace the formation- conception process of baths from their analog models necessarily incomplete, relating to the collection of known specimens described and illustrated by experts. Every change or disturbance introduced affects the entire building which tends to regain its equilibrium. The facts, data established by archaeologists and tangible evidence, are the

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determined in the detailed description of the specimen modeled and validated.

Key Word:
Architecturological reconstruction, virtual cognitive and collaborative model, analog model.

Introduction

This paper summarizes a long work which is a part of the research program dealing with modeling the process of architectural conception of Roman Imperial Baths. This work serves to establish an expert system that restores the baths from a trace. To achieve this object, we have implemented the matrices' model of the architectural organization (Dhouib, 2004). This model was proposed for the analysis, reproduction and conception of the architectural project.

We applied this model on the architectural system of Roman Imperial Baths. Crossing all levels of cognitive organization, we were able to identify the cognitive model of this type of building that will permit us then the return of any building belonging to this system. To attain this, we chose to work on the Roman Baths of Caracalla in Dougga because they are the well preserved baths in Tunisia.

The obtained results will allow us to experience the process of reconstruction that will facilitate the restoration of other Imperial Baths from their traces or remains.

This was what we have managed to do to the Baths of Ain dourra in Dougga. We intend to restore the baths as they were at the time of their construction. This is an architecturological study and not an archaeological one.

This study is based on statements prepared on site, plans and studies that are made on the thermal building and Roman architecture by specialists.

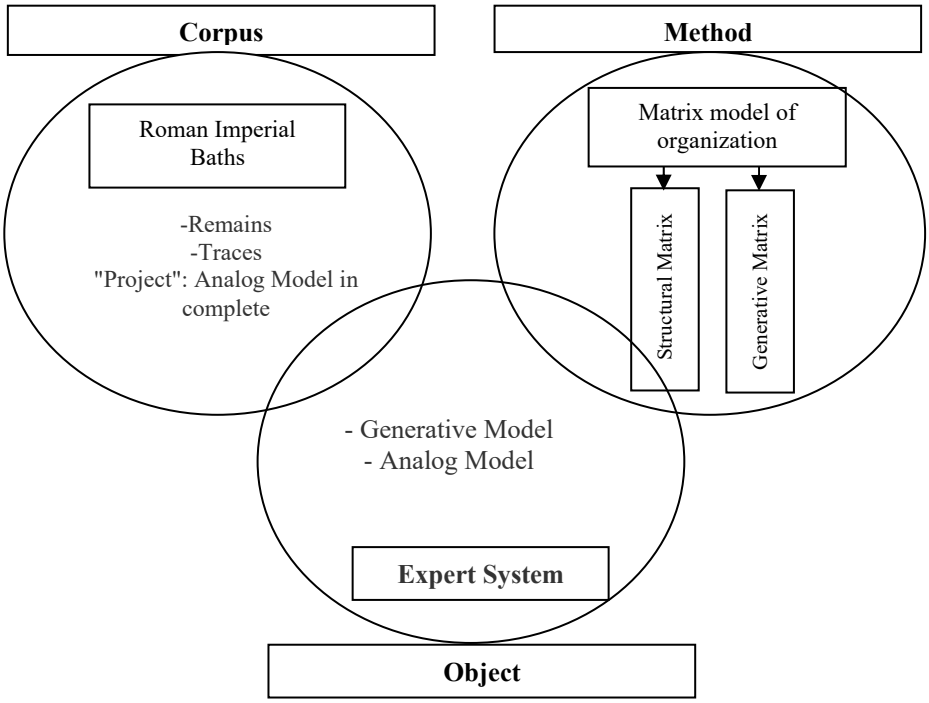


Fig.1: Research program supported by a team of architecturology and Conception Modeling (RTACM -RGSFAC).

The matrix model of organization

The matrix of organization is an architecturological model which is based on the following assumptions:

The epistemological assumption

We assume that knowledge is distributed according to the epistemological axis of actual and factual levels towards a more conceptual and theoretical one. The first level is the phenomenal domain made up by facts such as things, buildings……..

The second bearing includes tacit knowledge: knowledge and practice.

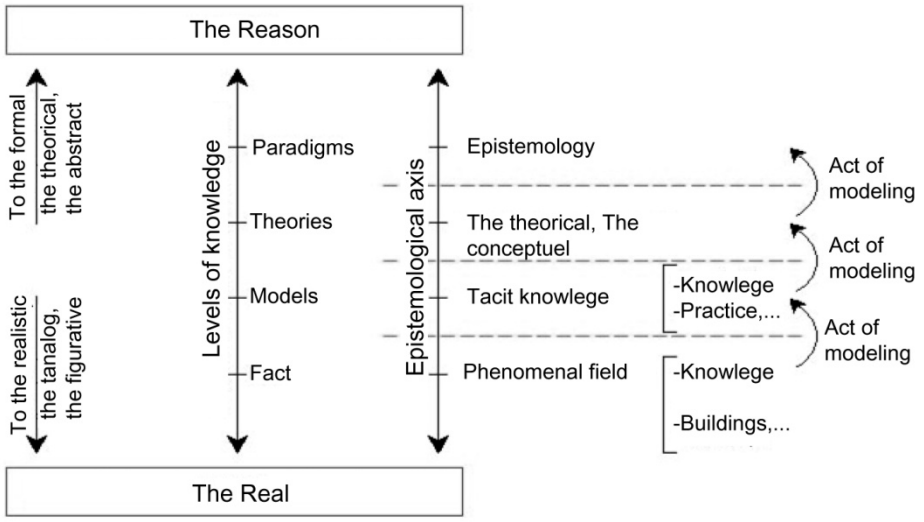


Fig.2: The epistemological assumption. (Dhouib M., 2004)

Our work focuses on four approaches. We can't move on to the following approach without completing the previous one.

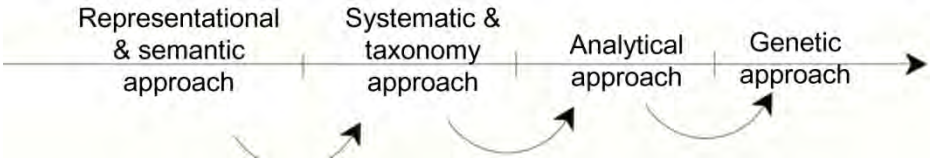


Fig.3: Sequence of the different cognitive perspectives. (Dhouib M., 2004)

Semantic and representational perspective

The first perspective involves an etymological study. This is a comprehension test of most of the vocabulary for architecture and resort topic. We define the names of places like "spa", "baths", "frigidarium", "tepidarium", etc...

Systematic and taxonomic perspective

The second perspective consists in identifying all specimens of Roman Imperial Baths in Tunisia. We rely essentially on the work of Yvon Thebert "Roman Baths of North Africa and their Mediterranean context: historical and archeological studies."

It has identified 11 Imperial Baths in Tunisia. We match each specimen with a registration form containing the state of

knowledge we have until now (location, dating, drawings, written documents...). That is the systematic and taxonomic perspective.

Analytical perspective

Having been given the defined collection of 11 spas, we proceed in the third perspective, to the decomposition and analysis to determine the rules and principles, that govern this class of buildings.

Genetic perspective

The fourth perspective is an attempt to redial from the generative model; we are running a series of rules derived from the results of the analysis. This sequence allows us to recover the analog model, generate the Imperial Baths and restore plans, sections and facades, while respecting the rules and internal consistency within the Roman architectural system.

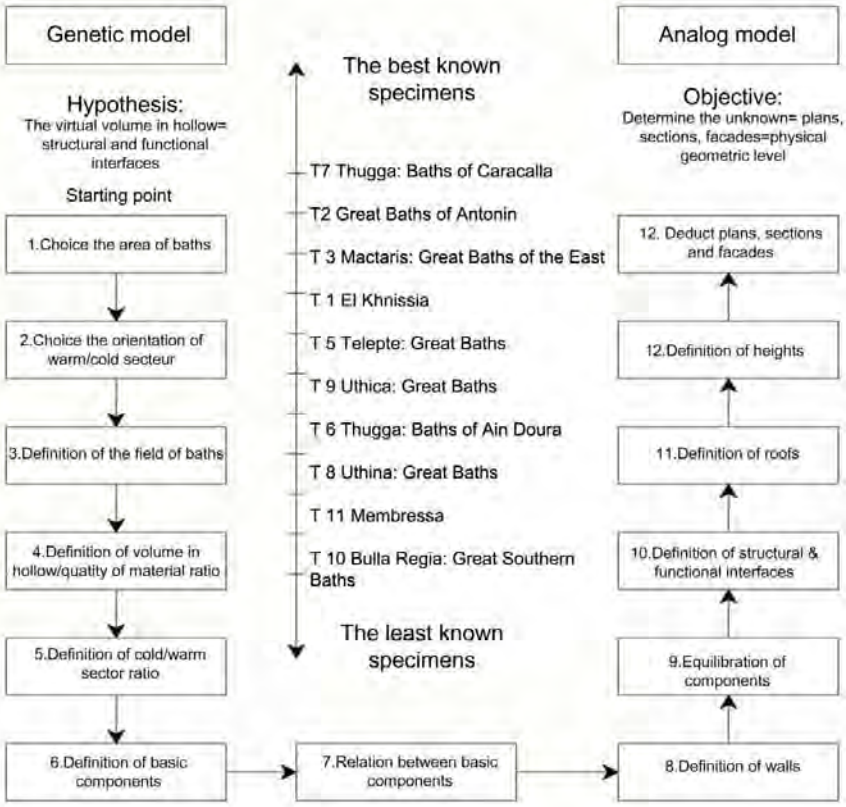


Fig.4: Genetic perspective. (Bouaita K., 2004)

The premise of the overall architectural system

We admit that there is a global architectural system that includes all local systems and all possible architectures: Roman architecture, Greek, Renaissance, modern architecture... Any architecture regardless of its nature, its geographical position and time which will be included in this global architectural system.

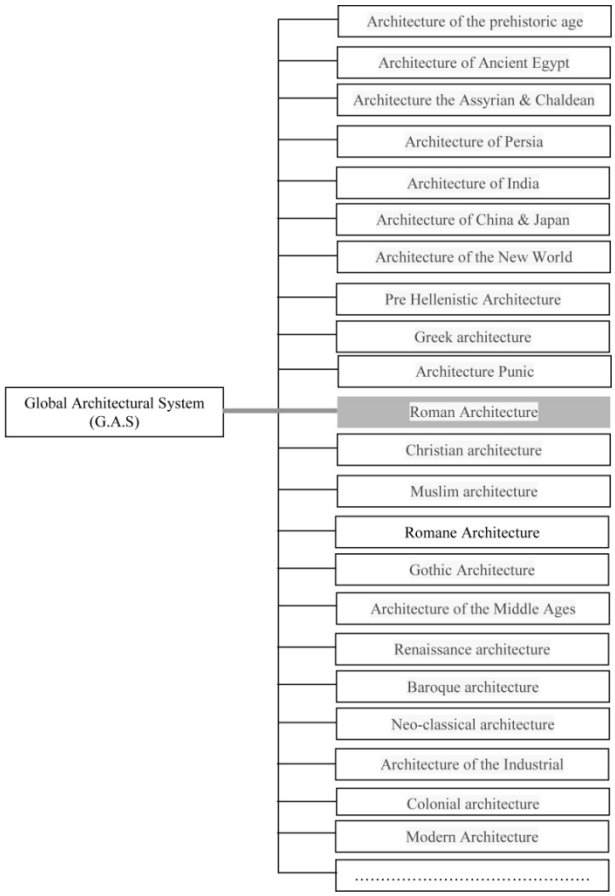


Fig.5: global Architectural system: Set of all architectures (Test Inventory). (Bouaita K., 2004)

The holographic assumption

Each architectural system is arborescent. We can establish a hierarchy that is a classification within this system. Each level of organization is

an "entity"[1]. Each entity is defined both as a whole constituting a full stand-alone and a part of a larger whole (interlocking objects into each other), a part of the whole.

Example n°1: This is a whole formed by a hall, a living room, etc... It is also a part of a larger whole that is the building.

Example n°2: The Roman architectural system is a "subsystem" of a local system's in an overall architecture. We can establish a taxonomy based on several criteria within the same subsystem:

-A classification according to the type of program (destination and function of the building).

Examples: military architecture, public architecture, domestic architecture, architecture of entertaining centers...etc.

- Or, a classification by province (location).

Examples: Province of Europe, Asia Province, Province of Africa...

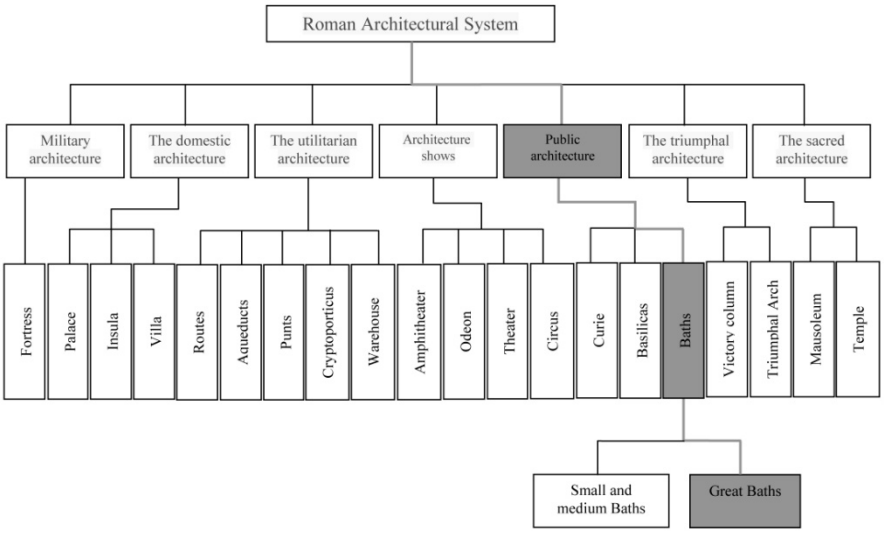


Fig.6: Taxonomy of Roman buildings according to their program. (Bouaita K., 2004)

[1] KOESTLER, A. (1965), « *Le cheval dans la locomotive, le paradoxe humain* »,Calmann-levy.

