

EXPERIENCING WARMTH IN UNDERGROUND ARCHITECTURE

by

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INTRODUCTION

The motivation behind this investigation has been a belief that the relationship between underground architecture and the human being is important. Most of the literature to date concerning underground architecture has been of a technical bias dealing with construction and engineering methods. There is a strong need to explore new avenues of thought which will further articulate the concept of architecture under the earth and explore the proposition of long-term underground living.

In recent years there has been a rebirth of this architecture. One of the main reasons for the increased interest has been reevaluation of earth's high thermal insulation characteristics. Less energy is needed to warm underground buildings in winter or to cool them in summer.

Underground architecture, however, bears the stigma of being uncomfortable and psychologically unpleasant. On the basis of surveys of people who work in underground offices, Robert Sommer concluded, "The major complaints concerned the stuffiness and stale air, lack of change and stimulation, and the unnaturalness of being underground all day."¹

This thesis shall demonstrate that there are characteristics of warmth beyond the thermal which can contribute to the creation of a viable underground architecture.

Good architecture encompasses the qualities of firmness, commodity and delight. The first chapter will discuss underground architecture's

firmness and commodity. The psychological implications of stereotypes will be subject of the second chapter. The concept of psychological warmth which restores delight in underground architecture will be explored in the last chapter.

CHAPTER 1

POTENTIALS OF UNDER- GROUND ARCHITECTURE

There are valuable properties of underground architecture that offer potential alternatives to our modes of building. This chapter will be concerned with the range of advantages in underground architecture, the most important being warmth through insulation that the earth provides.

According to James Scalisce, in the last half of the twentieth century a more harmonious relationship between man's shelter and nature has been sought. Underground architecture began to be reexamined in response to an increasing environmental awareness on the part of architects and public alike.

Kenneth Labs defines two types of underground architecture: lithotecture and terratecture. Lithotecture involves building in geologic strata using mining and tunneling techniques. Terratecture is construction in the soil environment. Terratecture is further classified as either berm-type or subgrade structures. (Fig. 1) Berm-type structures are essentially aboveground with earth mounded around the walls and perhaps the roof. Subgrade structures are predominantly below ground surface. Under the classification of terratecture, this thesis will deal with berm-type and subgrade structures involving long term inhabitation while using the phrase underground

berm/subgrade

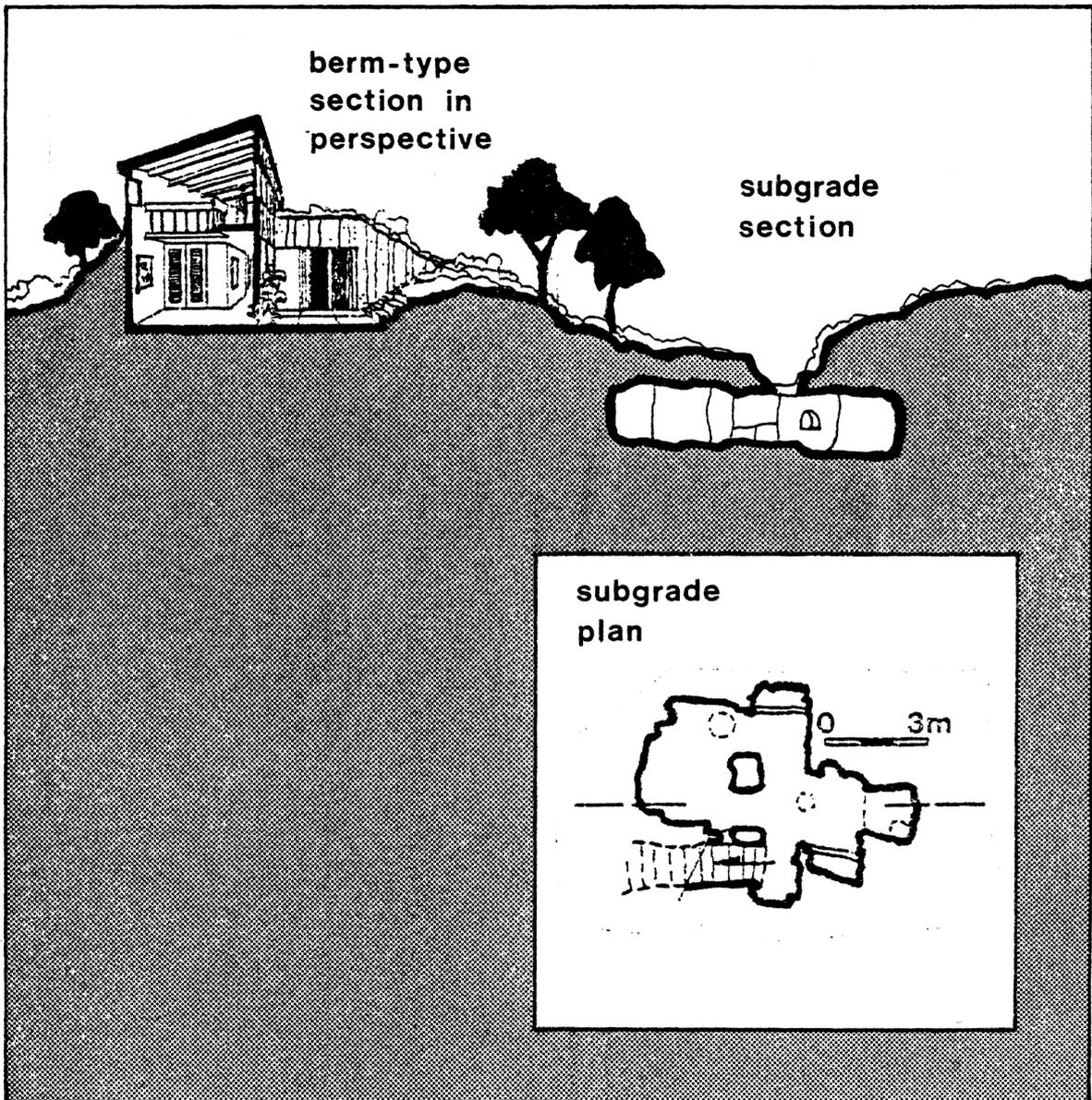


Fig. 1 Berm-type residence by John Carody
Subgrade residence, Apulia, Italy, 12-15 B.C.

architecture, as a general descriptive term.

There are numerous advantages to be gained by building underground, of which thermal warmth is particularly important. However the thermal aspect is only part of the warmth vital to underground architecture.

The advantages to be discussed are:

1. Thermal insulation
2. Preservation of important site artifacts and spaces
3. Security
4. Noise control
5. Ecological considerations.

1. Thermal insulation

In light of limited fuel supplies the most important advantage of underground architecture is its ability to provide thermal insulation. Generally subsurface temperatures are lower than aboveground temperatures in hot months and warmer than aboveground temperatures in cold months. This fact can bring about a savings in the amount of energy required to heat or cool an underground structure.

Studies have been done to determine the advantages of using earth as insulation in building design. These advantages are recognized as savings in the amount of energy which reduce the operating cost of a building. As an example of the quantitative approach, an insulation study is presented in Fig. 2. However, this thesis is concerned with the qualitative aspects of warmth and not so much with the quantitative.

insulation study

CASE NO.	INSULATION	ADDED COST	HEATING Btu/YR.	COOLING Btu/YR.	TOTAL Btu/YR.
1.	6" insul. in ceiling, 3/4" air in walls	0	1.224×10^7	4.139×10^7	5.363×10^7
2.	10" insul. in ceiling, 3/4" insul. in walls	\$200	1.079×10^7	3.898×10^7	4.977×10^7
3.	6" insul. in ceiling, 3/4" air in walls, 4' berm	\$200	1.101×10^7	3.776×10^7	4.786×10^7
4.	10" insul. in ceiling, 3/4" insul. in walls, 4' berm	\$400	9.372×10^6	3.656×10^7	4.593×10^7
5.	6" insul. in ceiling, reg. glass	\$250	1.440×10^7	3.810×10^7	5.250×10^7
6.	10" insul. in ceiling, Thermopane Glass, Zeolite	\$1550	6.600×10^6	3.140×10^7	3.800×10^7

Fig. 2 Computer study of insulation.

- Case 1. An aboveground house, 1800 sq. ft., used as a baseline model
- Case 2. Same as Case one with added insulation
- Case 3. Same as Case one with a 4' high soil berm
- Case 4. Same as Case one with added insulation and 4' high soil berm
- Case 5. An underground house, 1800 sq. ft., 12" sod roof
- Case 6. The same underground house with more insulation and double layer glass

2. Preservation of important site artifacts and spaces.

Another advantage of underground architecture is its ability to preserve historic items or pleasant spaces. The University of Minnesota Bookstore is a recent example of spatial as well as historic preservation. The campus of the University is densely developed with the bookstore site being one of the few remaining open spaces. Also a popular view of one of the oldest buildings on campus existed such that a building constructed aboveground would have destroyed the view. The architects designed an underground bookstore which preserved the original space and view. (Fig. 3)

3. Security

Underground architecture's security is another advantage. Underground buildings are strongholds against numerous natural disasters. They are protected from damaging high winds and associated dangers such as uprooted trees. Regarding seismic considerations, "...less damage occurs in a properly located subterranean structure than in one located above the surface." This fact has even led to studies which propose that nuclear power plants be built underground for security reasons.

4. Noise control

Another advantage of underground architecture is its potential for controlling noise. "Acoustical experts...have warned us that noise has increased to the point of threatening human happiness and health."³ Two ways of controlling sound energy are diverting it or absorbing before it reaches an area where it would be a problem. By building underground, shrubs and trees which absorb sound can be maintained. Their leaves,