The dialogic premise of the architectural place

We assume that every architectural place consists of a Globing Solid Device (GSD) that generating a Habitable Fluid Space (HFS) integrating the operating works system (Fluid, piping, electricity,). We offer a theming of architectural space based on the interaction between the habitable space and solid device. The characteristics of the walls (thickness, number of openings and their size) permits to define the interfaces between the different spaces.

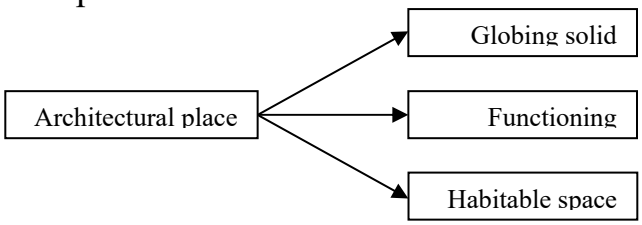


Fig. 7: Assumption of the architectural place. (Dhouib M., 2004)

The Globing solid is characterized by a plastic form and constructive structure while the habitable space is defined by custom, practicality, comfort and a lot of atmosphere having. Been given a real fact, a house, for example, is made up of different rooms defined by walls forming **the structural interfaces.** The interaction between the globing solid and the habitable space in each place of each room form the **functional interfaces.**

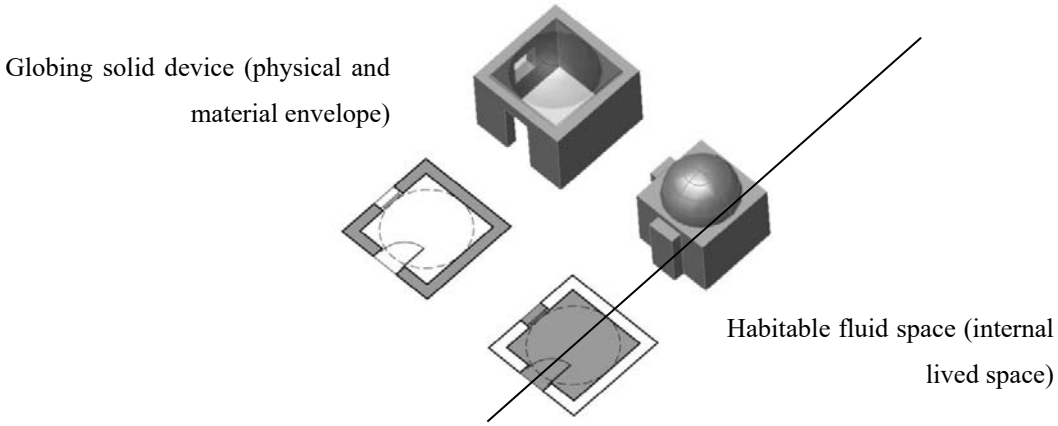


Fig.8: The structural and functional interfaces are the separative envelope between the two constitute of the architectural place. (Dhouib M., 2004)

The systemic assumption

By combining the dialogic assumption and the holographic one, we propose a structural decomposition of the architectural system. By superimposing a two-way table, structural interfaces (on the columns) and functional interfaces (on the lines), we obtain **a structural matrix.** This is a model or a general architectural that systematize the common properties to all individual's architectural systems.

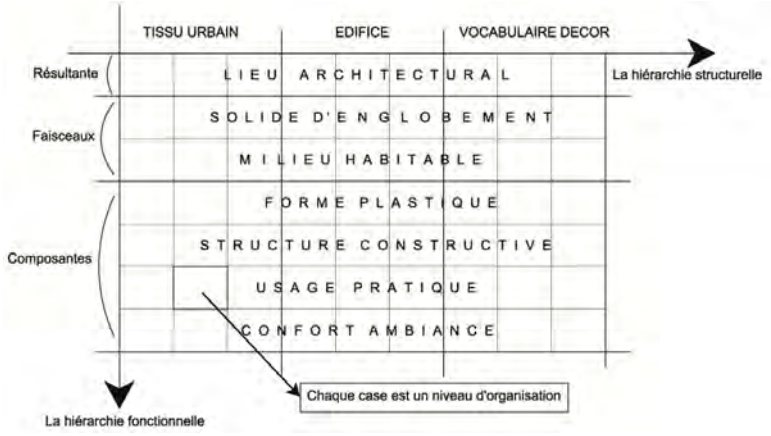


Fig. 9 : Structural Matrix. (Dhouib M., 2004)

If we choose to establish a study on a group of houses, we need a **qualitative hierarchy** of this group. In fact, we need to make a taxonomy or a classification of these houses into classes, families, types and variants.

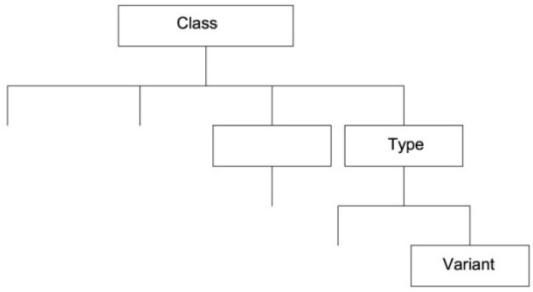


Fig.10 : Qualitative hierarchy. (Dhouib M., 2004)

The study of the genesis of these houses and their evolution at different time scales [long time (phylogeny), short period (ontogeny)] is a genetic hierarchy. By superimposing a double- entry table **the**

qualitative hierarchy and **genetic hierarchy,** we obtain a **generative matrix**. **The matrix of organization** combines both the structural matrix and the generator matrix at the same time.

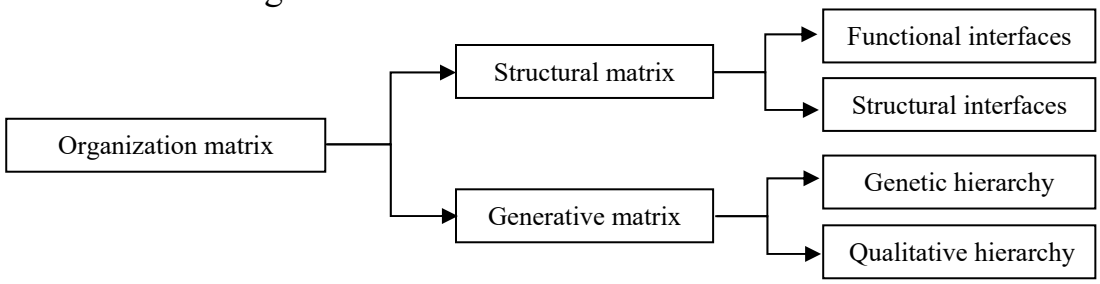


Fig. 11: Organization matrix (Model of DHOUIB M.).

Typo morphology of Roman Imperial Baths

Roman Imperial Baths

The Roman Imperial Baths are monumental institutions that differ from small to medium baths in their size and in their symmetrical circuit. They are intended not only to include all kinds of baths but also to cultivate the mind and he body. It also includes reading rooms, libraries, gardens, porches, palestra and racetracks for physical exercises.

This type of spa is subject to certain key parameters which are:

- The plan must be perfectly symmetrical and obeys an axiality.
- The connection between the frigidarium and caladium must be established through a tepidarium output.
- The plan presents a duplication of the program on both sides of the axis of symmetry formed by the natatio-frigidarium-tepidarium-caldarium. This axis is called the fire and water axis.

Uses, practices and names of places

The baths program is defined according to their size. Spaces making up the baths are classified according to their characteristics, spaces belonging to the warm sector or spaces belonging to the cold sector. The existence of additional spaces is related to the marking of the magistracy of the emperor or a geographical and chronological context.

Cold sector

Entrance hall: It is the piece of access to baths.
Hall of distribution: It is a room used as a gateway to access other parts. Their number depends on the size of the baths.
Apodyterium: It's a room where we get undressed and where we keep the clothes during the bath time. This area includes niches and wooden lockers for storing clothes.
Frigidarium: This is the last piece of the thermal bath. It lies on the axis of fire and water, the center of the bath building. It contains pools of cold water. This is the highest and the most prestigious part of the spas.
Natatio: It is an outdoor swimming pool. It is usually found in major spas in communication with the frigidarium.
Palestra: It is an open space reserved for sporting activities and it is surrounded by a covered walkway marked by some columns on its three or four sides.
Gymnasium: It is a covered space for practising sports. It is used in case of unfavorable weather.
Exedra: It is a space for rest and chatting.
Annexes: It is a storage of sports equipments.
Library: Schedule is a space that is not integrated into the building resort. Its presence is related to the huge size of these monuments to mark the magistracy of the emperor. The baths in our collection do not have a library.

Fig.15: Restitution of the apodyterium -Baths of Caracalla in Rome. (www.pagesperso-orange.fr/ thermes romains)

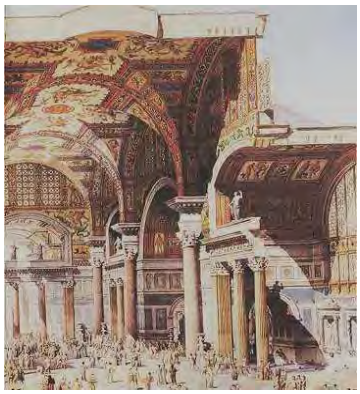


Fig.16: Restitution of the frigidarium- Baths of Diocletien. (www.maquettes-historiques.net)

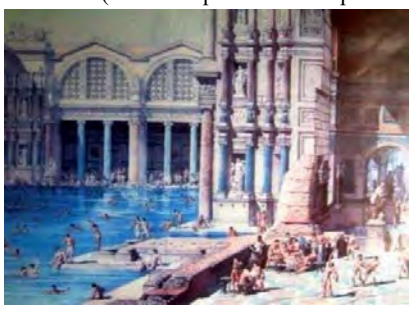


Fig.17: Restitution of the natatio – Baths of Diocletien. (www.maquettes-historiques.net)

Warm sector

Tepidarium: The main function of tepedarium is to ensure a transition. The bather stops at this space to lie in it to get used to the heat and to unclothe for the most cautious and to simply cross for the most robust[2] .There are two types of tepidarium:

Fig.12: Tepidarium input -Baths of Caracalla in Rome. (www.pagesperso-orange.fr/ thermesromains)

Tepidarium input: Also known as *"unctorium."* It is a room used only to get into the heating circuit. It is a room where the bather rubs oil and perfume several times depending on the circuit monitor. It is not equipped with pool.

Tepidarium output: It is a room used only for the exit of warm spaces. It is equipped with two *alvei* [3]offering the possibility of immersion in warm water before going to frigidarium.

Fig.13 : Laconicum des bains de Pompei. (www.mediterranees.net)

Destrictarium: It is a space where the bather gets rid of the mixture of dust and oil that covers the skin after the exercises. It appears in hot water drawn from a basin and low in ponds using footbaths.

Sudatorium / Laconicum: It is a dry oven at very high temperatures.

Caldarium: It's the hottest room. It is the main piece for the bath, but, the high humidity that reigns there can permit to take a steam bath. It is equipped with bathtubs, the largest of which is called

Fig.14 : Caldarium des thermes de forum.Source :www.dfj.vd.ch/gybur/branches/ latin/pompei/thermes_forum.htm

[2] THEBERT, Y. (2003), « *Les thermes romains de l'Afrique du Nord et leur contexte méditerranéen, études d'histoire et d'archéologie* », Library of French School of Athens and Rome.

[3] Hot tub

"solium" and the smallest is called *"labrum"*.

Praefurnium: It is a service area inaccessible to bathers. It is directly linked to the spaces of the warm sector and is used to power the kilns.

Warm swimming pool: It is an indoor warm pool.

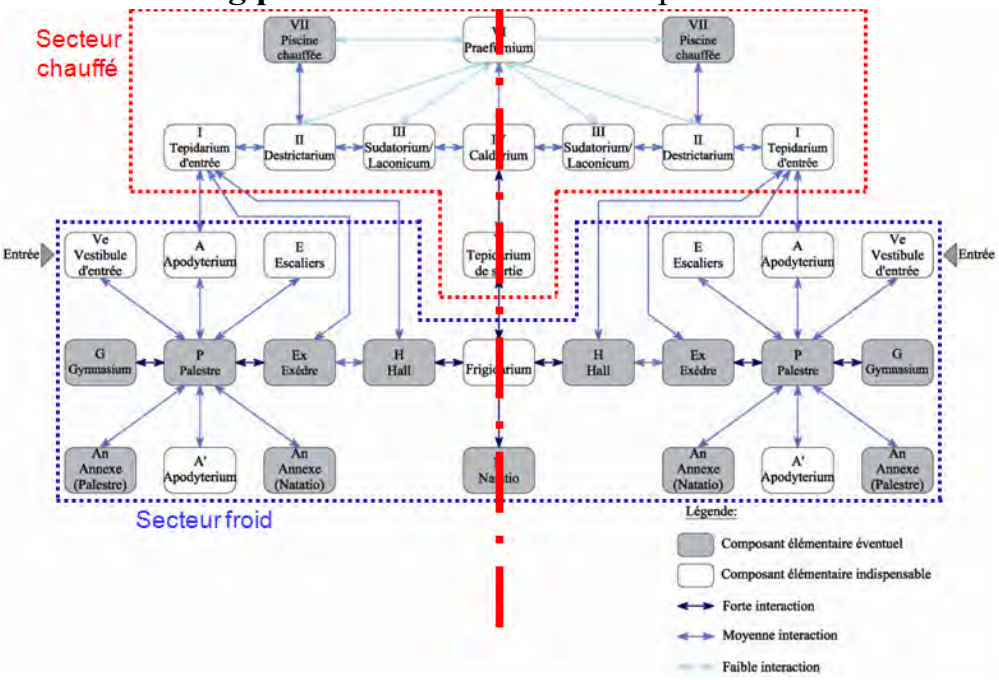


Fig.18: Organizational chart of the Imperial Baths showing the axis of fire and water. (Bouaita K., 2008)

Qualification of Roman Imperial Baths in Tunisia

Presentation of the collection of baths

We analyzed a collection of 11 Roman Imperial Baths in Tunisia and succeeded in establishing geometrical and physical qualifications of this type of building. This qualification has enabled us to define our cognitive generative model.