minnesota bookstore

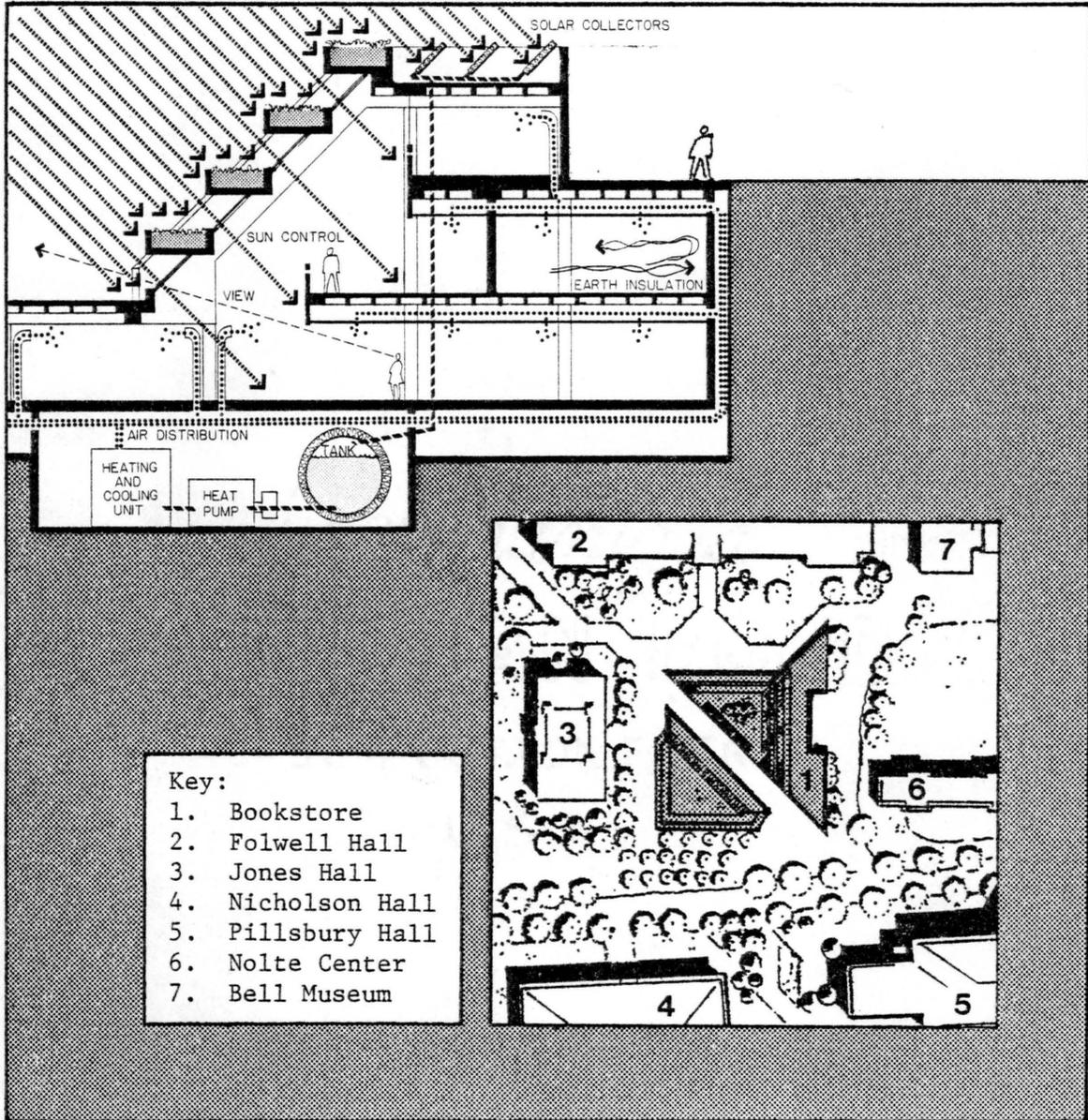


Fig. 3 University of Minnesota Bookstore section and plan, Myers and Bennett Architects/BRW
 A study of sun angles prompted the design of a series of louvers in the form of large planters, ranked along the south and west surfaces. Their spacing allows deep sun penetration during the winter while masking out the summer sun.

twigs and branches are flexible enough to absorb a high degree of vibration. The soft surfaces of lawns are also good sound absorbers. By placing a grassy or vine covered berm surface toward the source, overall noise may be reduced by eight to ten decibels. Such reductions are substantial since each decrease of ten decibels lowers the pressure on the human ear ten times.

5. Ecological considerations

In the realm of ecological considerations, Malcolm Wells has developed charts illustrating the advantages of his underground office in comparison to a typical aboveground office. (Fig. 4, Fig. 5) Each of the fifteen criteria can rate a score that ranges from minus 100 to plus 100. Wells' office scores plus 100. A conventional aboveground office of comparable size with a shingled roof and brick exterior scores minus 1000.

Summary

In this chapter the advantages of underground architecture, specifically subgrade and berm-type structures that involve long-term inhabitation have been generally described. Of the advantages, the warmth insured by the earth's high thermal insulation characteristics is particularly important in terms of energy savings.

This thesis, then shall demonstrate that there are stereotypes that negate underground architecture's viability and that psychological warmth is a response to negative stereotypes.

ecology study

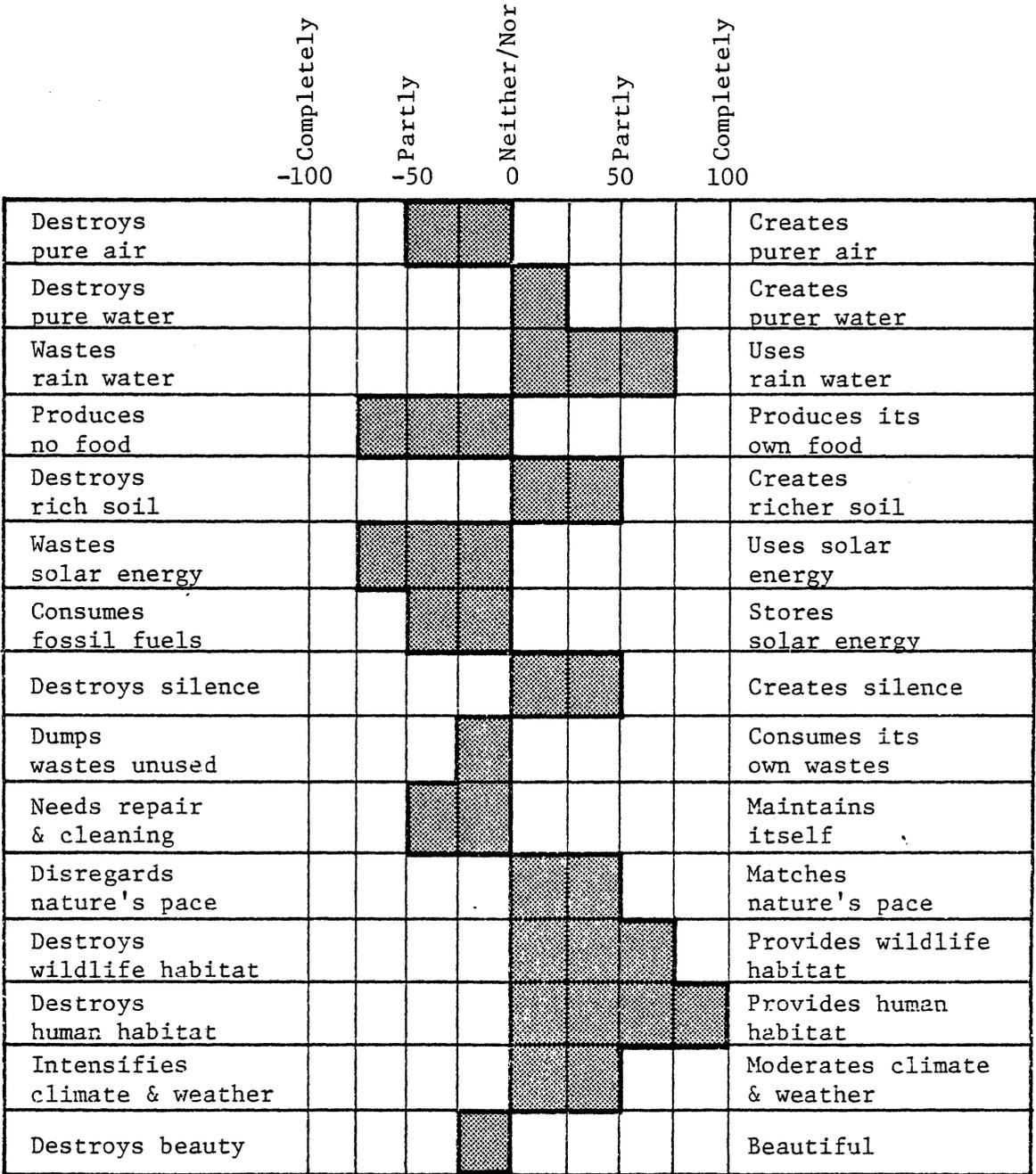


Fig. 4 Evaluation criteria, value +100
 Malcolm B. Wells, 1969 underground office.

ecology study

	Completely -100	Partly -50	Neither/ Nor 0	Partly 50	Completely 100	
Destroys pure air	■	■	■			Creates purer air
Destroys pure water	■	■	■			Creates purer water
Wastes rain water	■	■	■			Uses rain water
Produces no food	■	■	■			Produces its own food
Destroys rich soil	■	■	■			Creates richer soil
Wastes solar energy	■	■	■			Uses solar energy
Consumes fossil fuels	■	■	■			Stores solar energy
Destroys silence	■	■	■			Creates silence
Dumps wastes unused	■	■	■			Consumes its own wastes
Needs repair & cleaning	■	■	■			Maintains itself
Disregards nature's pace	■	■	■			Matches nature's pace
Destroys wildlife habitat	■	■	■			Provides wildlife habitat
Destroys human habitat				■		Provides human habitat
Intensifies climate & weather		■	■			Moderates climate & weather
Destroys beauty			■			Beautiful

Fig. 5 Evaluation criteria based on wilderness values, -1000.
Malcolm B. Wells, 1969 aboveground office.

CHAPTER 2

PSYCHOLOGICAL IMPLICATIONS OF UNDERGROUND ARCHITECTURE

The psychological response to underground architecture is affected by a myriad of images preserved by art, literature and the spoken word. Carl Jung's theory of archetypes offers a way of understanding how stereotypic images can affect our psychological disposition towards underground architecture.

Far from being a modern term, "archetype" was already in use before the time of St. Augustine and was synonymous with "idea" in platonic usage. Jung postulated that psychic functions are performed before birth. One of those functions is the propensity for creative fantasy. In the products of creative fantasy Jung claims that primordial images are made visible which become archetypes over time. The strength of the archetype theory is that there are images (archetypes) that appear consistently in culture, separated by time and space. In addition, archetypes can rearrise spontaneously at any time and place.

Of the various archetypes, the mother archetype offers particular insight into the issue of psychological warmth and underground architec-

ture. Like other archetypes the mother archetype appears under an almost infinite variety of manifestations. The qualities associated with the mother archetype are sympathy, all that cherishes, sustains and warms, that fosters growth and fertility. There is also a negative side to the mother archetype which may connote anything secret, dark, seductive, and inescapable. The mother archetype can be attached to a garden, cave, tree, deep well, corner and nook among other things.

Following from Jung's archetype theory the concept of underground architecture would render itself as a manifestation of the mother archetype; the most closely associated image being that of the cave. Indeed, the most noteworthy historic examples of underground architecture were either natural or man-made caves such as the Cones of Cappadocia and Lascaux Caves.

New evidence from Lascaux indicates early man found his cave dwelling not only expedient in terms of shelter, but also receptive to creative fantasies. (Fig. 6) Lascaux is beyond doubt an incredible record of man relating creatively to his dwelling in a way that has historian Georges Bataille citing Lascaux Caves as the birthplace of art.

While the impact of Lascaux is its interior spaces, the Cones of Cappadocia present themselves immediately by their exteriors as a triumph of man creatively adapting to his environment. (Fig. 7) Located 250 miles southeast of Ankara, Turkey, erosion left Cappadocia's soft volcanic rock in conic form. A unique landscape has been burrowed into, excavated and hewn out by generations for nearly 2000 years.