	Roman Baths	Dating	Area	Situation
T 1	El Khnissia	Unknown	1600	Sousse
T 2	Great Baths of Antonin	145 (or rather 157) -161	18000	Carthage

T 3	Mactaris: Great Baths of the East	199	4500	Maktar
T 4	Sicca Veneria: Great Baths	Unknown	Unknown	El Kef
T 5	Telepte: Great Baths	Unknown	> 3000 > 3000	Kasserine
T 6	Thugga: Baths of Ain Doura	End II sc. early III sc.	> 3300	Dougga
T 7	Thugga: Baths of Caracalla	211-217	1700	Dougga
T 8	Uthina: Great Baths	First half of the second sc.	> 3200	Oudna
T 9	Uthica: Great Baths	Unknown	5990	Utica
T 10	Bulla Regia: Great Southern Baths	Unknown	3300	Bulla Regia
T 11	Membressa	Unknown	> 1350	Beb El Mejez

Table 1: Roman Imperial Baths in Tunisia. (Thebert Y., 2003 and Bouaita K., 2008)

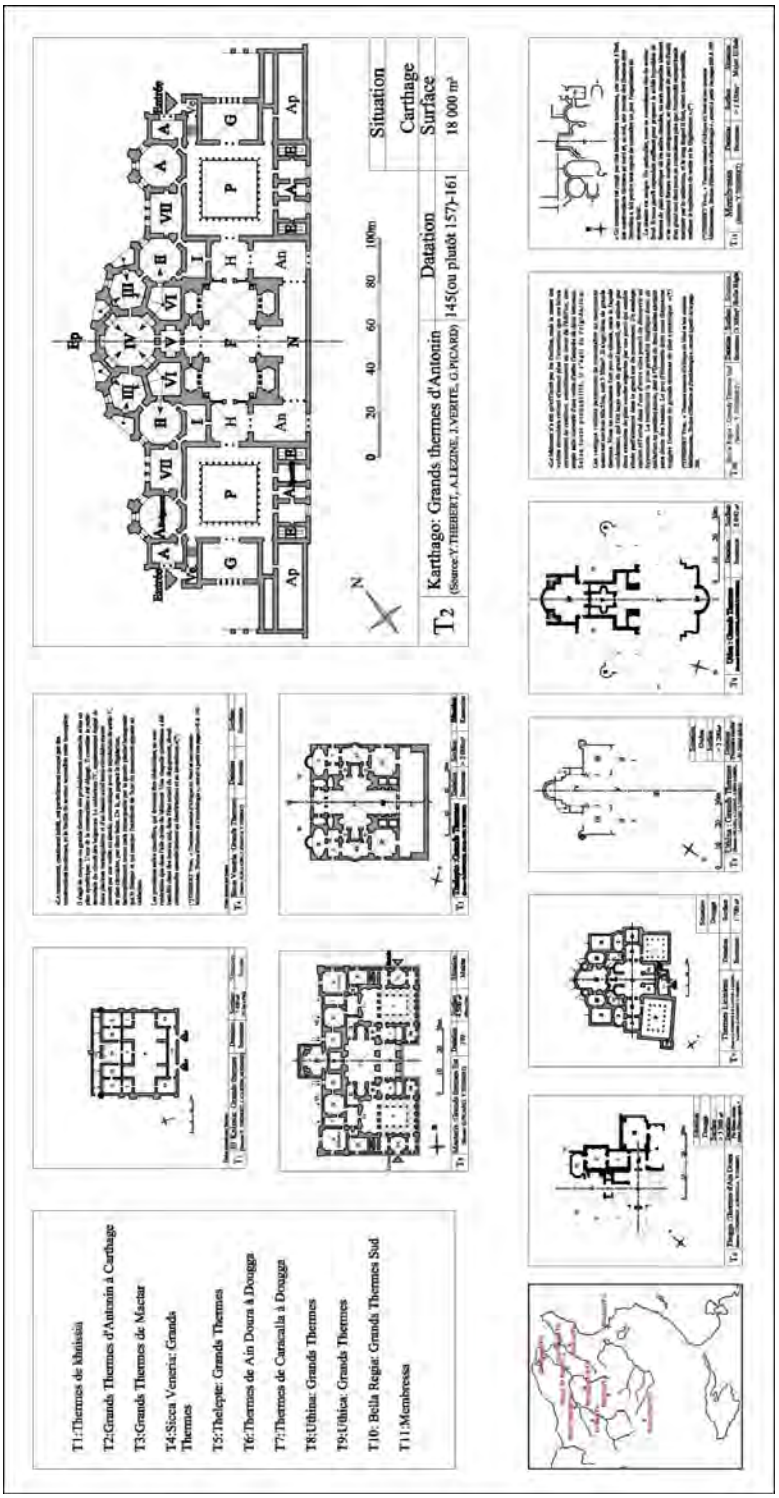


Fig.19: Roman Imperial Baths in Tunisia. (Bouaita K., 2008)

Analysis of the baths collection

Classification criteria

Thebert Y. classified the baths according to the typology into three categories and he mentioned that this classification has certainly an arbitrary part and can be refined by the analysis.

Small	Area is less than 1000m ².
Medium	Area is greater than 1000m ² and less than 3000m ².
Great	Area is greater than 3000m ².

Table 2: Classification of the baths according to their area. (Thebert Y., 2003 and Bouaita K., 2008)

An exam of medium and geat Roman Imperial Baths of Tunisia allows us to re-identify these buildings while respecting the classification of Thebert Y.:

Medium	Area is greater than 1000m ² and less than 3000m ².		
Great	Area is greater than 3000m ².		
	Area is greater than 3000m ² and less than 4000m ².	Area is greater than 4000m ² and less than 6000m ².	Area is greater than 6000m ².

Table 3: Classification of the baths according to their area. (Lichiheb H., 2011)

By opting for this new classification criterion, we identify the Baths of Tunisia as follows:

Baths whose surface is less than 3000m ²

T1: El Knissia in Sousse with an area of 1600m ².

T7: Thugga: Baths of Caracalla in Dougga with an area of 1700m ².

T11: Membrassa in Bab El Mejez with an area of more than 1350m ².

Baths whose surface is greater than 3000m ² and less than 4000m ²

T5: Telepte: Great baths in Kasserine with an area greater than 3000m ².

T6: Thugga: Baths of Ain Doura in Dougga with an area greater than 3300m.

T8: Uthina: Great baths in Oudna with an area greater than 3200m ².

T10: Bulla Regia: Great Southern Baths with an area of 3000m ².

Baths whose surface is greater than 4000m ² and less than 6000m ²:

T3: Mactaris: Great Baths of the East in Mactar with an area of 4500m ².

T9: Utica: Great Baths in Utica with an area of 5990m ².

Baths whose surface is greater than 6000m ²

T2: Karthago: Great Antonine Baths in Carthage with an area of 18000 m².

We will not study the great Baths in El Kef (T4) and the Baths of Membrassa in Mejez El Bab (T11) because we haven't sufficient information for their study.

Frequency spaces

We notice in this table whether there are basic components of the places in the baths after the previous refined typology.

		Baths whose surface is> 1000 m² and <3000m ²		**Baths whose surface is> 4000 m² and <6000m ²**		**Baths whose surface is > 6000m ²**
	The baths Components	T1	T7	T3	T9	T2
	I: input Tepidarium	X	X	X	X	X
	II:Destrictarium	X	X	X	X	X
	III: sudatorium / Laconicum	X	X	X	X	X
	IV: Caldarium	X	X	X	X	X
	V: Tepidarium output	X	X	X	X	X
	VI: Praefurnium	X	X	X	X	X
	VII: Warm pool					X
	Ve: Entrance hall	X	X	X		X
	A: Apodyterium (swimmers)	X	X	X		X

A: Apodyterium (sports)			X		X
F: Frigidarium	X	X	X	X	X
P: Palaestra		X	X	X	X
G: Gymnasium					X
N: Natatio			X	X	X
Ex: Exedra		X	X		
H: Hall of Distribution		X	X		X
E: Stairs	X	X	X	X	X
Ap: Annex (palestra)		X	X		X
An: Annex (natatio)					X

Table 3: frequency Spaces. (Lichiheb H., 2011)

The program of the baths, whose surface is less than 3000m ²:

-Warm sector: I: Tepidarium input, II: Destrictarium, III: sudatorium / Laconicum, IV: Caldarium, V: Tepidarium output, VI: praefurnium.

-Cold sector: Ve: Entrance hall, A: Apodyterium, F: Frigidarium, P: Palestra, Ex: Exedra, H: distribution Hall, E: Stairs, Ap: Annex (palestra).

The program of the baths, whose surface is greater than 4000m ² and less than 6000m ²:

-Warm sector: I: Tepidarium input, II: Destrictarium, III: sudatorium / Laconicum, IV: Caldarium, V: Tepidarium output, VI: praefurnium.

-Cold sector: Ve: Entrance hall, A: Apodyterium, F: Frigidarium, P: Palestra, Ex: Exedra, H: distribution Hall, E: Stairs, Ap: Annex (palestra).

The program of the baths, whose surface is greater than 6000 m²:

-Warm sector: I: Tepidarium input, II: Destrictarium, III: sudatorium / Laconicum, IV: Caldarium, V: Tepidarium output, VI: praefurnium.

-Cold sector: Ve: Entrance hall, A: Apodyterium, F: Frigidarium, P: Palestra, G: Gymnasium, H: distribution Hall, E: Stairs, Ap: Annex (palestra), An: Annex (natatio).

This analysis allowed us to draw a first set of remarks:

-The gymnasium is used in very great baths as a space that replaces the palestra in bad weathers for practising sports in the open space.
- Baths have a gymnasium or an exedra, not both, in the same building. This allows us to state the following hypothesis: the Exedra in the small spas is replaced by the gymnasium in great baths.
- The distribution space is multiplying with the increase in the area of the baths.

Warm / cold sector proportions

	Warm area compared to the total area	Cold sector compared to the total area	Useful area of the warm sector compared to Total of Useful area	Useful area of the cold sector compared to Total of Useful area
Baths whose surface is less than < 3000m ²	39.74%	60.25%	38.43%	61.56%
Baths whose surface is <6000 m² and> 4000m ²	37.90%	62.09%	31.44%	68.61%
Baths with a surface area greater than 6000m ²	28.85%	71.14%	22.10%	77.90%

Table 5: Warm / cold sector proportions. (Lichiheb H., 2011)

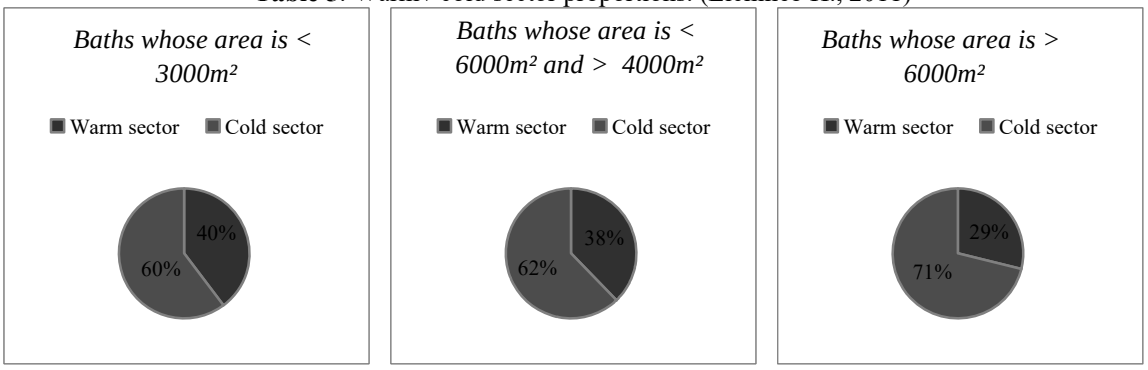


Fig.20: Warm / cold sector proportions. (Lichiheb H., 2011)

The proportion of cold sector increases with the increase of the area against the proportion of warm sector. This is due to a change of program in cold sectors by adding new spaces and the warm sector retains its essential basic components. The proportions change from 2/5 to 1/5 for the heated area and 3/5 to 4/5 for the cold sector.

Proportions of areas of the components within the warm sector

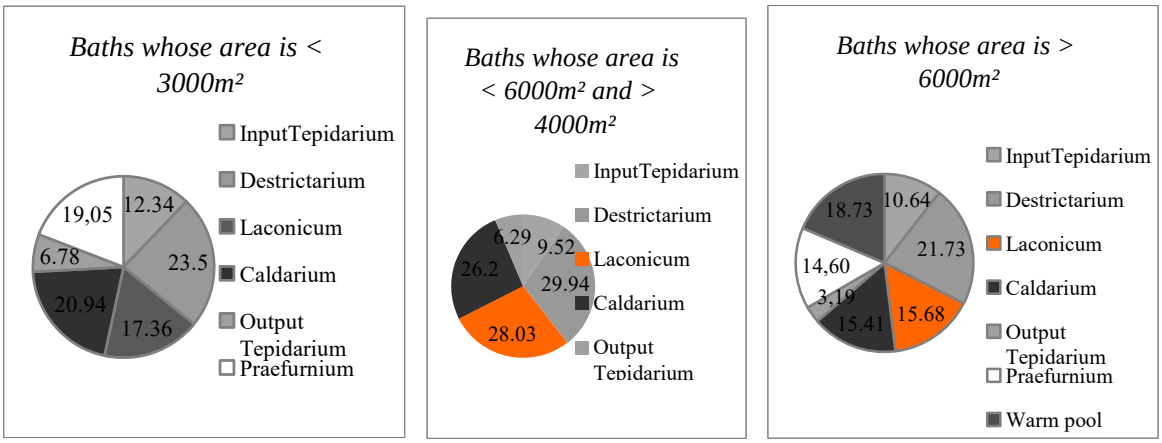


Fig.21: Proportions of areas of the components within the warm sector. (Lichiheb H., 2011)

From this analysis and by classifying the basic components of the warm sector according to their size in a descending order, we obtain:
- The destrictarium with an area that exceeds the 1/5.
-The caldarium, the laconicum and praefurnium with areas that do not exceed generally 1/5 for each.
-The tepidarium input with an area that does not exceed the 1/10.
-The output tepidarium with an area less than 1/10.

Proportions of the components within the cold sector

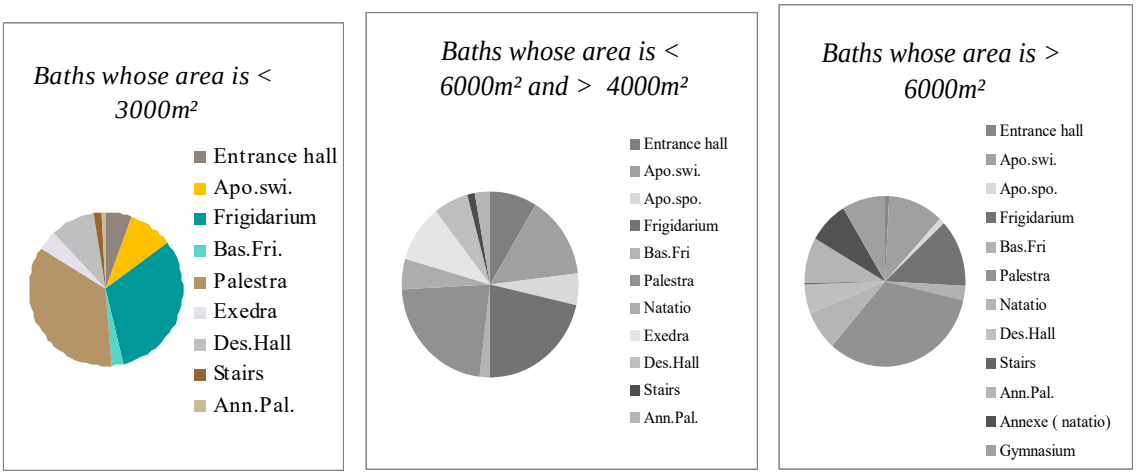


Fig.22: Proportions of the components within the cold sector. (Lichiheb H., 2011)

From this analysis, we notice that the most important areas according are: the frigidarium, the palestra and the apodyterium. The last two spaces kept the same proportion (about 3/10 of the useful area for the palestra and about 1/10 of the useful area of the cold sector for apodyterium) irrespective of the size of the baths. Consequently, the proportion of frigidarium decreases with the increase in total area.

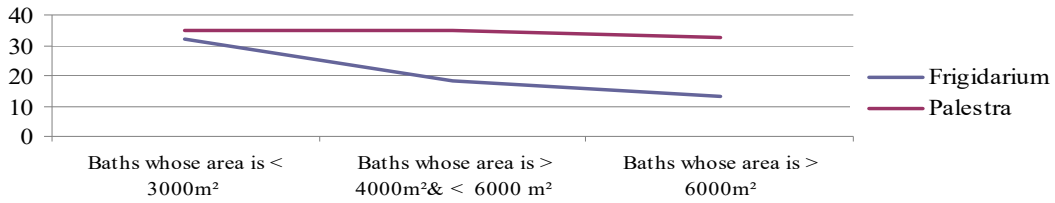


Fig.23: Proportions of the frigidarium and palestra within the cold sector. (Lichiheb H., 2011)

Form and length / width ratio of the entities

- Baths' Form:

We study in this part, the relation between length and width of the form in which to view the baths.

	Baths whose area is < 3000m²	Baths whose area is < 6000 m² and > 4000m²	Baths area is > 6000m²
Length (m)	43,87	71,21	266,5
Width (m)	41,13	48.08	100,34
Length / width ratio	1,06	1,52	2,65

Tab.6: Form of baths. (Lichiheb H., 2011)

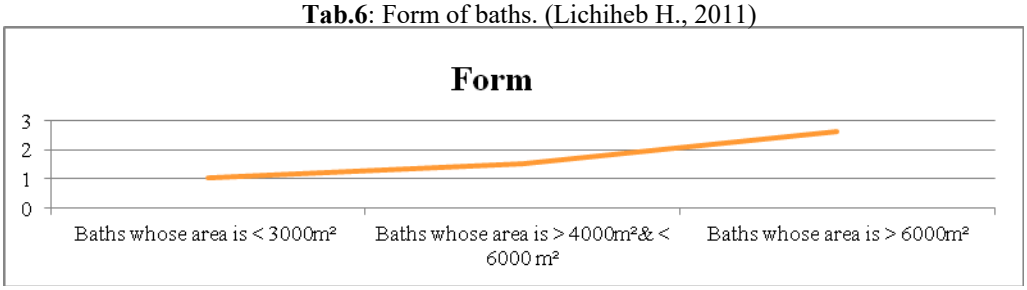


Fig.24: Length / width ratio. (Lichiheb H., 2011)

Through this analysis, we notice that if the area of baths increases, plans will be stretched in length.

Lezine A. mentioned that the plans of the baths that have a linear arrangement of the warm rooms are stretched in length. This idea is the one that allows the distribution inside the most rational. But it was not always possible to take[4].The plan may be imposed by the form of the site. It's the case of the great baths in Utica where the dimensions of the site did not allow development in length.

- Length / width ratio of components:

In this section, we will prepare a study of the relation between length and width of all basic components.

[4] LEZINE, A. (1961), « *Architecture romaine d'Afrique : recherches et mises au point* », PUF.

Space	Length / width ratio	Global	Interpretations
Tepidarium input		Rectangle	- The input and output tepidarium can be centered or misaligned. - The entrance is either by length or width.
Destrictarium		Rectangle (area <6000m ²) Square (area.> 6000m ²)	-The form can be octagon, lobed form...
Laconicum	Varies from 1 to 1.5	Rectangle (area <6000m ²) Square (area> 6000m ²)	It takes different forms: rectangle fitted with two semicircles on the width, simple rectangle, square, hexagon…
		Rectangle (area <3000m ²) Square (area> 3000m ²)	-It consists of three basin -The two-input are centered.
Tepidarium output	Close to 1	Near the square	-The form in most cases is a rectangle with two basins.
Praefurnium	Close to 1	Rectangle or square close	
Entrance vestibule	Moyen de 2 Through 2	Rectangle Rectangle	
Apodyterium	1.5	Rectangle	It takes different forms and is

swimmers (s)	average		equipped with niches.
Apodyterium swimmers (b)	Close to 1	Square or almost square	
Apodyterium sportifs Apodyterium sports	1.5 average	Rectangle	
Frigidarium Frigidarium	Through 2	Rectangle	It has 2, 3 or 4 pools.
Palestre Palestra	Close to 1	Near the square	-It features a gallery on three or four sides.
Exedra	Moyen de 2 Through 2	Rectangle	
Hall of destribution	Close to 1	Square or almost square	-It provides links between 3 or 4 spaces. -The form is square.
Appendix palestra	Close to 1 (Exceeding 3)	Rectangle (sur. >6000m²) Rectangle (Sur.> 6000m²)	

Table 7: Length / width ratio of components. (Lichiheb H., 2011)

Physical Level of materiality

At this level, we study the relation between the useful area of spaces and the quantity of wall material.

	Baths whose area is <3000m ²	**Baths whose area is <6000 m and> 4000m ²**	**Baths whose area is> 6000m ²**
Useful Area	74.9%	71.02%	66.4%
Qty.of material	25.1%	28.9%	33.6%

Table 8: Proportions of the useful Area and quantity of material. (Lichiheb H., 2011)

We notice an increase in the proportion of the quantity of material and a decrease in the proportion of the useful area of around 5% each in connection with the increase of the area.

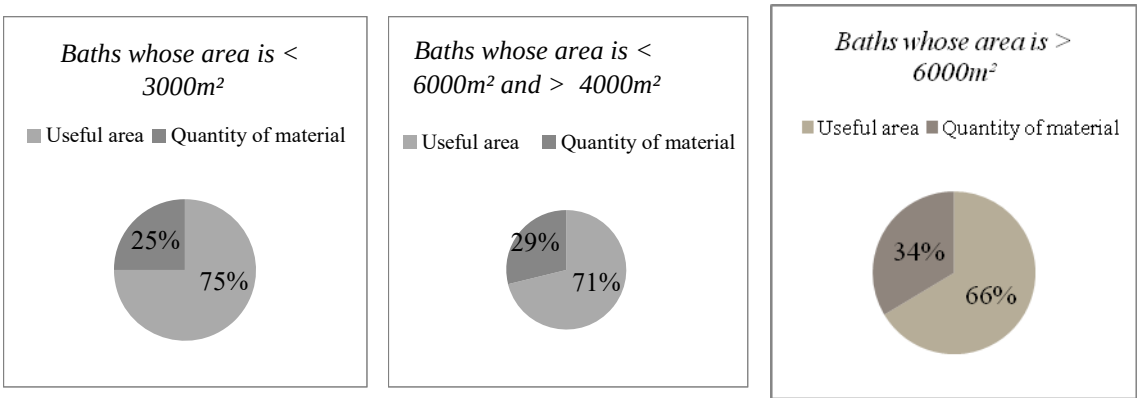


Fig.25 : Proportions of the useful Area and quantity of material. (Lichiheb H., 2011)

	Spa whose area is <3000m²	**Baths whose area is> 4000m² and <6000 m²**	**Baths whose area is> 6000m²**
Qte. of material of warm area	43.66%	54.86%	43.12%
Qte.de cold of material sector	56.34%	45.13%	56.88%
Qte.de of material of warm sector / Warm sector	27.54	41.95	50.9
Qte.de of material sector cold / cold sector	23.44	21.06	27.23

Table 9 :Proportions of the useful Area and quantity of material. (Lichiheb H., 2011)

We note that:

- The percentage of the quantity of material in warm sector and the quantity of material in the cold sector compared to the useful area of each is moderate.
- The quantity of material in the warm sector is twice of that in the cold sector for the baths whose area is greater than 6000m ². On

the other side, it is moderate between the two sectors to the baths whose area is less than 3000 m².

Orientation spaces

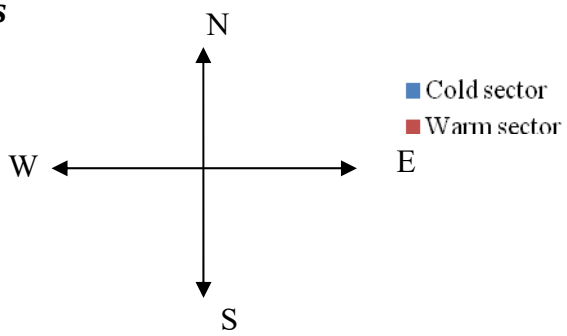


Fig.26 : Orientation spaces. (Bouaita K., 2008)

Conclusion

This analysis allowed us to identify a set of geometric and physical rules forming a generative grammar. From these rules and following the strata of the logical and mathematical reproduction, we can reconstruct the Roman baths of Caracalla and determine their analog model.

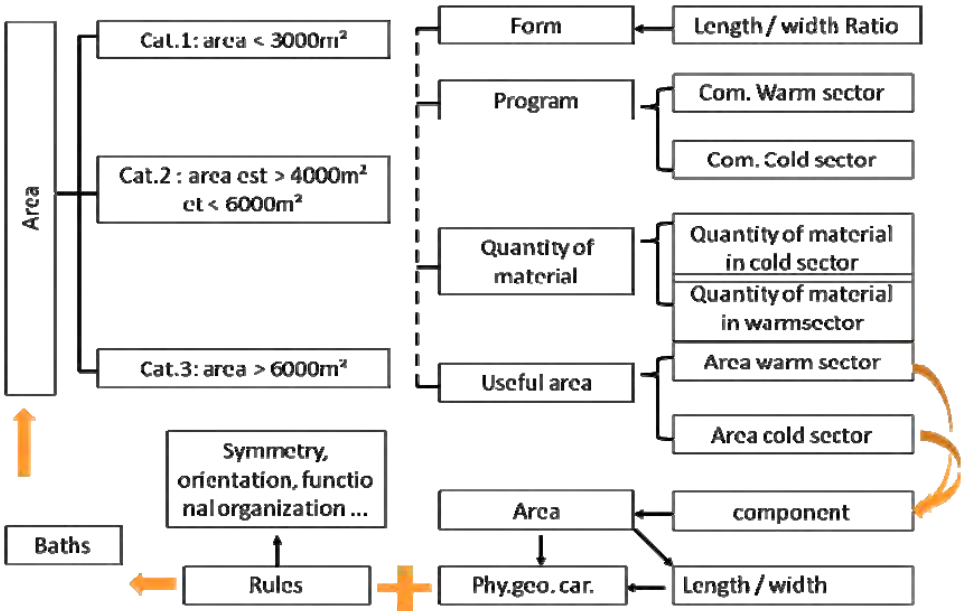


Fig. 27 : Process of architecturological reconstruction. (Lichiheb H., 2011)

Interpretation of the Roman Imperial Baths in Tunisia

Architecturological Reconstruction of the Baths of Caracalla to Dougga

Presentation of the Baths of Caracalla in Dougga

These baths have long been known Licinian baths dating from the reign of Gallienus . This designation has been challenged by recent research in particular those of Michel Christol. Christol M. proposed a dating of the reign of Caracalla (211-217) confirmed to an inscription of 375-383, the period of their restoration. They are also called Antonians Baths in a recent publication of Khanoussi M[5].

They are located in the southwest zone of the city of Dougga in a slope of 6 m elevation with an area of 1700m ². They are classified as the Imperial Baths although they do not obey the criterion of perfect symmetry.

Fig. 28 : Entrance hall.

Fig. 29: Frigidarium.

Fig. 30 : Small Palestra.

Physical and geometric model

This is an analog representation that includes the graphic elements (level plans, sections and facades). This allows us to establish a virtual model. In developing these, our analysis is based on the publications of Thebert Y. and Poinssot C.

[5] KHANOUSSI, M. (2008), « *Dougga* », Agency for development of heritage and cultural promotion, coll. Sites and monuments in Tunisia.