Although they are outstanding examples of underground dwellings,

lascaux cave

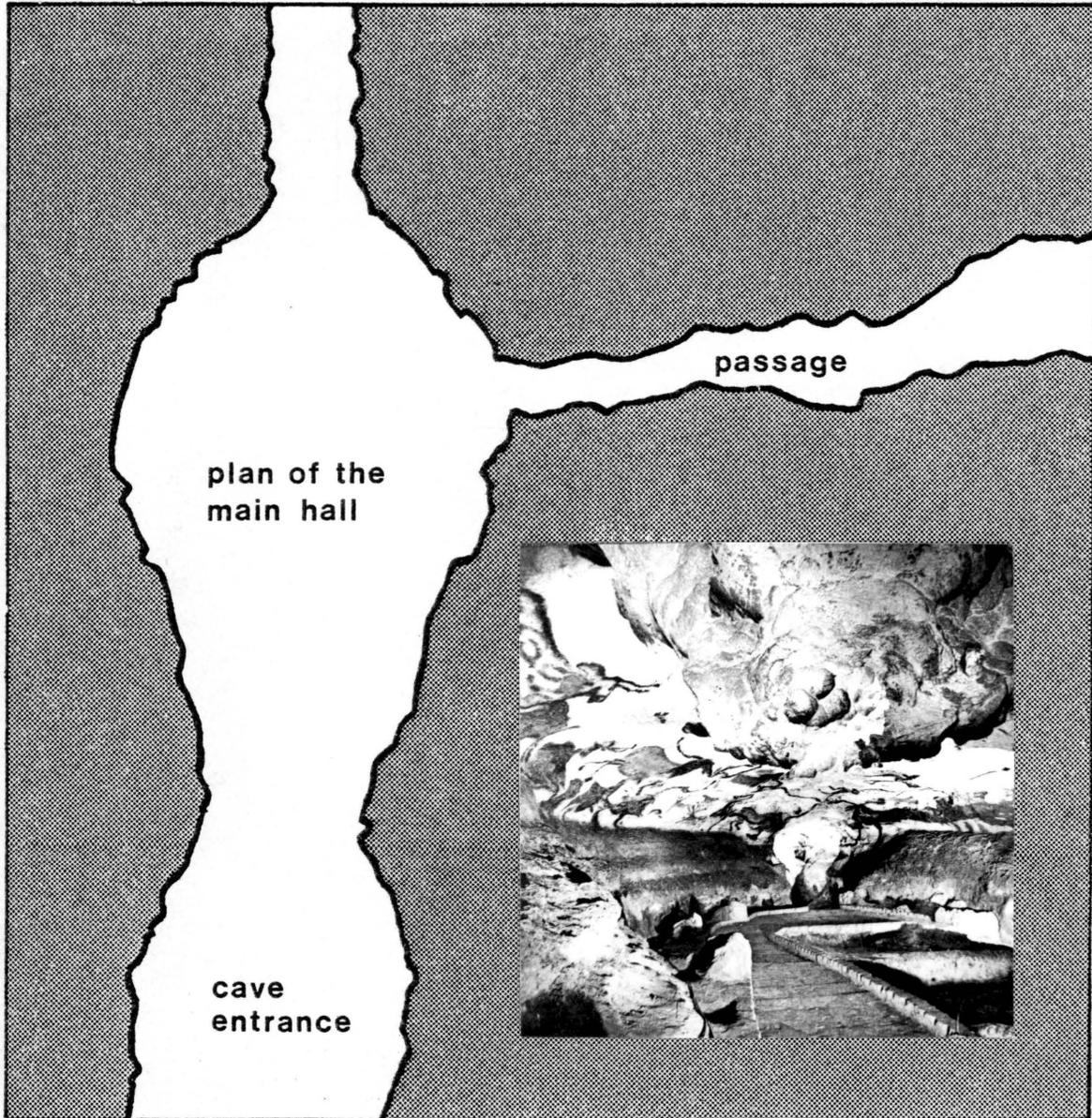


Fig. 6 Lascaux Cave, Valley of the Vezere, France
 ". . . such appears the Lascaux Cave, which transports us back to those dim, lost moments when the human voice first began to make itself heard." --Georges Bataille, Lascaux

cappodocia

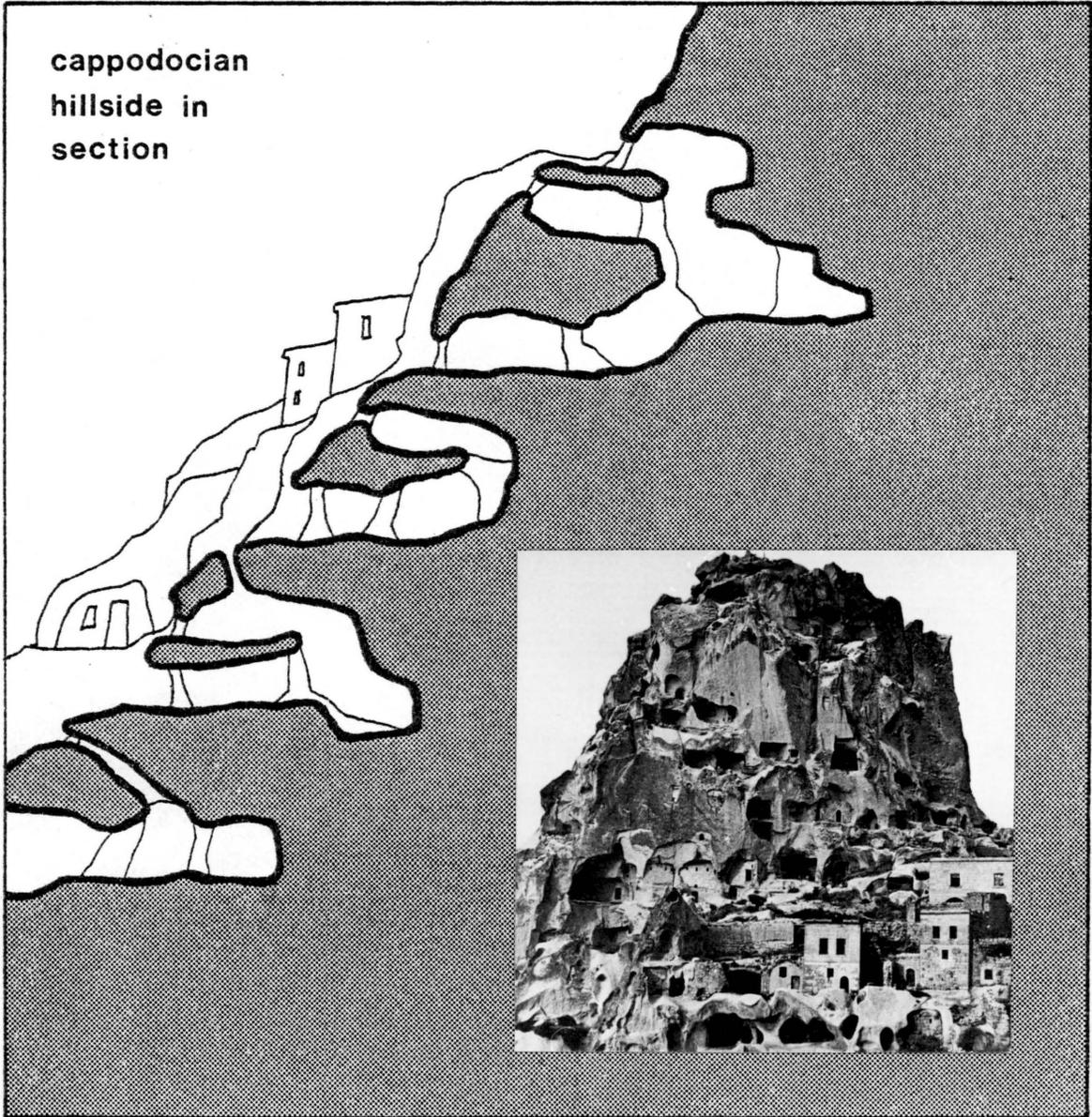


Fig. 7 Cappodocian residences

The volcanic rock, being very porous, makes unusually good thermal insulation. Inside present day dwellings brightly colored woven rugs are hung on walls and placed on floors.

Lascaux and Cappadocia are rivaled by the image of caves which are dark and lifeless. The cold and confining feeling associated with many caves parallels the negative attitudes towards underground architecture. Why is there no delight in the prospect of living under the earth's surface?

Stereotypes

Through the ages men have created an enormous number of myths and stereotypes concerning the experience of being underground. The examples presented in this chapter constitute the more notable ones, some which date back for centuries.

Perhaps the most far reaching underground stereotype is the conception of hell as a place inside the earth. Myth holds that many have descended but few have returned from the bowels of hell. Those who were fortunate enough to escape became heroes. Greek and Roman mythology is full of Hades-tested legends.

Hercules ventured into the underworld where he obtained permission from Pluto to carry Cerberus, the three headed dog, "to the upper air provided he could do it without the use of weapons; and in spite of the monster's struggling he seized him, held him fast, and carried him to Eurystheus, and afterwards brought him back again."⁴

"And thence the dog
With triple head brought to these
realms of light."⁵

-Euripides

Theseus was detained as a prisoner in Hades after an unsuccessful attempt to carry off Proserpine, who had been kidnapped into the lower regions

and there raped by Pluto.

"'Tis he, 'tis he: he comes to us
From the depths of Tartarus.
For what evil doth he roam
From his red and gloomy home?"⁶

-Barry Cornwall

Perseus descended into hell to obtain Pluto's helmet.

"The young adventurer, rendering
himself invisible by means of
Pluto's helmet, first visited the
cavern of the Graeae."⁷

-Bullfinch

The descriptions of hell in literature over the last three centuries give important insight into the beliefs of countless readers. John Milton refers to hell as a deep, dark abyss.

"...into what Abyss of fears
And horrors hast thou driv'n me; out
of which I find no way, from deep
to deeper plung'd!
Thus Adam to himself lamented loud
Through the still Night...with black Air.
Accompanied, with damps and dreadful gloom"⁸

When describing death, Milton stresses an awareness of an actual physical movement of the soul from above to below the earth.

"How shall I part, and whither wander down
Into a lower world..."⁹

For Christians until the time of Dante, only Jesus Christ was able to journey into the depths of hell and return after encountering the multitude of condemned souls. Dante carried further the notion of hell as an underworld home for the dead by writing as if he had made an expedition underground. In so doing, he identifies a wide range of underworld zones corresponding to the types of offenses committed by the inhabitants during their lives. (Fig. 8) Dante also meets up with Lucifer, "the wicked grub which bores through the world." 10 During the time that Dante lived the public accepted his writings as truth. Many present day readers still adopt Dante's conception of hell. Thus Dante reinforces in his readers the Aristotelian doctrine that somewhere underground there is a place that negates all human happiness and well-being.

For other men at different times, hell was at the earth's center or under volcanoes. Irishmen claimed that the pit of Saint Patrick opened into hell. Regardless of differences of opinion as to the exact underground location of hell, it was commonly regarded as a place of no escape. C. S. Lewis put it in twentieth century terms when he claimed that those in hell can never really be again.

Another underground stereotype having a centuries old origin is that of Plato's cave. Platonists believed Plato's cave to be as real as any underground cavern that a person might experience. The myth of Plato's cave creates the impression that men perceive reality as if they were in the dim light of a cave. In Plato's view, reality passes behind men's

hell as seen by Dante

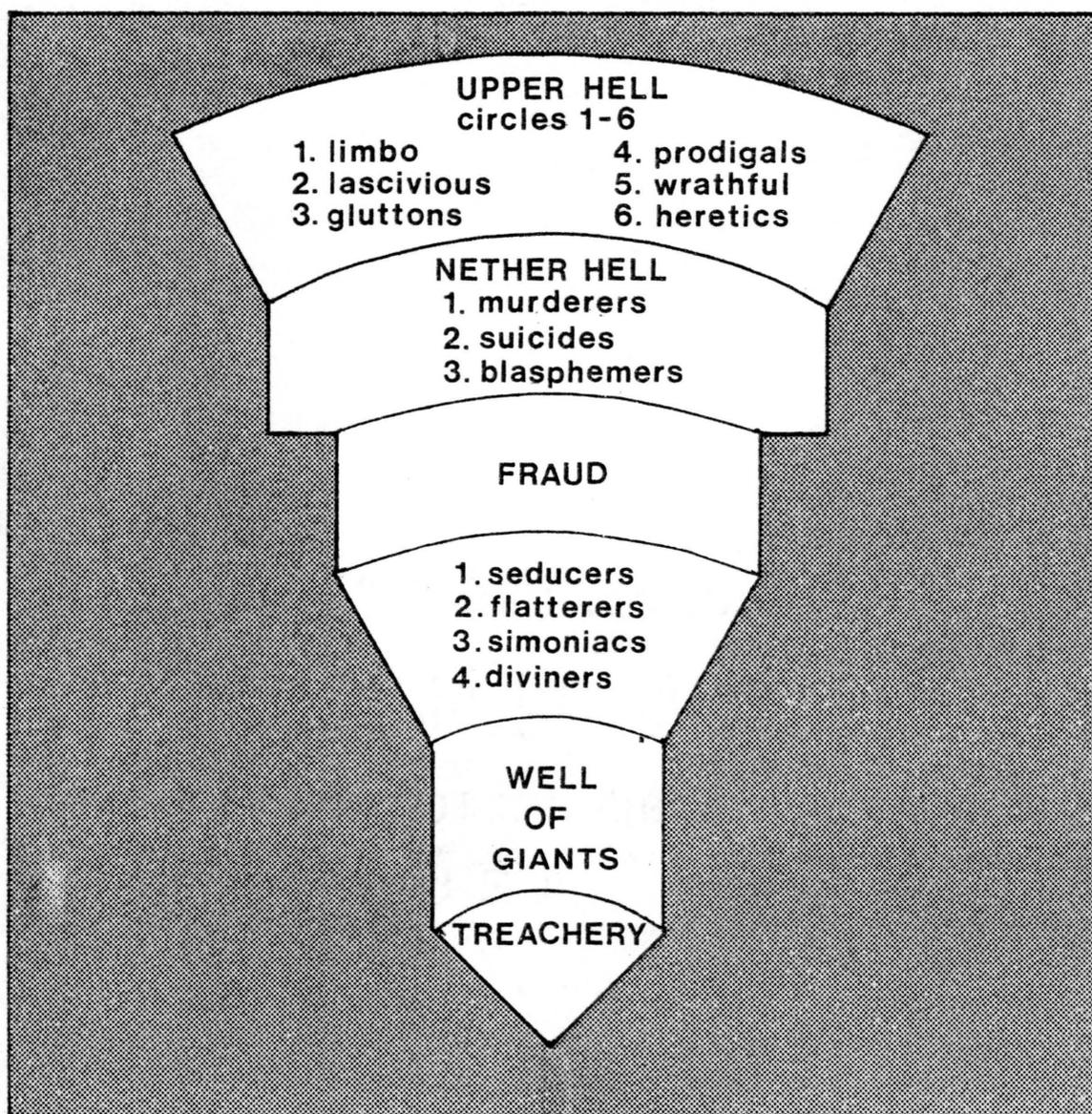


Fig. 8 A section of hell

It is easy to go down into Hell . . . but to climb back again, to retrace one's steps to the upper air--there's the rub."

--Virgil, Aeneid

backs, casting shadows on the cave wall; men can only perceive the shadows. The important point is that the underground environment is stereotyped as dark and uncertain.

The story of King Minos' labyrinth describes the experience of being underground in a way that parallels the Christian concept of hell. Located on the island of Crete, the labyrinth was an underground maze which served as the home of the half-bull, half-human Minotaur. King Minos would stand at the entrance of the hell-like labyrinth and send the souls which appeared before him into the depths. Once inside the labyrinth, the condemned would eventually be eaten by the Minotaur. It took a super hero like Theseus to overcome the Minotaur and find his way out of the maze.

Pompeii was thriving when it was suddenly turned into an underground mass graveyard. By virtue of Vesuvius, the world was presented with a powerful, nightmarish image of the underground experience.

A stigma similar to Vesuvius, except more recent in its impact, is the underground stereotype associated with coal mines. (Fig. 9) According to British author Matthias Dunn, the death toll for the Durham and Northumberland coalfield was a shocking 1,468 between the years 1790 and 1840. Besides the possibility of rock falls and water flooding, poor ventilation caused the build-up of methane gas which frequently exploded resulting in the fiery deaths of great numbers of miners. As technology advanced and the threat of methane explosions decreased, the danger of coal dust explosions increased. It was not until 1920 that regulations came into effect limiting the amount of

coal mines



Fig. 9 Hillside mine, Forest of Dean, Britain
"Conditions underground for the men . . . were always uncomfortable, frequently dangerous, and the work was invariably arduous."
--Anthony Burton, The Miners

coal dust in the atmosphere. However, controversy still exists concerning air quality in mines.

The Victorian response to miners and their environment was generally one of disgust.

"The number of illegitimate is here disproportionately large and indicates what does on among the half-savage population belowground."¹¹

T. S. Ashton explains the miner's social characteristics as a function of their environment.

"Coal miners have always been a class apart, with mentality and aspirations unlike those of the rest of the working class. This spiritual isolation is largely a reflection of physical isolation."¹²

Not only did there exist the sentiment of social inferiority within the underground environment, stereotypes were prevalent debasing the physical appearance of miners or pitmen as they were called.

"The 'outward man' distinguishes a pitman from every other operative. His stature is diminutive, his figure disproportionate and misshapen; his legs being much bowed...his cheeks being generally hollow; his forehead low and retreating...I never saw a jolly looking pitman."¹³

Even the proximity of a mine had a negative effect on aboveground citizens. D. H. Lawrence's description of life near a coal mine leaves little pleasant to the imagination.

"But even on windless days the air always smelt of something under-earth: sulphur, iron, coal, or acid. And even on the Christmas roses the smuts settled persistently, incredible, like black manna from the skies of doom...the house was full of the stench of this sulphurous combustion of the earth's excrement."¹⁴

The underground experience that had, perhaps, the strongest effect on more people of the first half of the twentieth century than any other occurred during World War I. Of the 6 million French soldiers, 11 million German soldiers, 2 million American soldiers and millions from various other countries, most suffered at one time or another in the trenches. The suffering that occurred in the trenches due to the ravaging war was beyond belief. Once entrenched, soldiers were, in effect, prisoners of the trench until the order was given to charge or retreat. Life in the trenches was a constant battle against bullets, bombs, rats, lice, trenchfoot, paranoia and cramped space.

Summary

Some of the discussion in this chapter has been based on myth, some has its roots in actual happenings of historical significance. There are many stereotypes not mentioned that have an influence on the local and regional levels. Virginians, for example, would identify strongly

with the images produced by the many caves and caverns of the area: Mammoth Cave, Dixie Caverns, etc. In the national and world arenas underground stereotypes associated with coal mining are becoming increasingly important as the energy shortage forces the re-emergence of coal as a major fuel.

The importance of stereotypes is that they have been preserved by word of mouth or by literature such that they have an effect, however, subtle, on our conception of the underground environment. Stereotypes of underground living as dark, dangerous and inescapable are a part of our cultural heritage that must be dealt with.

An architectural response to the negative feelings of being underground is the concept of warmth. It has been established that thermal warmth is available in underground architecture by earth insulation. How can psychological warmth be achieved and delight be restored to underground architecture?

CHAPTER 3

ISSUES OF WARMTH IN UNDERGROUND ARCHITECTURE

"Water grows colder and colder and colder,
and suddenly it's ice.
The day grows darker and darker, and
suddenly it's night.
Quantitative changes suddenly become
qualitative changes."¹⁵

This chapter will deal with the components of psychological warmth in underground architecture. It is a search for the delight that distinguishes underground architecture from underground building. Psychological warmth is qualitative as it allows individual assessment of warmth based on personal feelings. Because it is qualitative, understanding in the area of psychological warmth occurs through the asking of philosophic questions: questions that demand meaning.

There are two largely ignored factors that have a great deal to do with the way in which we experience warmth in underground space or in any work of architecture for that matter. The first is the realization that so-called opposites, warmth and cold, light and dark, solid and

space, cause and effect are poles of the same thing. One can not exist without the other. Warmth has no meaning without coldness. From the Zen perspective the relationship of opposites is expressed as Yin and Yang.

The second factor, closely related, is that we are strongly tuned in to the notion of the world as an assemblage of separate things. In fact we are so convinced that this narrowed kind of perception is the only real way of seeing the world that, as Alan Watts puts it, "We are fully hypnotized by its disjointed vision of the universe."¹⁶

Watts describes this condition further by suggesting that we are in the habit of playing a game of black-and-white with opposites; or more accurately, a game of black-versus-white. Nothing could be more poignant in describing the present day conceptions of underground architecture. We play the game of warm versus cold in thermal terms by placing extreme emphasis on energy savings. We assume that by placing a building under the earth, warmth is insured. But ironically, underground structures have developed the (stereotype of being unpleasant, "cold feeling" places.) We cannot see the whole for the parts; in this case, the thermal part. What is needed is a rebirth of the full meaning and implications of the word warmth.

Building underground has a great deal to do about warmth. This makes sense to most people. But it makes sense solely on a quantitative basis—Btu efficiency, dollars and cents saved. (Warmth is far more than statistical information.) Oversight of this fact is perhaps the main reason that underground structures are not a popular building type. A quick look

at building codes across the country reveals that there is a great deal more support for aboveground structures than subsurface structures. The point here is that warmth is more than a quantity. It is also a quality.

In light of the strong influence of economics in our society, it is understandable that we find our trust being placed in quantities rather than qualities. Qualities are largely subjectively valued. Quantities are generally objective and more easily translated into economic terms. Lewis Mumford recognized a growing lack of faith in man's subjective nature.