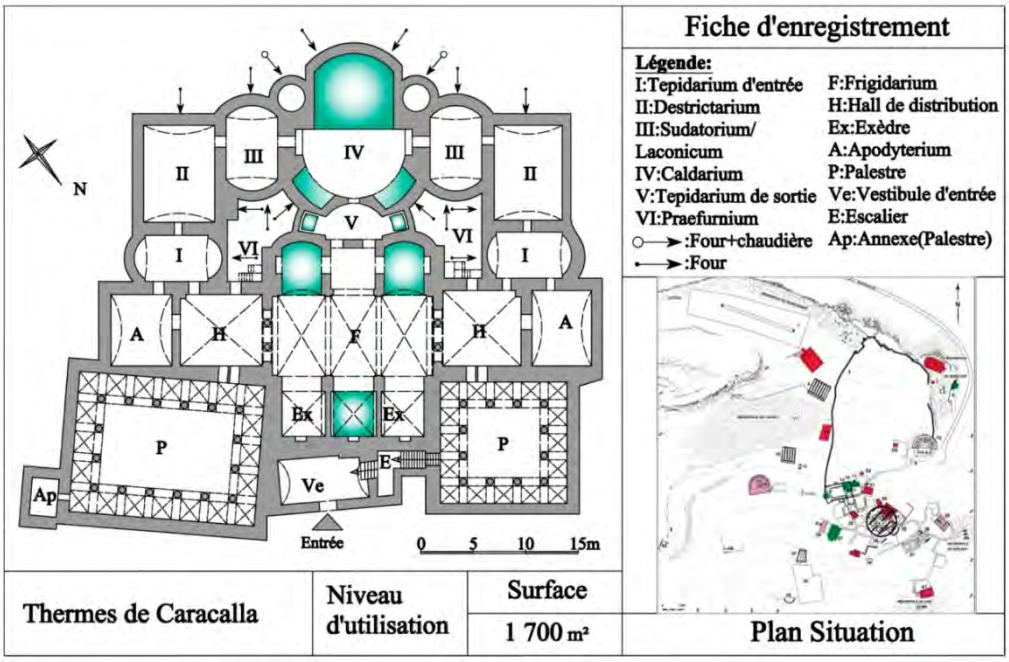


Fig. 31: useful level of the baths of caracalla. (Lichiheb H., 2011)

The heights of the elevations and the form of roofs are hypothetical. We base our analysis on the measures taken in situ and the writings of Thebert Y. while taking as a reference:

- The restitution of the Great Antonine Baths in Carthage established by Lezine A.

- The restitution of the Great Baths of the East in Maktar established by Picard G.

- The restitution of the archaeological site of Dougga established by Golvin. JC

This architectural and analog model is a hypothesis of restitution in terms of architecturological reconstruction that was possible by the tests on the baths.

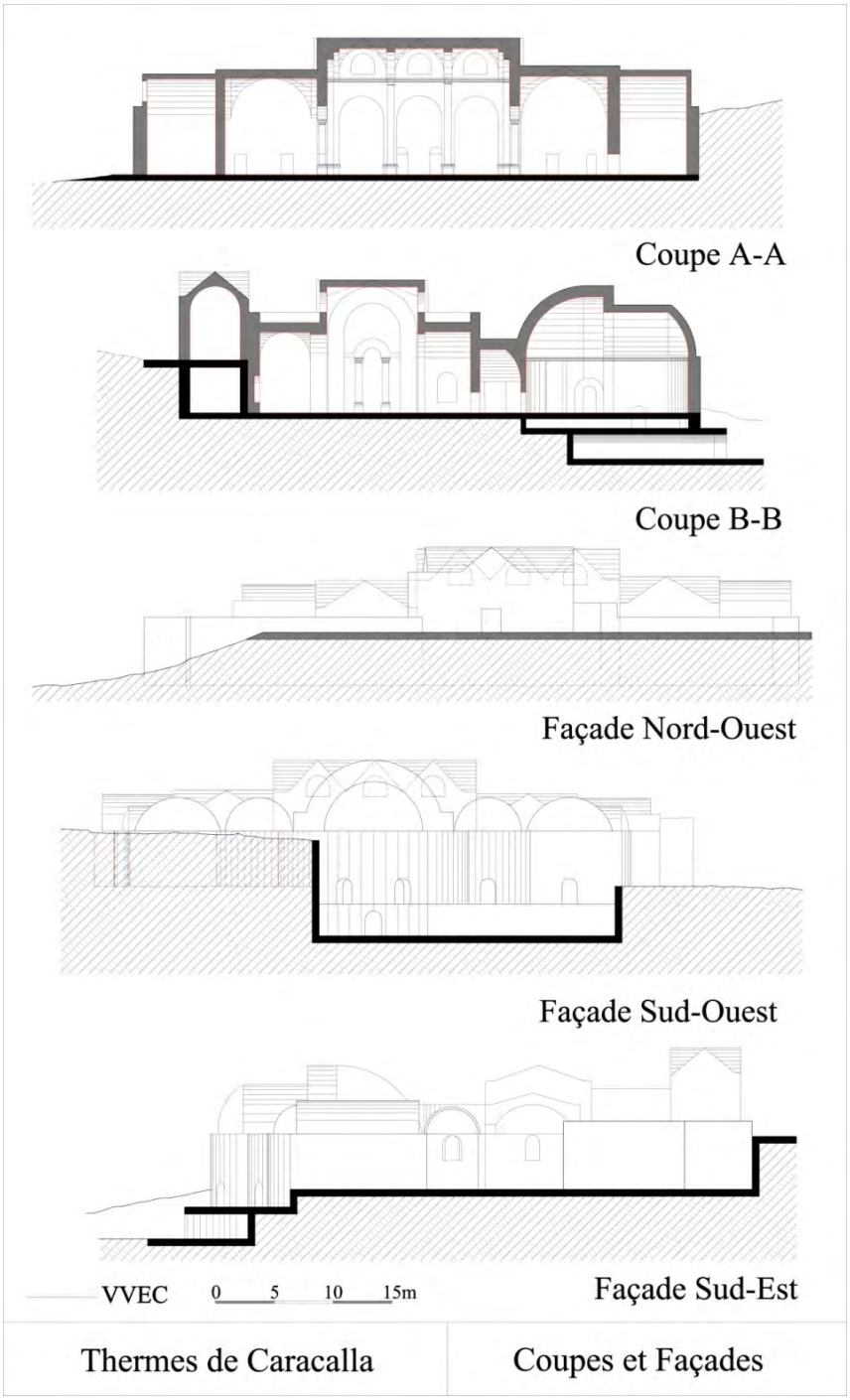


Fig. 34: Sections and facades of the baths of Caracalla. (Lichiheb H., 2011)

Virtual and Active model

The physical and geometric model allows us to establish a virtual, active and primary model that accepts changes and modifications from other studies either at the building or at the decor.

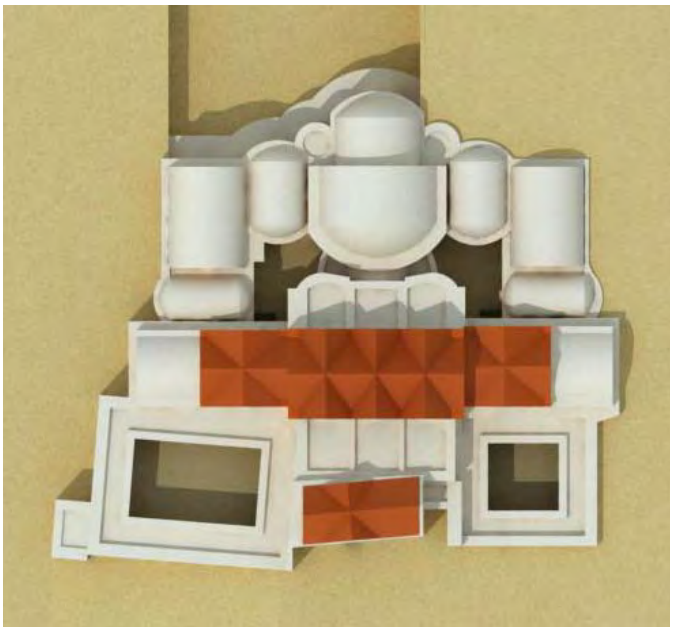


Fig. 35: Masses Plan of Baths of Caracalla in Dougga.

Fig.36 -37: Perspectives of Baths of Caracalla.

Fig. 38: Reconstruction of the palestra of baths of Caracalla.

Fig. 39: Reconstruction of the Caldarium of baths of Caracalla in Dougga.

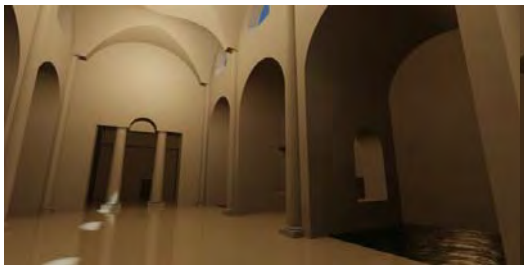


Fig. 40: Reconstruction of Frigidarium (1) of baths of Caracalla in Dougga.

Fig. 41: Reconstruction of Frigidarium (2) of baths of Caracalla in Dougga.

Fig. 42: Reconstruction of Frigidarium (3) of baths of Caracalla in Dougga.

Fig. 43: Reconstruction of Frigidarium (4) of baths of Caracalla in Dougga.

2D & ½ Plan

2D & ½ Plan is the expression of the roofs on the plan. It presents the virtual volume in hollow on plan.

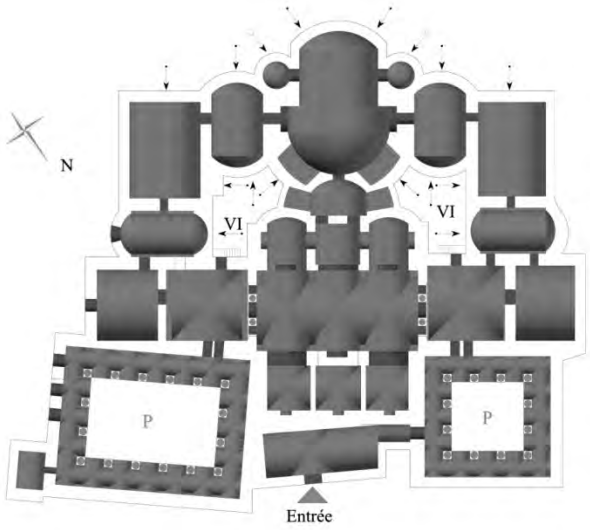


Fig. 44: 2D & ½ Plan of Baths of Caracalla. (Lichiheb H., 2011)

-The Virtual Volume In Hollow (VVIH)

The virtual volume in hollow is the structural and functional interface between Habitable Fluid Space (HFS) and Globing Solid Device (GSD).

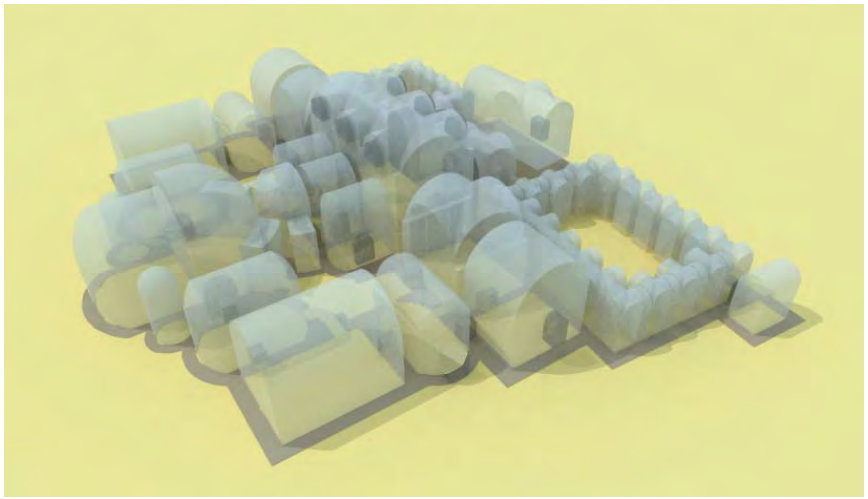


Fig. 45: The virtual volume in hollow. (Lichiheb H., 2011)

The architectural place

We assume that the virtual volume hollow (VVIH) is necessary and sufficient to determine the architectural place which is composed of habitable fluid space (HFS) and Globing solid device (GSD); inter-determined and determinants of this interface.

Fig. 46: Reconstruction of the baths of Caracalla with the VVIH. (Lichiheb H., 2011)

Conclusion

The analysis has facilitated the reconstruction of the Baths of Caracalla and the elaboration of the analog model. But we want to experiment the transformation process to test the effectiveness of the genetic model obtained. We tested transformations to the baths of Caracalla before starting the restoration of the Baths of Ain Doura.

Transformation of the Roman Imperial Baths of Caracalla in Dougga

At this level, we run the model of the organization matrix and thus we experiment the transformation process that will allow the reproduction and reconstruction of any other baths belonging to this system. We assume in this part, that the reproduction of Imperial Baths of Caracalla is possible with some changes and by following the rules of the system identity. For each thermal processing, we propose to establish an analog model with a comparative analysis controlling the effectiveness of this model.

Transformations are not arbitrary. We will change some parameters such as terrain, area, and the program as a way to test the rules obtained. The Baths of Caracalla are classified as the imperial Btahs but their plan is a partial symmetry and their area is reduced to1700m ^{2}. These two characteristics do not obey the criteria to classify them in this category baths. So the changes are intended to change either of these to confirm their membership in this category, apply the method of reconstruction Space (Dhouib M., 2004) and test results.

Transformation 1

Hypothesis A

As noted above, these baths are located on terrain that gave birth to the imperial baths with an asymmetrical plan. In this transformation, we are working on flat ground while maintaining the identity and coherence of the system and while keeping the location of the input without exceeding the limits of grip to the ground or the configuration of the existing Baths.

Reformation of the architectural model analog

Physical geometric model

By following the stages of the method of reconstruction space, we have succeeded to:

- define the physical model.
- create a perfectly symmetrical plan.
- obtain a symmetrical and continuous circuit.

This model includes terms of useful level, sections, elevations and perspective views.