"Though the full personality is a necessary basis for creative activity in science as elsewhere, nothing except a radical transformation in the method and purpose of the scientist can overcome the persistent limitations that spring from its absence from the original mechanical world picture itself. Man cannot, even in theory, eviscerate his necessary organs and reduce the whole field of his activities to that which is observable and controllable without presenting a defective picture of both his own nature and the world he lives in. To dismiss the most central fact of man's being because it is inner and subjective flux, as experienced in floating imagery, dreams, bodily impulses, formative ideas, projections, and inventions and above all with increasing lucidity in language—the world that is open to human experience can neither be described nor rationally understood. When our age learns that lesson it will have made the first move toward redeeming for human use the mechanized and electrified wasteland that is now being constructed at man's expense and to his permanent loss."¹⁷

Warmth as Mumford's floating imagery, dreams and so on is a necessary part of any underground structure that involves human habitation.

It follows from the subjective nature of qualitative warmth that its philosophy will be descriptive rather than proscriptive by empirical

proof. Indeed some of the greatest expositors of the subject of warmth have been masters of description: poets.

"Existence thus involves increasing tension between upward and downward pulls—toward the realm of rarity, warmth, light and toward the realm of density, cold, dark. The pull is not only observed in physical phenomena, it operates too in our souls."¹⁸

The quote above is a description of themes that are dominant in T. S. Eliot's poetry. Significant is the emphasis placed on opposites—warmth and cold. Cold makes reference to warmth. Warmth makes reference to cold. Eliot does, in fact, consider cold and warmth as partners.

"Winter kept us warm..."¹⁹

Speaking in a manner that is paradoxical at first, Eliot energizes the image of warmth by making reference to winter which is cold. He revitalized our experience of warmth by embracing extremes.

Bachelard carries further the notion of a vibrant interplay of warmth and cold.

"And we feel warm because it is cold out-of-doors. Further on in this deep-winter "artificial Paradise" Baudelaire declares that dreamers like a severe winter. 'Every year they ask the sky to send down as much snow, hail, and frost as it can contain. What they really need are Canadian or Russian winters. Their own nests will be all the warmer, all the downier, all the better loved...' Like Edgar Allen Poe, a great dreamer of curtains, Baudelaire, in order to protect the winter-girt house from cold added 'heavy draperies that hung

down to the floor.' Behind dark curtains, snow seems to be whiter. Indeed, everything comes alive when contradictions accumulate."²⁰

He specifically identifies coldness as the reference point that gives life to warmth. However, he is not referring merely to a rise in temperature in going from "outside" to "inside." Bachelard is speaking of the quality of warmth that draws sustenance from images...snow seen from behind heavy curtains...nests enclosed by a winter blanket of snow.

Hermann Hesse puts warmth into action by involving it in a scenario.

"The boys, insulated in thick coats and shaws, wandered in dark clumps across white fields... throughout the entire land—in towns, villages and isolated farmhouses—they knew that parents and brothers and sisters were expecting them in warm, festively decorated rooms."²¹

Many images of warmth can be identified with a corresponding reference to coldness. The warmth of "thick coats and shaws" implies the existence of coldness. The warmth created by "clumps" of boys "across white fields" implies the existence of coldness. Also increasing is the fusion of warmth with "festively decorated rooms," which suggests images of thick walls, fireplaces, warm colors, and pools of light.

Thus far it has been shown that by contrasting warmth with coldness, coldness becomes a reference point for warmth. Sartre talks to great lengths of the importance of a reference point to give a particular thing meaning. The function of a reference point is realized, of course, only if it is referred to. It is therefore imperative that the reference point be accessible. To concentrate on one thing, such as warmth, to

the extent of completely precluding its reference point, coldness, is to make warmth static and lifeless. Over time, warmth cannot be experienced without reference to its contrasting compliment, coldness.

Saadi recognized the importance of contrast in his Sufi writings.

"Man's state is that of changing lightning. One moment it appears and at another vanishes. We are sometimes sitting in high heaven; on other occasions we cannot see the back of our feet. Were a sufi always to remain in a state of grace he would desire the pleasures of neither this nor the next world."22

As mentioned previously, a person may be in a place that is thermally comfortable, but feel that the place is cold. Imagine a bare cubed-shaped room, sunk into the ground with no windows; instead, rows of fluorescent lights in the ceiling. The room, being thermally comfortable, will provide a person with an initial sensation of warmth as one enters from cold temperatures outside. Over time, though, a person will likely develop the perception that the room is a cold-feeling place. The condition whereby a space, especially an underground space, is warm thermally yet cold experientially is all too common. Since it is a common condition it should have a formal title...pseudo-warmth.

Pseudo-warmth is the condition whereby one initially experiences warmth in a space (usually thermal warmth), but over time becomes desensitized to the initial warmth. In the process of desensitization one forgets the coldness or the images of coldness that predicated the existence of a warm space. Are there ways of minimizing the negative aspects of underground architecture that will, in turn, promote the

quality of psychological warmth without reducing physiological warmth? It is the contention of this thesis that there are two broad categories that are proponents of psychological warmth for underground architecture: the warmth of light and the warmth of spatial elements.

Warmth of light

As man's technological knowledge increased he began to recognize and appreciate the ways light interacted with his buildings. Psychological warmth developed along with the manipulation and mastery of light effects. Three of the ways that light can meet the need for psychological warmth will be discussed: pools of light, texture and warm colors.

POOLS OF LIGHT (Fig. 10)

It is not enough to provide underground buildings with well-lit spaces. Neither is it sufficient according to the Committee on Colorimetry to specify light of a warm spectra when attempting to design a psychologically warm underground space. "Even when warm light bulbs and tubes are used in offices, subjective judgements of coldness seem to persist." 23 The standard lighting practices of the twentieth century have required that nearly all buildings, particularly offices, be designed with a uniform light level.

pools of light

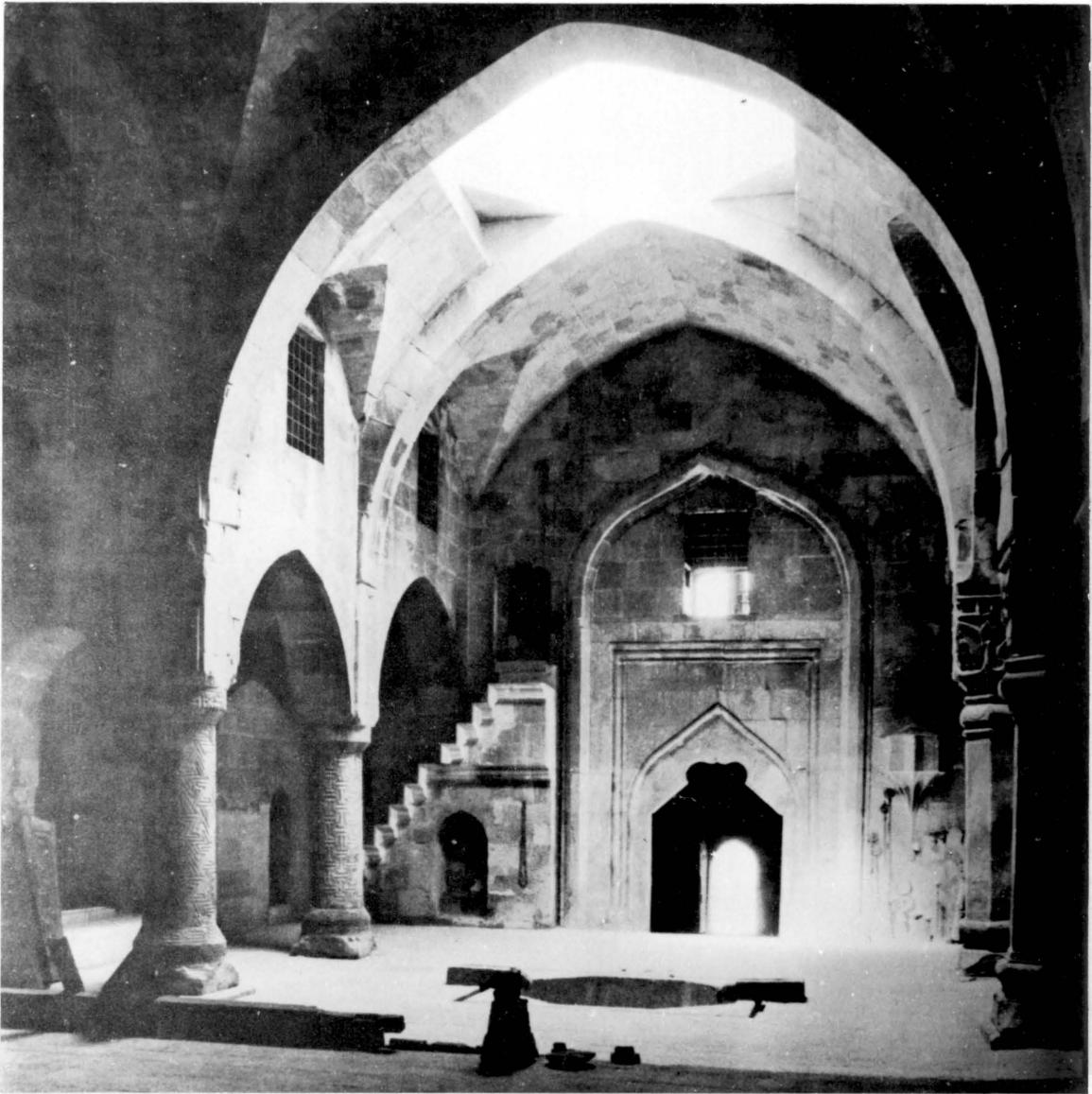


Fig. 10 Interior, Divrig Mosque and Hospital
" . . . leading from light to light through a brief darkness."
--Longfellow, A Covered Bridge at Lucerne

Many fine restaurants, however, do not conform to the standard practice of uniform lighting. A goal of most fine restaurants is to provide a psychologically warm atmosphere within which to dine. In contrast to offices, restaurants are great patrons of pools of light: light that is nonuniform.

Christopher Alexander postulates that places are defined by light. He goes on to say, "People are by nature phototropic. They move towards areas of light, and, when stationary they orient themselves toward the light."²⁴ Uniform light levels offer no opportunity for a person to move toward or become oriented to light because light is everywhere; there is no escape. When established as a matter of habit, uniform light levels become the perpetrators of a psychologically cold and static spatial experience.

Pools of light on the other hand, give people a source for orientation. Large, impersonal spaces are divided into smaller, more intimate places by pools of light. A kitchen counter becomes more personal when bathed in a pool of light. A corner becomes a warm spatial experience when a corner fireplace contributes its pool of light.

The key to the psychological warmth of pools of light is in the concentration of light that illuminates a particular place. The means for creating light pools range from a simple window to skylights, fireplaces, and directional artificial lights. Thus one principle for the creation of psychological warmth in underground architecture is

pools of light.