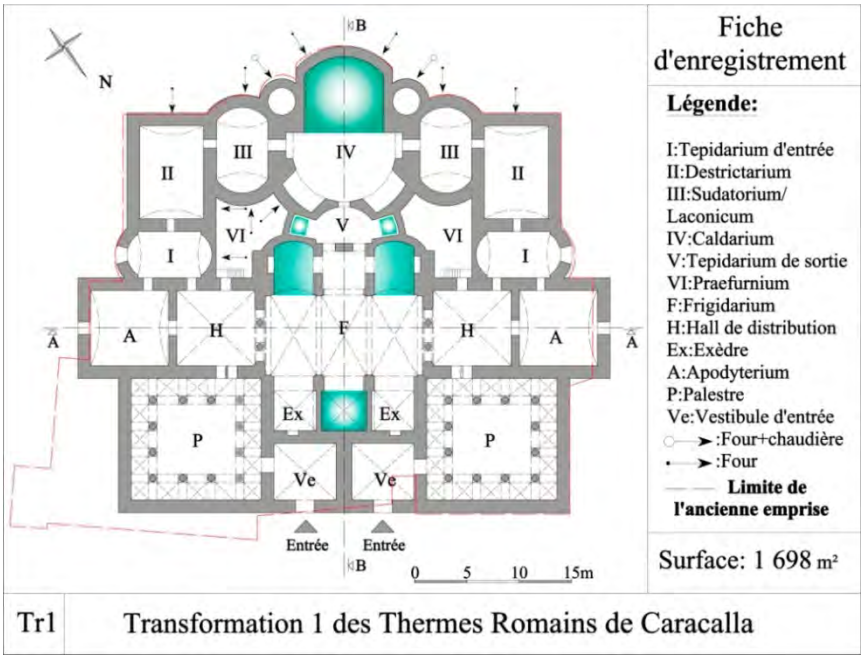


Fig. 47: Useful level of transformed baths of Caracalla Tr 1. (Lichiheb H., 2011)

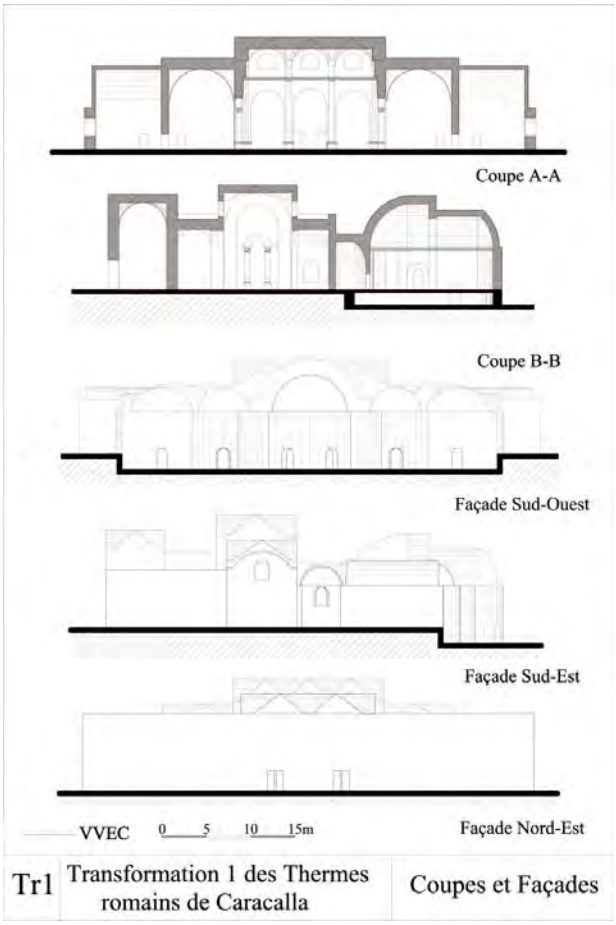


Fig. 48: Sections and facades of transformed baths of Caracalla Tr1. (Lichiheb H., 2011)

Virtual and active model

Fig. 49: Masses plan of transformed baths of Caracalla Tr1. (Lichiheb H., 2011)

Fig.50: Perspective of transformed baths of Caracalla Tr1. (Lichiheb H., 2011)

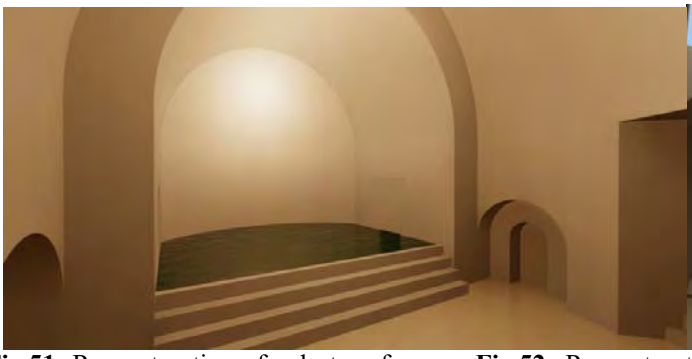


Fig.51: Reconstruction of palestra of transformed baths of Caracalla Tr1. (Lichiheb H., 2011)

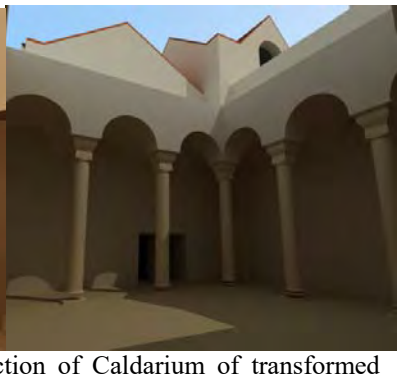


Fig.52: Reconstruction of Caldarium of transformed baths of Caracalla Tr1. (Lichiheb H., 2011)

Fig.53: Reconstruction of Frigidarium (1) of transformed baths of Caracalla Tr1. (Lichiheb H., 2011)

Fig.54: Reconstruction of Frigidarium (2) of transformed baths of Caracalla Tr1. (Lichiheb H., 2011)

2D et ½ Plan

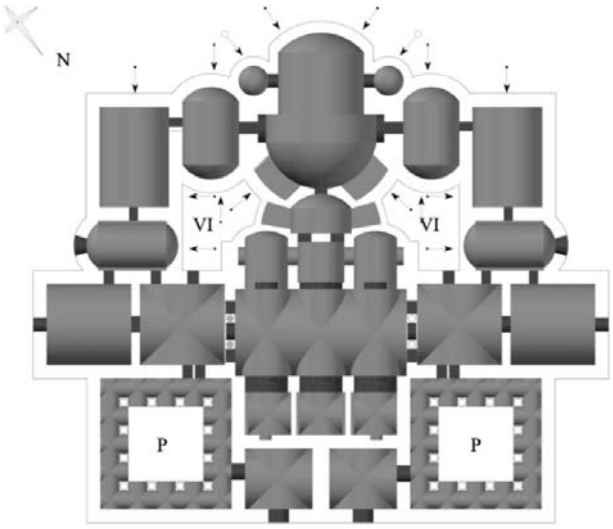


Fig.55: 2D & ½ Plan. (Lichiheb H., 2011)

Virtual volume in hollow (VVIH)

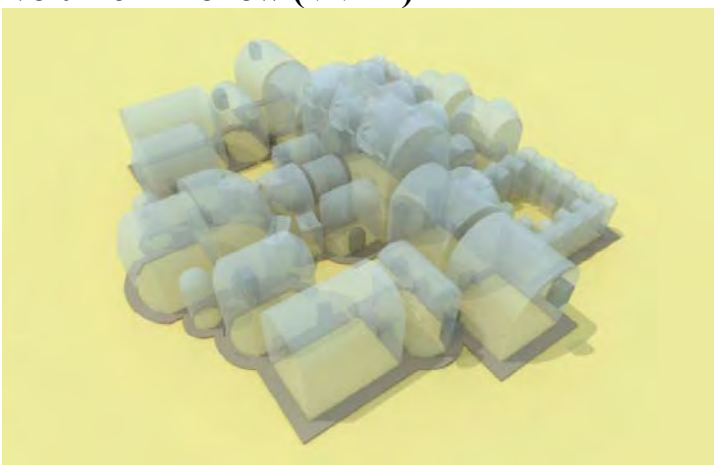


Fig.56: virtual volume in hollow. (Lichiheb H., 2011)

Architectural space

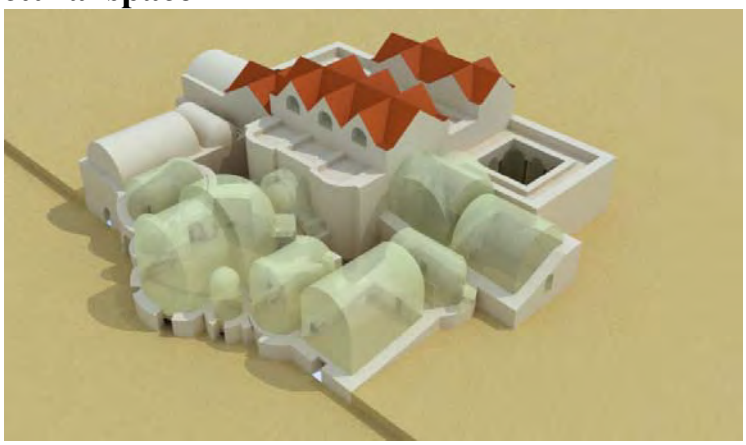


Fig.57: Reconstruction of transformed baths of Caracalla Tr1. (Lichiheb H., 2011)

Transformation 2

Hypothesis B

We work on a flat terrain while increasing and maintaining the orientation. We want to attain an area in excess of 4000m ². To do this, we add additional spaces in the program generally present in the program of this category of Baths.

These areas are:

- Natatio: strengthening the axis of fire and water and the appearance of the imperial baths by adding a cold water basin

located in the culmination of this axis. It is directly linked to the frigidarium.

- The Exedra was already present in the built baths but its location and size are not adequate to the program of imperial baths (it was designed in the frigidarium with a small area). We re-inserted into the baths with the size and location that suit them (directly related to the palestra).
- Apodyterium sports: the increase of the surface and the addition of the exedra and natatio requires a separation between the changing room for swimmers and athletes.
- Entrance vestibule split: the baths are transformed with the split entry vestibules on either side of the axis of symmetry and are designed as "the imperial model."

The surface has reached 3612m ² (excluding palestra) and 4139 m² including gymnasia. The axis of fire and water is completed, which affirms the imperial aspect with a perfect symmetry and a symmetrical and a continuous circuit.

Reformation of the architectural model analog

Physical and geometric model

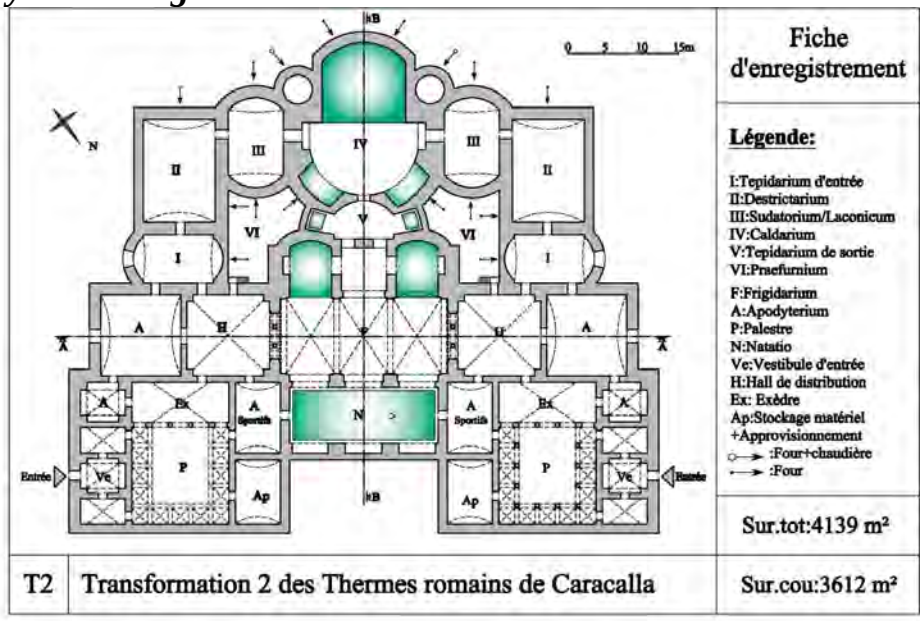


Fig.58: Useful of transformed baths of Caracalla Tr2. (Lichiheb H., 2011)

Fig.58: Useful of transformed baths of Caracalla Tr2. (Lichiheb H., 2011)

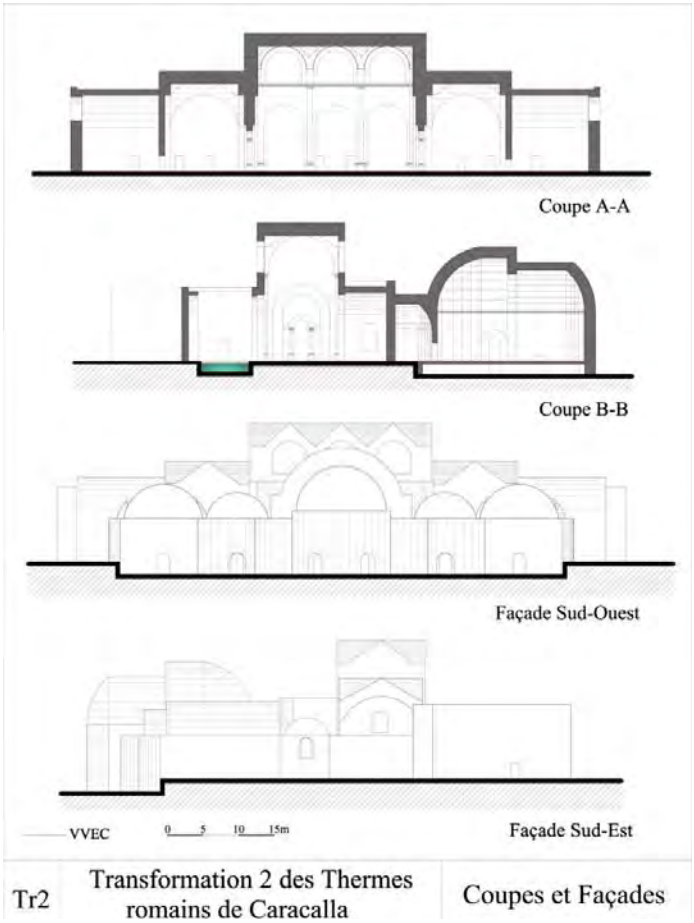


Fig.59: Sections and facades of transformed baths of CaracallaTr2. (Lichiheb H., 2011)

Virtual and active model

Fig. 60: Masses plan of transformed baths Tr2. (Lichiheb H., 2011)

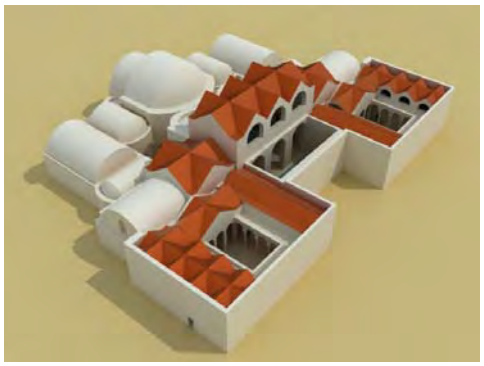


Fig.61: Perspective of transformed baths Tr2. (Lichiheb H., 2011)

Fig. 62: Reconstruction of palestra. (Lichiheb H., 2011)

Fig. 63: Reconstruction of natatio. (Lichiheb H., 2011)

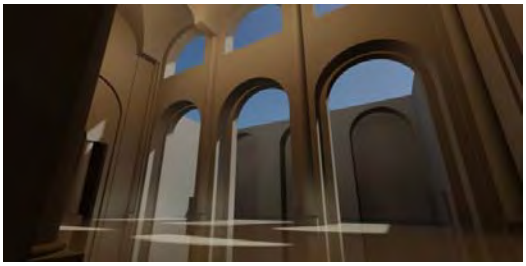


Fig.64 : Reconstruction of Frigidarium (1). (Lichiheb H., 2011)

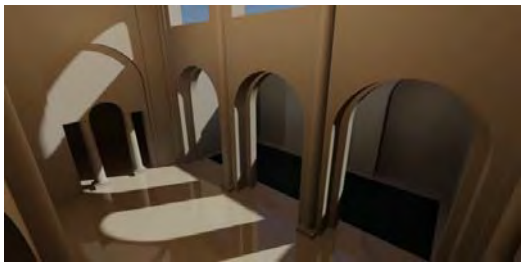


Fig. 65 : Reconstruction of Frigidarium (2). (Lichiheb H., 2011)

2D & ½ Plan

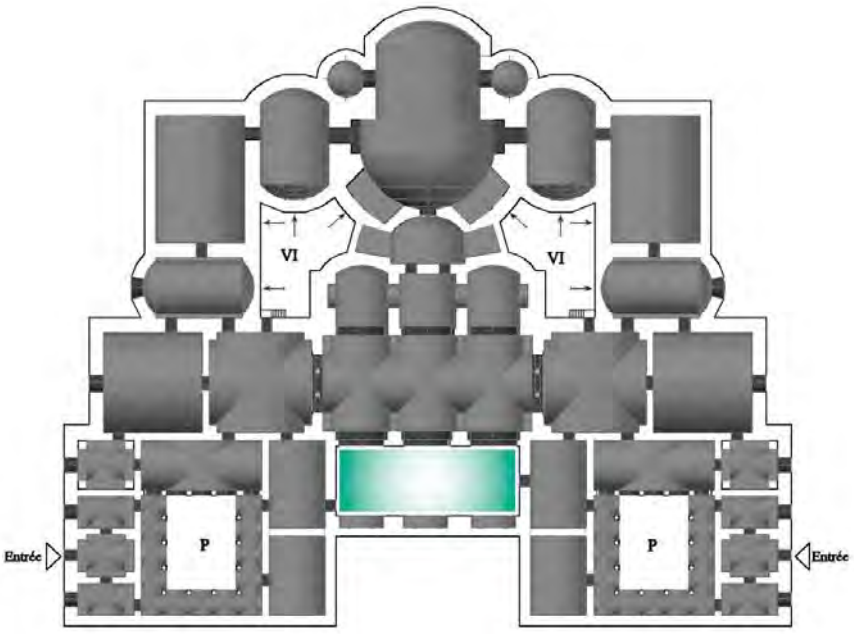


Fig.66: 2D & ½ plan (Lichiheb H., 2011)

The virtual volume in hollow (VVIH)

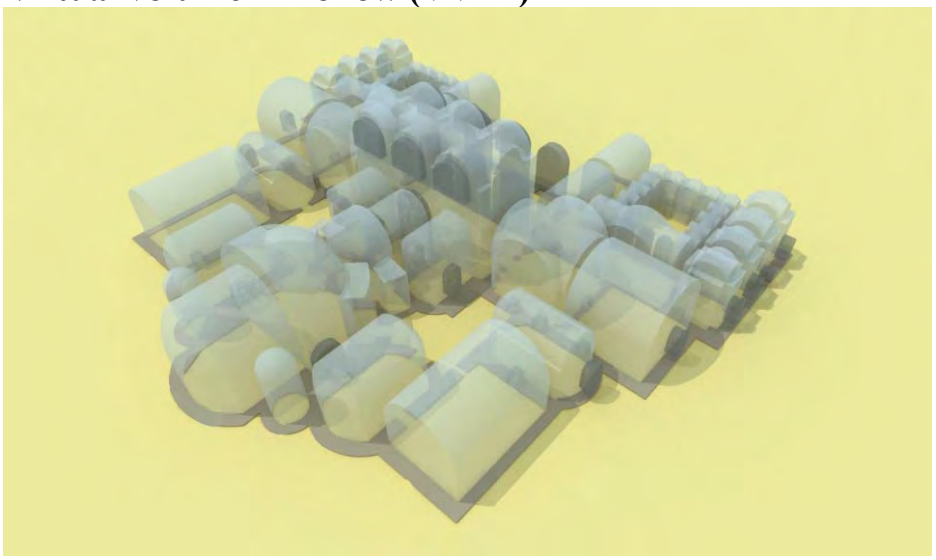


Fig.67: Virtual volume in hollow. (Lichiheb H., 2011)

The architectural space

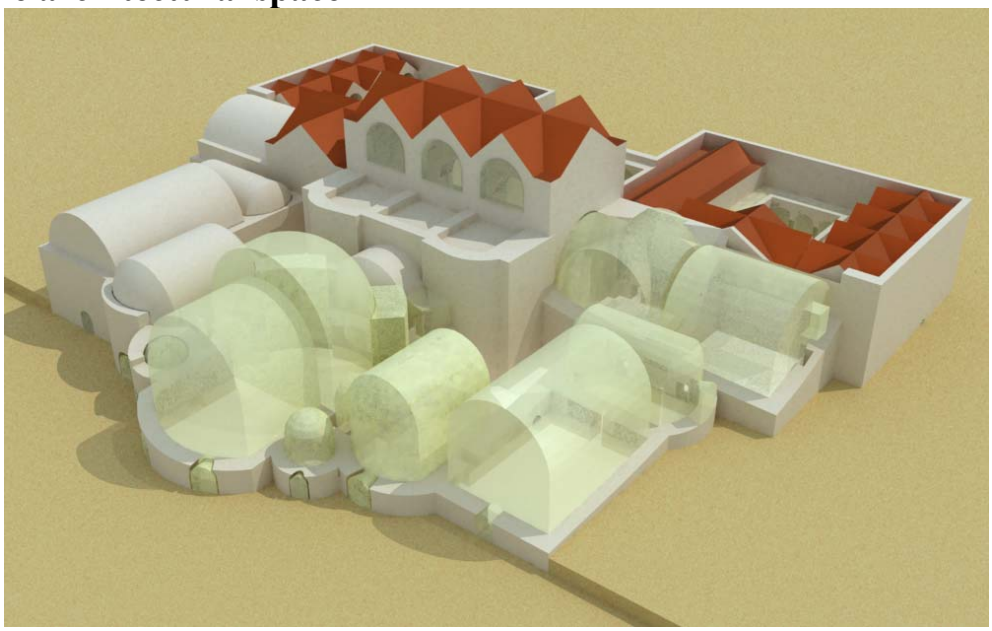


Fig. 68: Reconstruction of transformed baths Tr2 with VVIH. (Lichiheb H., 2011)

Conclusion

We have shown from transformations on the Roman Imperial Baths of Caracalla that we can interpret while not leaving their system identity. But we want to test the obtained genetic model test and its effectiveness. To do this, we tried to restore the Roman Imperial Baths in Ain Doura in Dougga.

Reformation of the Baths of Ain Doura in Dougga

In this chapter, we experiment our model. From a fragment of baths of Ain Doura in Dougga, we propose an architecturological re-conception through the implementation of the virtual cognitive and collaborative model.

Presentation of Bths of Ain Doura

These baths are located in the archaeological site of Dougga in Tunisia. They are an imperial type of baths and built on slop (elevation about 15m). Their dating went back to the period between the late second century and the early third century. Their size is greater than 3300m ².

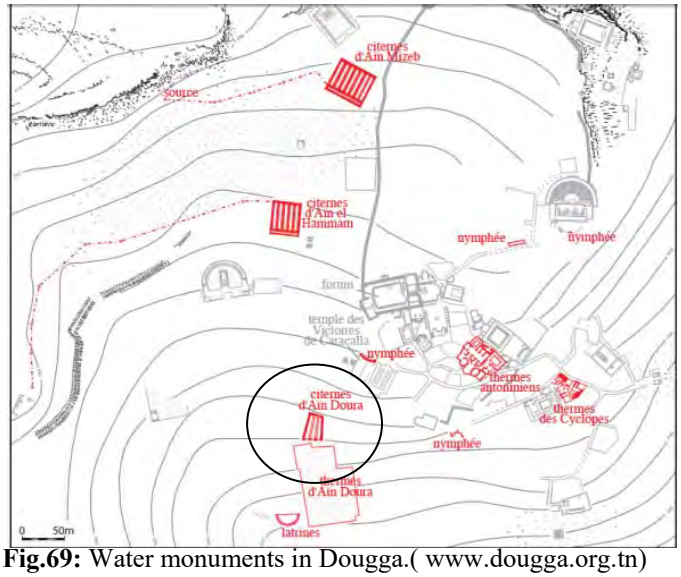


Fig.69: Water monuments in Dougga.(www.dougga.org.tn)

The name “Ain Doura” is the name of the source water that feeds them next to the baths in the high ground.

The Archaeological excavations are still incomplete. The fourth century is a phase of beautification baths recognizable by the addition of mosaics.

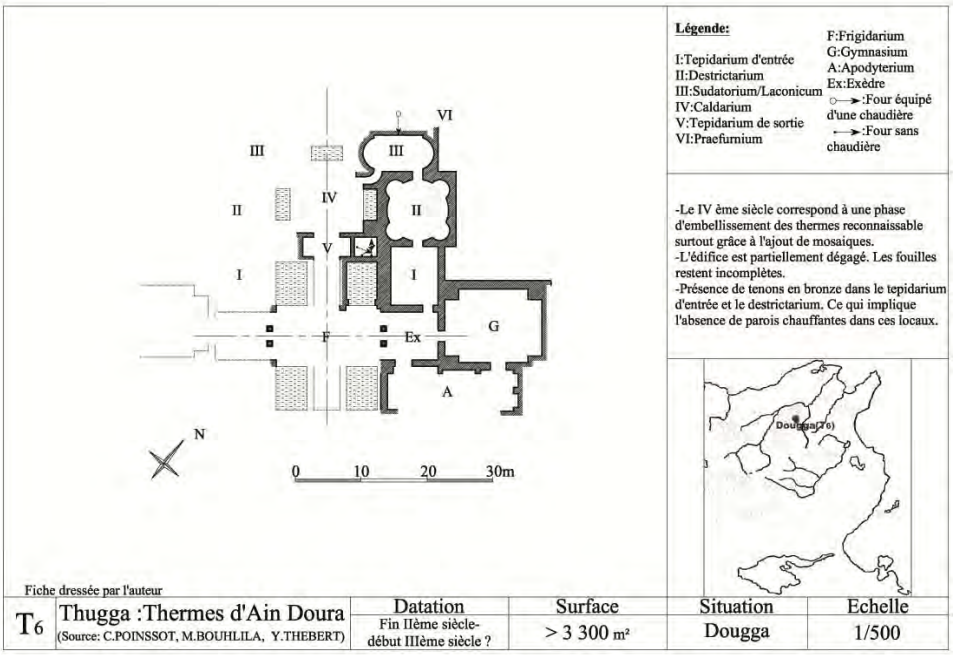


Fig.70 : Baths of Ain Dourra. (Drawing by Bouaita K., 2008)

Fig. 71: Frigidarium.

Fig. 72 : Frigidarium.

Fig. 73: Caldarium.

Physical and geometric model

By operating our expert system and experimenting the genetic model already obtained, we propose a test of architecturological reformation of the Baths of Ain Doura.