TEXTURE (Fig. 11)

"We want the floor to be comfortable,
warm to the touch, inviting."²⁵

Once light is admitted into an underground building it illuminates the various surfaces therein. Three of these surfaces—the floor, ceiling and walls, will be either psychologically warm and friendly or cold and impersonal.

When someone specifies a particular texture for the walls of a house, for example, that person is, in effect, putting their own mark on the wall. Through texture a person can experience the psychological warmth of communion with a wall.

Texture can occur in the form of the marks a surface receives from daily use. The way a well-trod wood floor feels is a result of experiencing a surface textured by everyday wear. Areas of the floor that are frequently traveled become polished paths. Marks are created where heavy furniture sits or is slid on the floor. The entire experience of the floor includes creating texture by making personal marks on the floor, seeing the texture, and touching the textured surface.

Peter Pragnell would classify the wood floor as a friendly object and thus an object which is regarded with warm feelings. "The importance of the friendly object is that it manifests human relevance."²⁶ It invites participation. "What we make of the object is pretty much up to us."²⁷

texture



Fig. 11 Underground residence, Baldasre Forestiere

At the turn of the twentieth century in California Forestiere hand dug his home and orchard where climate and soil conditions could be controlled. Incorporated in his building is the texture of native stone, rough concrete and bare earth.

Texture can render the surface of a wall as a friendly object. One can participate with a textured wall by seeing it (the visual level), touching it (the tactile level), and by hearing sounds reflected off of it (the auditory level). For walls, plaster is a good example to examine because it comes in various forms, each having a distinctive texture and corresponding psychological warmth. Soft, white plaster is warm in color, warm to the touch and mellow in sound. Cement plaster is opposite in each respect.

The principle of texture collaborates well with the principle of pools of light. Textural qualities are most apparent under non-uniform light levels where shadows can occur distinctly. Once benevolent lighting is established texture allows a person the psychological warmth of participating with surfaces in an underground building.

WARM COLORS (Fig. 12)

In relation to light, "...the most obvious origin of warmth is in the spectral characteristics of the light sources. There has been considerable study of spectral characteristics of light sources and it is now accepted that these light sources have a fairly 'warm' spectra. However, even when warm light bulbs and tubes are used in offices, subjective judgements of coldness seem to persist."²⁸ The Committee on Colorimetry of the Optical Society of America goes on to conclude that there must be other characteristics beyond light sources that affect the warmth of a space. Indeed,

this thesis is grounded on the premise that warmth is multifaceted, embodying both physiological and psychological factors. One of those factors is color.

Typically people like the inside of redwood houses with wood paneling or the interior of a courtyard especially towards evening. There is also a typical dislike for windowless interior offices equipped with fluorescent lighting. These situations indicate that people have a clear subjective impression of relative warmth or coldness of different spaces. A study by N. Collins reveals that individual observer stability in such judgements is high: a reliability coefficient of .95 for warmth and .82 for coldness. (Fig. 12)

However, designing a warm space in terms of color is not a simple matter of specifying red and yellow walls. It is not just the color of objects and surfaces that affects the warmth of a space. The warmth of light in a particular space depends on a complex interaction between the color of the light sources and the way this light bounces off the many surfaces.

The light in a hospital lit by fluorescent tubes, bouncing off green walls, is cold light in the green-blue range. In a room with an abundance of natural light the overall light is warm because natural light has a predominantly warm spectra. Hence, in a green field of grass on a sunny day the light is still warm even though the surroundings, the grass and sky, are cool colored.

The warmth of a space in terms of color can be identified by holding

warm colors

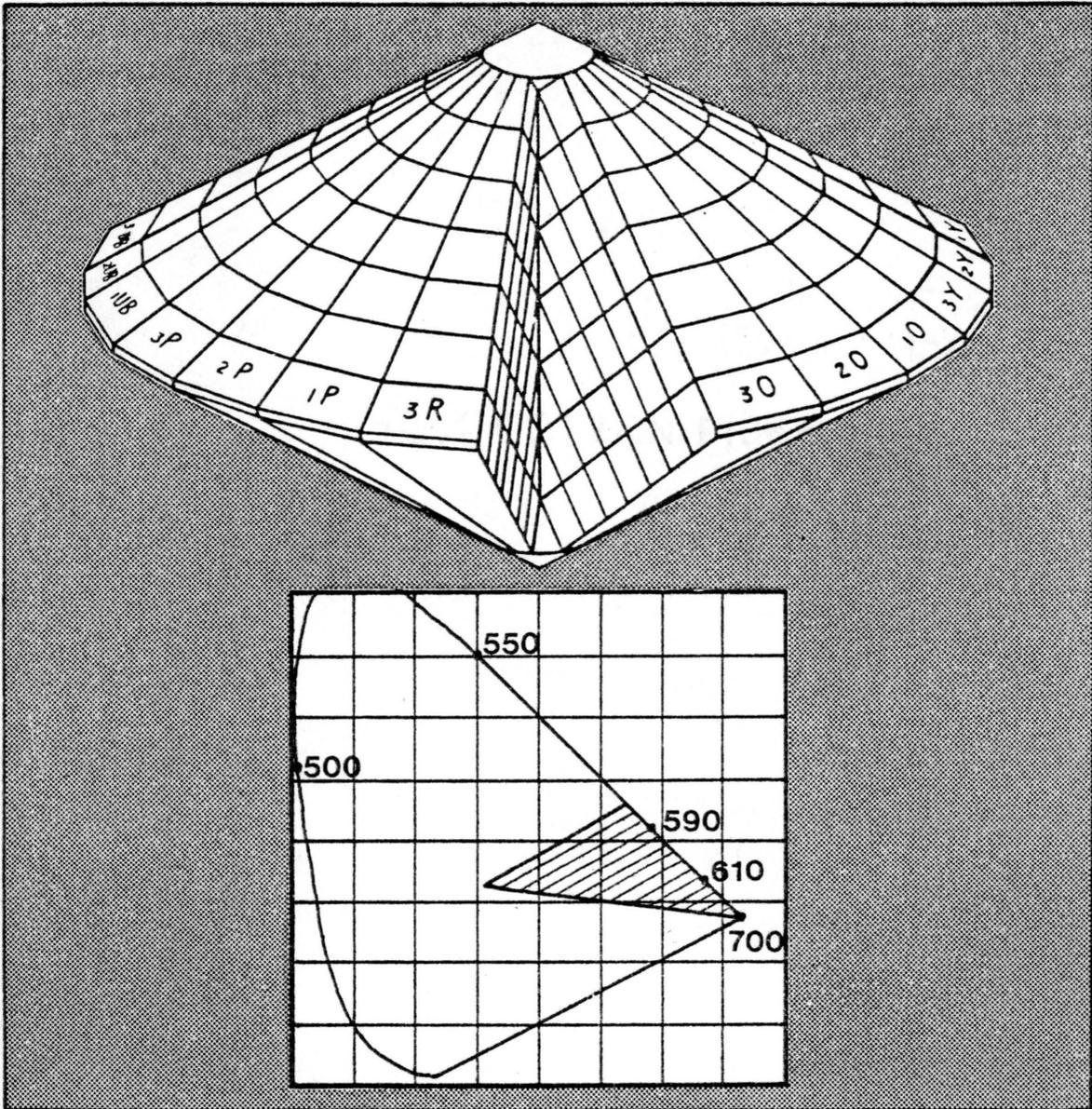


Fig. 12 Chromaticity diagram

The hatched area represents the warm region. It is based on a number of empirical results, assimilated by Gunter Wyszencki and W. S. Stiles. The maximum for "warmest" judgements is at a wavelength of 610 millimicrons.

a white object up to the light. The object will have a red-yellow tinge if the light is warm and a blue-green tinge if the light is cool. In some cases the color will be so slight as to require the use of a spectrometer for evaluation.

To summarize, light in an underground building will be either in the yellow-red range or the green-blue range. Whether it be from sunlight, direct artificial light, reflections from walls and carpets, or reflections from outside—if the total light is yellow-red in color, that light is warm.

SUMMARY

The previously discussed principles regarding light in underground architecture are commensurate to psychological warmth. Each principle can be applied without conflict to the others. The principles are listed as follows with a recapitulation of what aspect of light each principle concerns.

1. Pools of light
the way light is distributed in a space.
2. Texture
the way light interacts with the exposed surfaces in a space.
3. Warm colors
the color of the total light (natural, artificial, reflected) in a space.

Warmth of spatial elements

The second broad category of psychological warmth is the warmth of spatial elements. As mentioned in the discussion of archetypes, underground space is capable of imparting to its inhabitants feelings associated with other spaces such as the cave. In an underground space, as in a cave, one may experience warmth and security on the positive side. However on the negative side there may exist the cold feeling of inescapability.

No attempt will be made to construct a rigid formula that will completely avoid the negative aspects of underground architecture. Instead, a number of subspaces in respect to general underground space will be offered as spatial elements of warmth.

These spatial elements will be discussed primarily in terms of their qualities that pertain to psychological warmth. But as stated in the introduction, efforts to introduce psychological warmth into underground architecture should not reduce the effective physiological warmth of building under the earth. Therefore whenever the psychological aspects of the spatial elements coincide with physiological principles, the discussion format will be flexible enough to include references to those physiological principles.

The spatial elements to be explored are:

1. Fireplaces
2. Corners
3. Windowseats
4. Courtyards
5. Thick walls

FIREPLACES (Fig. 13)

"The fire confined to the fireplace was no doubt for man the first object of reverie, the symbol of repose, the invitation to repose. One can hardly conceive of a philosophy of repose that would not include a reverie before a flaming log fire. To be sure, a fire warms us and gives us comfort. But one only becomes fully aware of this comforting sensation after quite a long period of contemplation."²⁹

In one paragraph Bachelard has identified both the physiological and psychological warmth that a fireplace provides. Of course an open fire will give off heat to warm the body. In this respect there are other forms of warmth (solar, gas, oil, coal, electric) that will keep one warm more efficiently than burning wood. It is Bachelard's last sentence that pinpoints the value of a total experience with the fireplace. The other forms of physiological warmth, solar, gas, etc., have little, if any, psychological warmth.

The fireplace induces psychological warmth through three sensory avenues: seeing the fire, smelling the fire and hearing the fire.

fireplaces



Fig.13 Residence, N. Y., Bruce Helmes, Architect
"Trudging back bone-cold from a walk on a winter afternoon,
aware of a fire blazing at home . . . it is easy to
hallucinate the fragrance of woodsmoke."

--Frank Rowsome, The Bright and Glowing Place

Even a fourth approach is possible when one cooks over the flames: tasting the fire.

There is no substitute for fire and its container the fireplace. It comes the closest to providing a total experience of warmth. Most important is that the fireplace(s) be accessible by view from many points in the room. It is equally important that the fireplace not be located such that paths cut through its immediate space. This would disrupt the interplay between the fire and those that sit around it.

The psychological warmth of a fireplace can be heightened by providing an adjacent view of the outside environment. (Fig. 21) Visual proximity of extremes, warmth (the fire) and cold (outside) creates an exhilarating contradiction, each acting as a relief for the other.