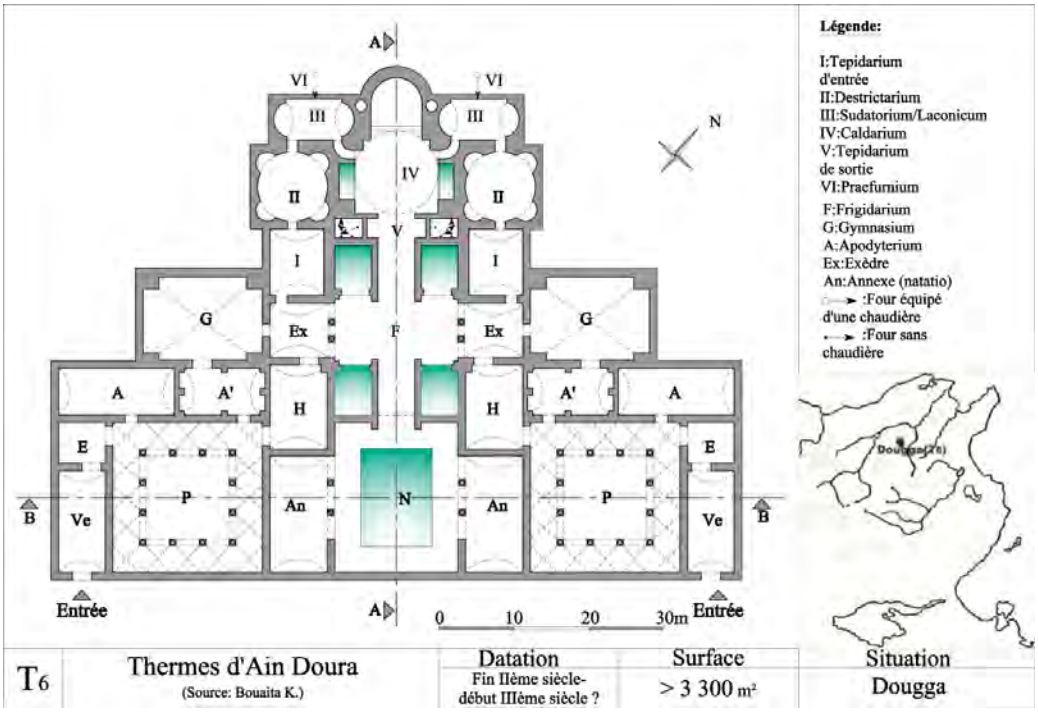
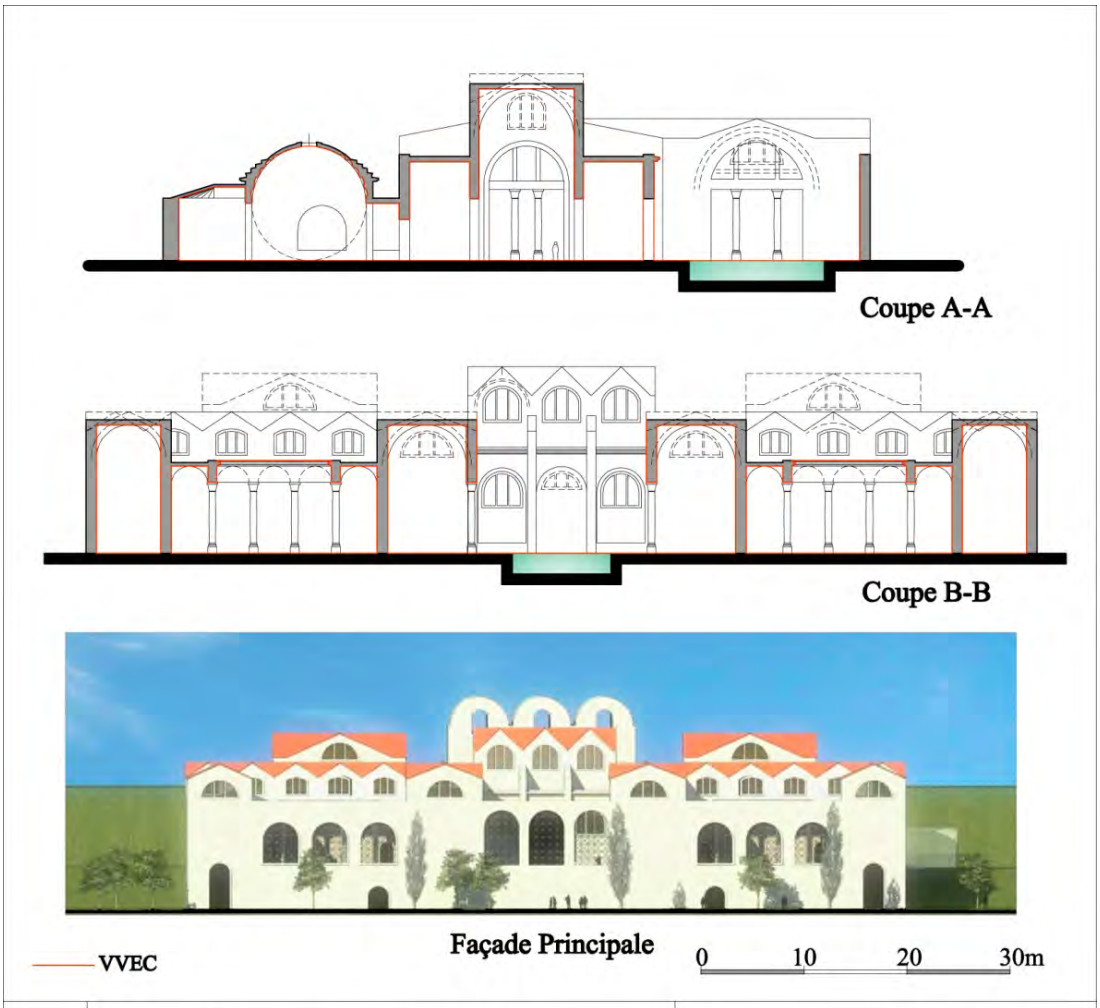


Fig. 74: Plan of Btahs of Ain Dourra in Dougga. (Bouaita K., 2011)



T6	Les Thermes romains d'Ain Doura	Coupes et Façades

Fig. 75: Section and facades of Btahs ofAin Dourra in Dougga. (Bouaita K., 2011)

Virtual and active model

Fig.**76**: Masses plan of Btahs of Ain Dourra. (Bouaita K., 2011)

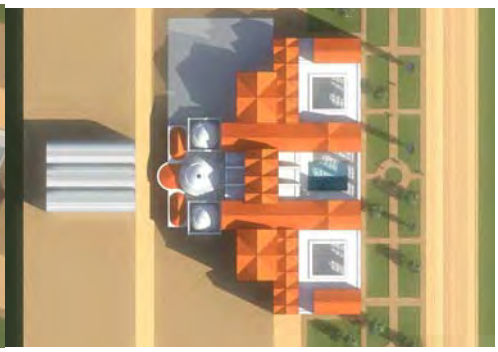


Fig.**77**: Perspective of Btahs of Ain Dourra (Bouaita K., 2011)

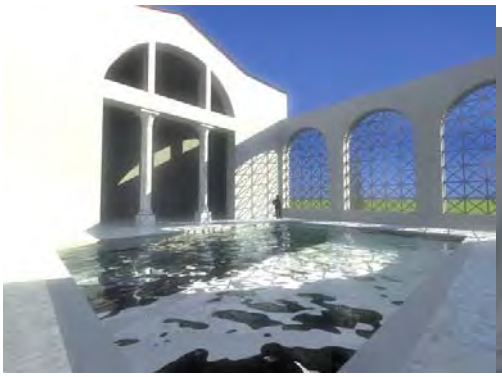


Fig.78: Restitution of palestra of baths of Ain Doura in Dougga. (Bouaita K., 2011)

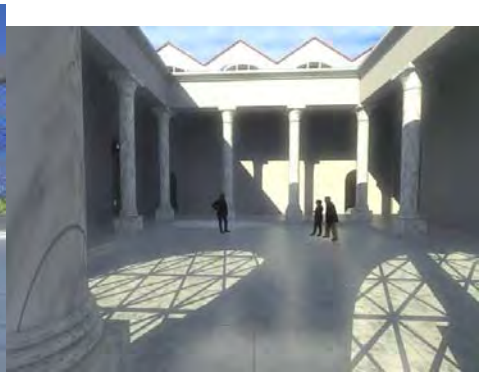


Fig.79: Restitution of the natatio of baths of Ain Doura in Dougga. (Bouaita K., 2011)

Fig.80: Restitution of Frigidarium of baths of Ain Dourra. (Bouaita K., 2011)

Fig. **81**: Restitution of Caldarium of baths of Ain Dourra. (Bouaita K., 2011)

-Plan 2D& ½

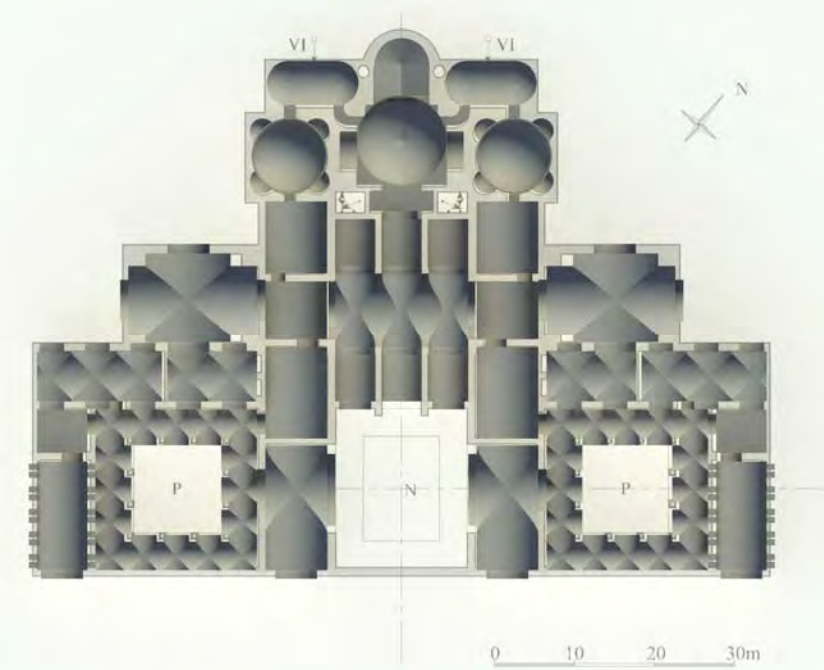


Fig. **82**: 2D & ½ Plan. (Bouaita K., 2011)

-The virtual volume in hollow (VVIH)

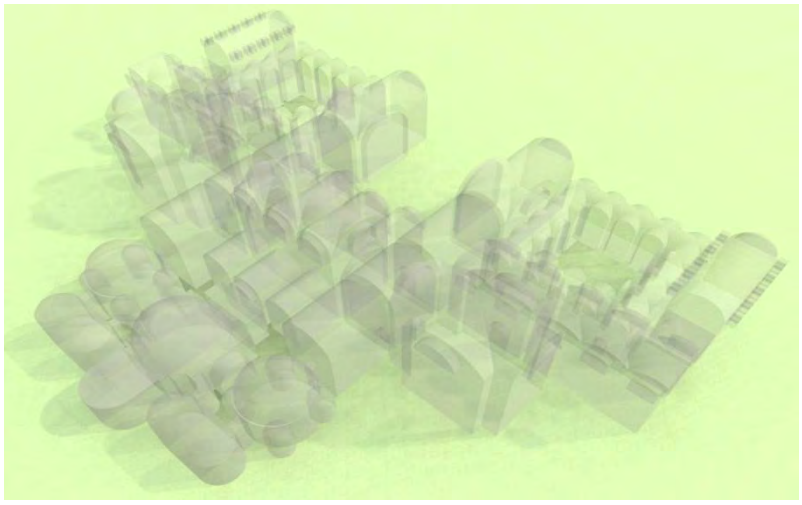


Fig. 83: Virtual volume in hollow. (Bouaita K., 2011)

The architectural space

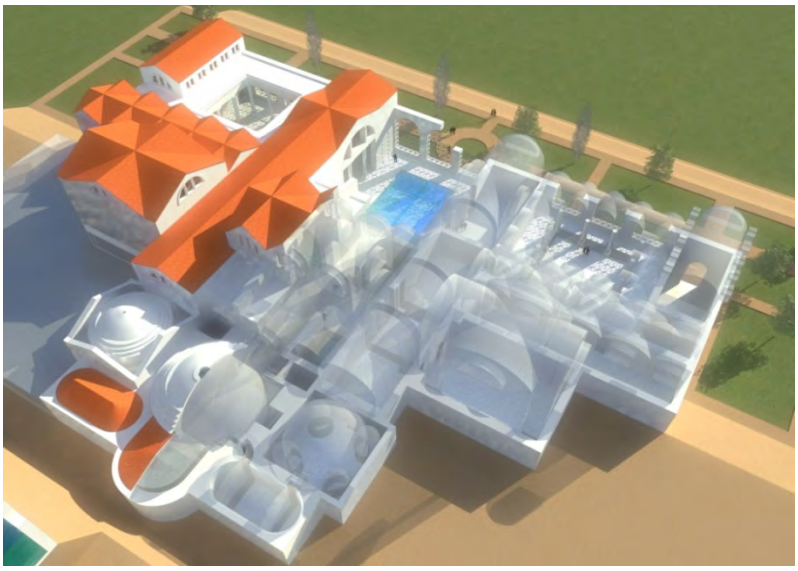


Fig. **84**: Architectural space. (Bouaita K.,

Conclusion

This research made by researcher's architects developing History-Archaeology-Architecture polarity, aimed to establish the modeling of the conception through the modeling of old buildings. Far from the idea of taking the role of the archaeologists, we propose to establish, through the virtual and cognitive reconstruction, the virtual, the cognitive and collaborative model as active and dynamic and as a collaboration interface between various specialists. Each data or each new evidence provided by experts can be immediately incorporated and sound decisively on the whole project.

The poetic assumption

The modeling work of Roman Imperial Baths has been facilitated by the fact that these buildings seem to reflect the worldview and the ideal of Roman culture in their scheduling. They are variations of the same model prototype, which appears to be an illustration of a paradigm. Architectural space acts as a harmonious universe where order, stability and perfection are achieved by the artifice of symmetry and proportions. All disorders and contradictions are evacuated.

The symbolism of the architecture means that it forges links between heaven and earth, spirit and material and combines the tangible and intangible. The virtual volume in hollow (VVIH) also seems to be the interface between the building as a body: the building and the physical conformation, and the building as a spirit: poetry and aesthetic expression and space-time configuration. This configuration reflects the worldview of a civilization.

The architecture space presents a double dialogic: A content dialogic / the container (GSD: Globing solid device / HFS: habitable fluid space), added the dialogic material / spiritual (build-conformation / performance-configuration).

The Knowledge of Roman culture, its worldview and its aesthetic and poetic paradigm can produce important information.

Identity and individuation

In the event that our hypothesis (expert system) is validated, there is nothing to move the reconstruction of the baths from the remains of fragments and traces, in the conception of novel specimens. It is then enough to give the size of the projected baths. The expert system proposed variants of the prototype, all of which are unique specimens. The question that arises is where the variety is, why you do not get baths that are completely identical?

The VVIH is as a specific mechanism in the field of architecture, universal mechanism of inter- intra and trans -equilibration described by Piaget as the general mechanism of intelligence (Piaget and Garcia,1983). Components tend to assert their identity and integrate into the units and entities that assert them even while incorporating the elements in a set. And the dynamic of transformation–formation in a balanced and stabilized set produces a specimen with the same type of identity. Cases of total identity appear to be borderline cases almost never achieved and unintended. The assertion of entities and its equilibration to different layers of integration seems to be a universal principle that produces the variety in unity.

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