CORNERS (Fig. 14)

"Close space! Close the kangaroo's pouch!
It's warm in there."³⁰

The corner is one of the most prevalent and perhaps one of the least understood spatial elements. Its ability to instill the feeling of psychological warmth is bound up in its physical intimacy.

"I am the space where I am."³¹ The corner permits one to have a sense of personal space. "An imaginary room rises up around our bodies, which think that they are will hidden when we take refuge in a corner."³²

The corner is mentioned specifically in Jung's writings as a mani-

corners

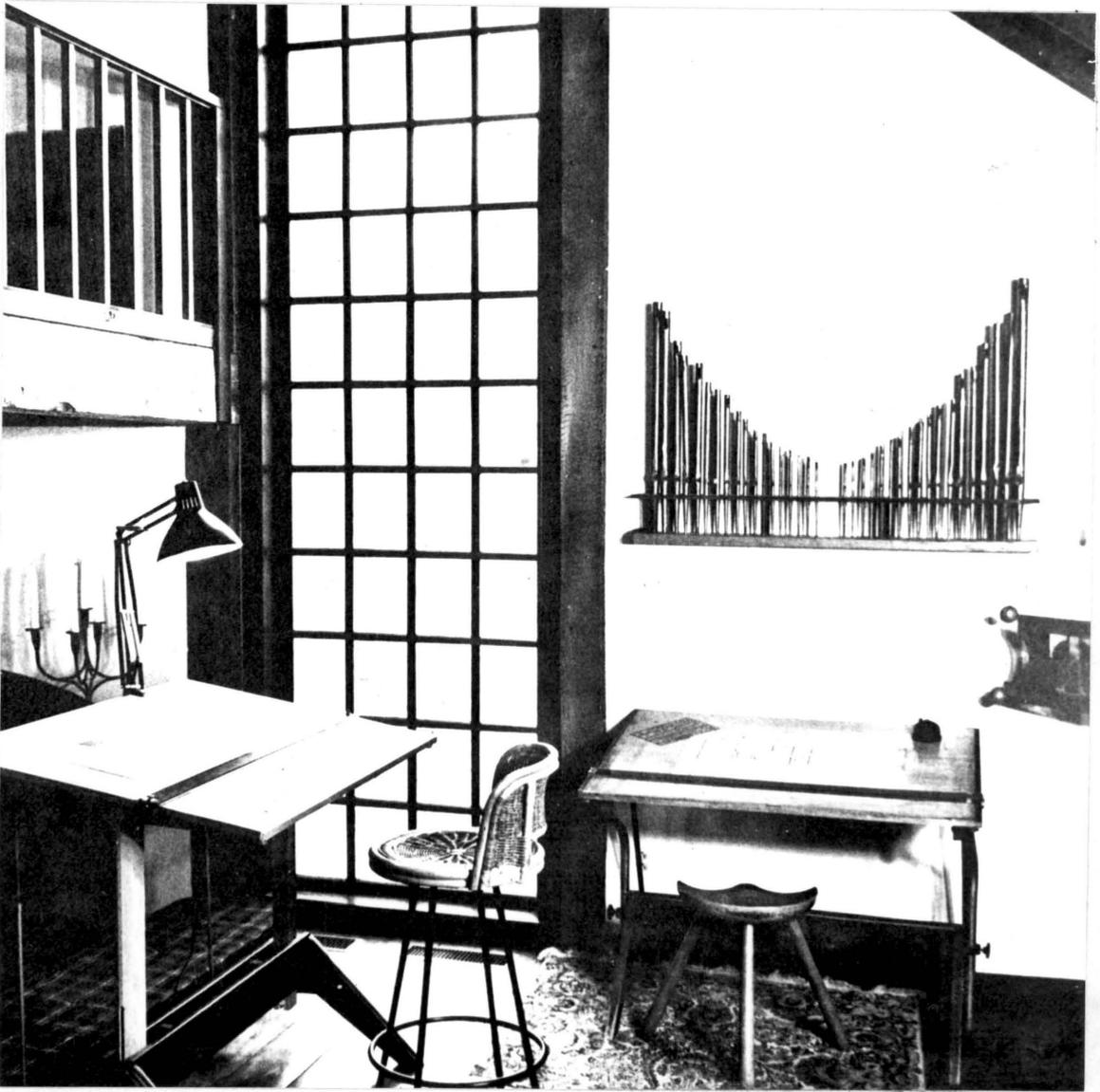


Fig. 14 Residence, N. J., William Thompson, Architect
"And all who live in corners will come to confer life upon
this image, multiplying the shades of being that characterize
the corner dweller." --Bachelard, Poetics of Space

festation of the mother archetype. Through the image of the mother archetype the notion of a corner's intimacy can be translated into the quality of psychological warmth. However, the negative aspects of the mother archetype are factors to be considered also. "To be cornered" is a phrase that speaks to the corner of no escape. Corners of no escape are those in which one feels strongly restricted and enclosed. They are even more stifling when located in the recesses of an underground building. Hence, the corner as an element of psychological warmth calls for a way of escape.

Perhaps escape is brought about by an inclined ceiling that carries the view up and away. Traditionally a nearby window has served as a relief for the corner. With the development of the corner window, in which two panes of glass meet at right angles, an even stronger relief was possible. The fireside corner is another way of providing escape for the corner that is otherwise, stifling. By locating the fireplace near the corner, the warmth and repose of the fireplace are introduced.

In summary, it is the corner's spatial intimacy that is the key to its psychological warmth. It is the same closeness of space that can make the corner feel inescapable. In underground architecture the corner requires a way of escape.

WINDOWSEATS (Fig. 15)

What is a windowseat? How large should it be and how should it be oriented for it to be a psychologically warm place?

windowseats

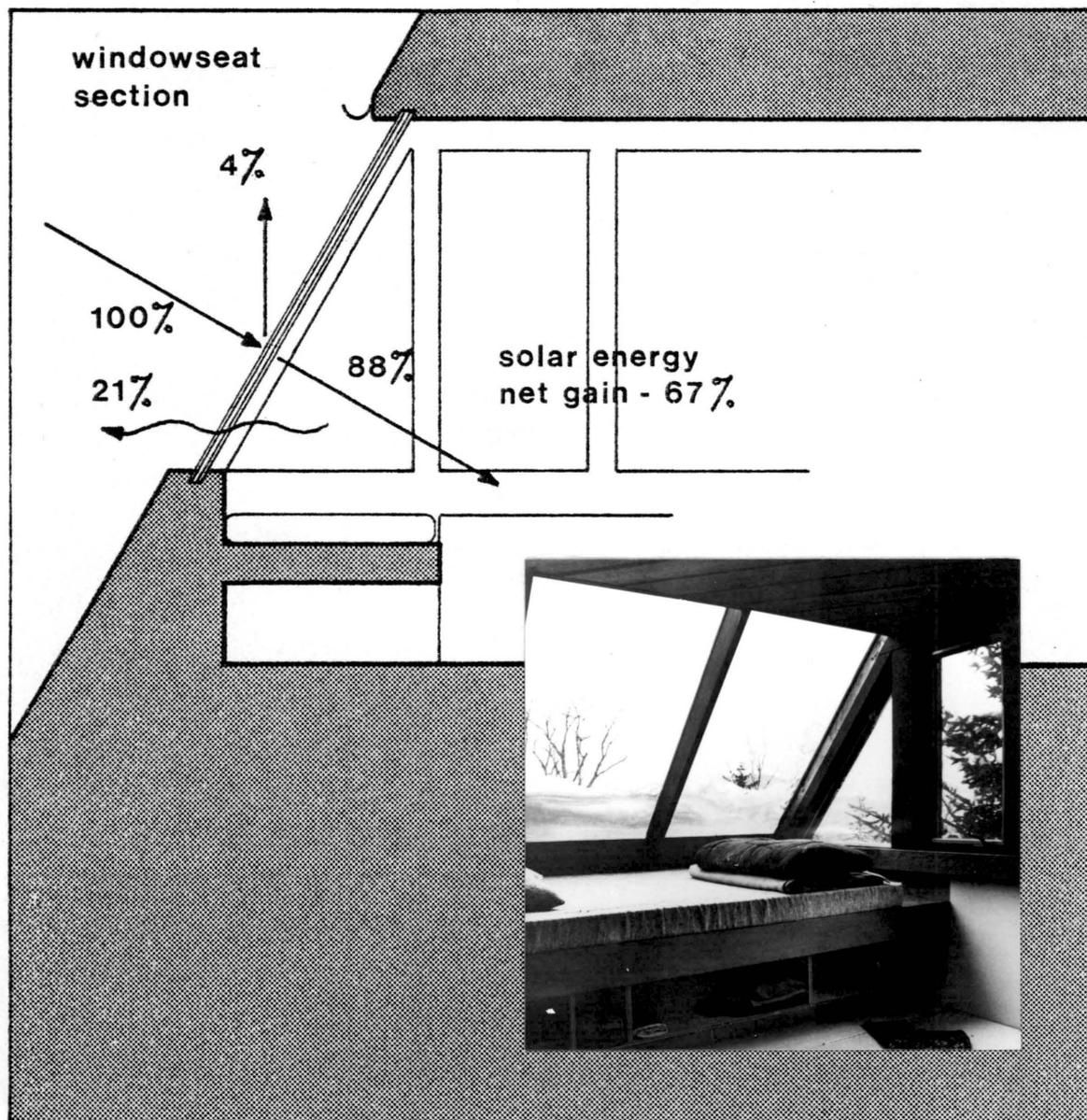


Fig. 15 Residence, Vermont, John Hauser, Architect
 "This evening I shall sit down at the edge of dusk . . . I shall watch night fall." --Jules Supervielle, Gravitation

The windowseat is, in essence, a space hollowed out from a wall where a seat is built adjacent to a window. Ideally the sitting area of a windowseat should be large enough for one person to fit comfortably, two persons at most.

A common objection to underground buildings is the lack of cues as to the condition of the outside environment. The windowseat provides the psychological warmth of being able to enjoy the comfort of an intimate interior space while observing outside conditions. A singular excitement occurs when sitting in a windowseat watching snow fall or trees dance to a winter wind. This excitement is integrally related to the feeling of psychological warmth. It is an excitement brought about by contrasts: the contrast of being as close to the outside as possible while still being inside the building, the contrast of being in the intimate space of the windowseat opening on to a larger interior room on one side and the "great outdoors" on the other side.

In respect to the outdoors a windowseat should not be placed in a north facing wall as the great amount of heat lost through the window in cold months would diminish the physiological warmth of the building in general as well as render the space of the windowseat physiologically cold.

The ideal orientation for a windowseat is a southern exposure with shade during the hot months. Shade can be provided by deciduous trees, overhangs and screening devices. Deciduous trees give shade in summer, then by losing their leaves allow the warmth of sunlight to penetrate

the building in winter. Overhangs and screening devices can be placed such that the light of the summer sun is blocked out and light from the low winter sun is admitted. The warmth of light is not only physiologically sensed in terms of the heat gained from solar radiation, but also is of a psychological nature occurring in the communion with sunlight.

Thus the windowseat offers underground architecture a threefold experience of warmth.

1. The physiological warmth of heat gained by the admission of winter sunlight.
2. The psychological warmth of communion with sunlight.
3. The psychological warmth of an intimate, womblike space.

COURTYARDS (Fig. 16)

"Car nous sommes ou nous ne sommes pas."
 ("For we are where we are not")³³

In the Renaissance courtyards were an integral part of noble homes. They provided an "outside" that was accessible at all times without fear of interruption. Being enclosed on the sides, climate could be controlled to a degree not only in the courtyard proper, but also in the rest of the house via the courtyard. If the court was large and filled with sunlight, cool air would flow from the narrow, shaded streets through the house to the courtyard. If the court was small and shaded with sunny spaces surrounding the house, cool air flowed from

courtyards



Fig. 16 Cuarto Dorado, south facade, Alhambra, Granada
 "The self-same sun that shines upon his court hides not
 his visage . . ."
 --Shakespeare
The Winter's Tale

the courtyard through the house to the street.

In terms of physiological warmth the courtyard allows the winter sun to penetrate the interior of a building while it creates a space protected from harsh winter winds. With the addition of deciduous trees or screening devices the courtyard can easily be shielded from the summer sun. Also with respect to physiological warmth, one must be sure that the courtyard is in proportion to the surrounding underground building. If the building is small and the courtyard is large the advantage of the earth's insulating properties will be wasted by exposing too much of the building to open air.

It is possible to bring the psychological warmth of sunlight to portions of a building that are totally below the ground line by excavating a courtyard from the earth. With the addition of a pool, the shimmering warmth of light reflected off water becomes possible.

In the winter the courtyard becomes a stage for images of coldness: snow, frost and fallen leaves. The visual experience of the signs of coldness outside serves to psychologically reinforce the warmth of interior spaces of the building. By designing direct visual access to a courtyard, one can indeed be where one is not, in an imaginative sense. This is extremely important for an underground building. Visual access to the outside environment is more important psychologically, according to Robert Sommer, than the actual amount of light that penetrates the building.

Summarizing, courtyards can be of value to underground architecture

by providing the psychological warmth of light and view.

THICK WALLS (Fig. 17)

Thick wall is a descriptive term referring to a wall that has spaces carved out of it. Thick walls can contain a variety of spaces:

1. Shelves
2. Cupboards
3. Niches
4. Leaning posts
5. Windowseats
6. Open closets.

It is by creating spaces in a thick wall that the quality of psychological warmth is achieved. An invitation is extended for inhabitants to come into an intriguing physical as well as visual contact with the wall. This is a sharp contrast to the attitude in which walls are thin, slick, hands-off items commonly associated with a cold, impersonal feeling.

Christopher Alexander proscribes a minimum wall depth of four centimeters. In an underground building the increased thickness is complementary to the structural requirements for supporting the added weight of the soil. Alexander proposes a thick wall that is essentially a space frame which bears great loads more efficiently than a standard, solid load bearing wall.

When paired with the principles of pools of light, thick walls take

thick walls

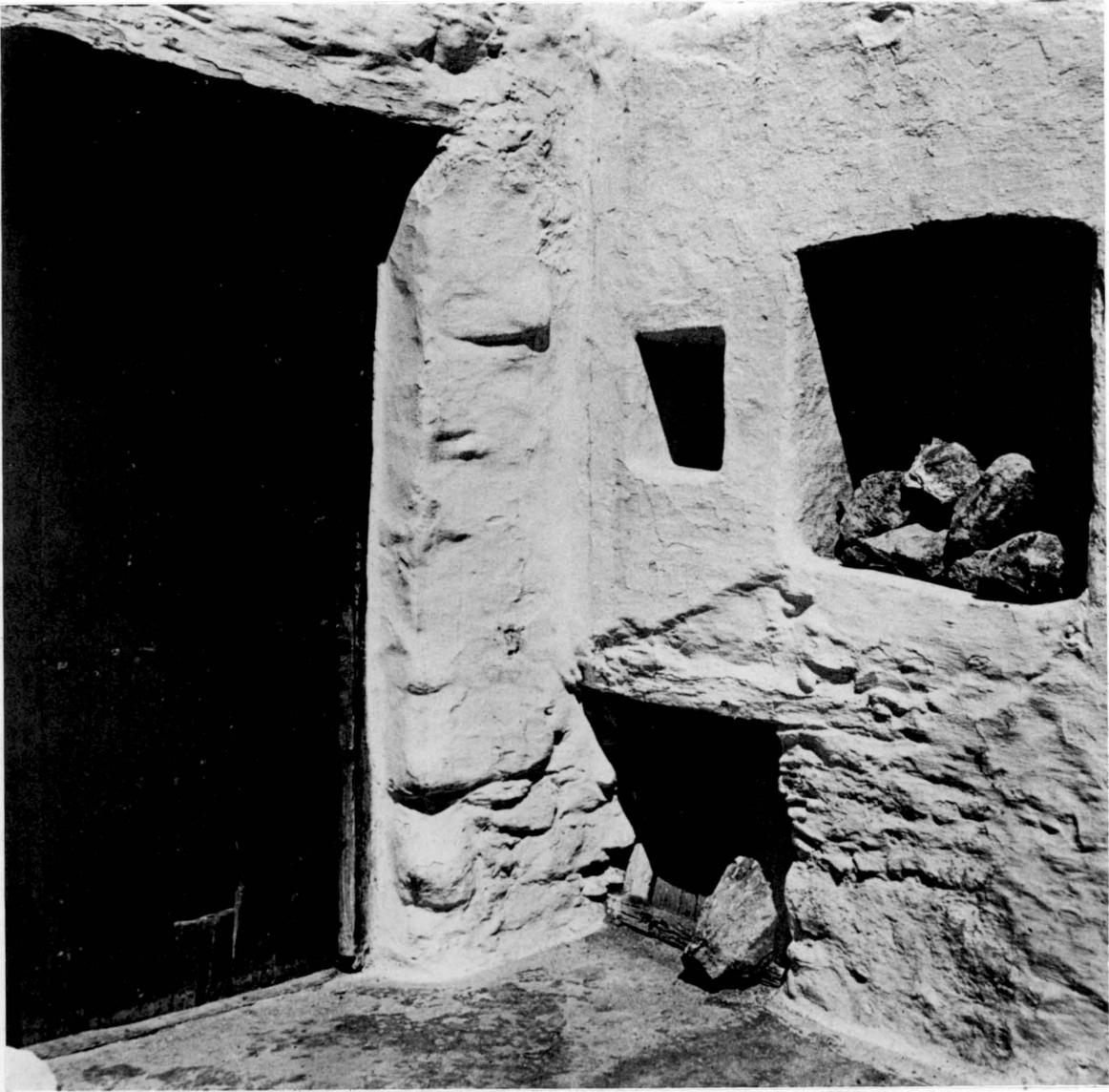


Fig. 17 Residence, Skyros, Greece

"Within this framework, the individual artisan-builder has expressed himself in the details."

--Goldfinger

Villages in the Sun

on the quality of a textured surface. The significance of texture finds further support for Alexander's observation that wall surfaces, "... large, flat and unbroken..."³⁴ very often lack character and warmth.

In conclusion thick walls add psychological warmth to underground architecture by the interaction, both visual and tactile, they make available to inhabitants.

Summary

The five spatial elements of warmth that have been discussed are not newly created, although the windowseat, courtyard and, in some cases, the fireplace have become historic relics, rarely seen in current architecture. They convey the quality of psychological warmth by various means: the warmth of light and spatial intimacy. They go beyond the banality of being mere space. For the inhabitants of underground architecture, the spatial elements provide warmth that can contribute to a rich living experience.

CONCLUSION

It has been argued that underground architecture has great potential as an alternative to aboveground architecture by virtue of its numerous advantages: thermal insulation, preservation of site, security, noise control and ecological considerations. Despite these advantages there are stereotypes which have a negative psychological impact hindering people's acceptance of underground architecture. Therefore the concept of psychological warmth is offered to restore delight in underground architecture and to transform underground building into underground architecture.

The concept of psychological warmth can be applied to underground architecture by two components: the warmth of light and the warmth of spatial elements. Both components are multifaceted in the warmth they create: the fireplace providing an everchanging image of warmth for all the senses, warm colors creating a subtle overall feeling of warmth. A courtyard becomes, on a snowy day, an arena for viewing coldness; on a sunny day, a playground for the warmth of light. The windowseat allows one to become intimate with the warmth of a personal space and, with a turn of the head, be refreshed by a look at the outside environment. The warmth of texture encourages an intimate experience with the surface of a wall or floor.

Underground architecture can not be truly viable without attention paid to the full range of human experience, physiological and psycholo-

gical. By the careful interplay of elements of warmth, the creation of static, cold feeling places can be avoided and warmth can be experienced in underground architecture.

FOOTNOTES

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- (3) Gary O. Robinette, Plants, People and Environmental Quality (n.p.: National Park Service, 1972), p. 36.
- (4) Thomas Bullfinch, The Age of Fable (Philadelphia: David McKay, 1898), p. 182.
- (5) Ibid.
- (6) Ibid., p. 68.
- (7) Ibid., p. 144.
- (8) John Milton, Paradise Lost (N.Y.: Odyssey Press, 1935), pp. 342-8.
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- (10) Alighieri Dante, Inferno (Bloomington: Indiana University Press, 1971), p. 231.
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- (13) Edwin Miller, ed., Eyewitness: The Industrial Revolution in the North East (Newcastle-upon-Tyne: Sunderland College of Education, 1968), pp. 19-20.
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- (24) Christopher Alexander, Houses Generated by Patterns (Berkeley: Center for Environmental Structure, 1969), p. 125
- (25) Christopher Alexander, A Pattern Language (New York: Oxford University Press, 1977), p. 1089.
- (26) Peter Pragnell, "The Friendly Object," Harvard Educational Review, Vol. 39, No. 4, 1969, p. 36.
- (27) Ibid.
- (28) Committee on Colorimetry, op. cit., p. 117.
- (29) Gaston Bachelard, The Psychoanalysis of Fire (Boston: Beacon Press, 1964), p. 14.
- (30) Maurice Blanchard, Le Temps de la poesie (Paris: G.L.M., 1948), p. 32.
- (31) Noel Arnaud, L'etat d'ebauche (Paris: n.p., 1950), p. 127.
- (32) Bachelard, The Poetics of Space, op. cit., p. 137.
- (33) Pierre-Jean Jouve, Lyrique (Paris: Mercure de France, 1956), p. 59.
- (34) Alexander, Houses Generated by Patterns, op. cit., p. 138

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- Fig. 3 Ibid., p. 125, 128.
- Fig. 4 Ibid., p. 219.
- Fig. 5 Ibid.
- Fig. 6 Georges Bataille, Lascaux (Switzerland: Skira, 1955), p. 45,48.
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- Fig. 9 Anthony Burton, The Miners (London: Andre Deutsch Limited, 1976), p. 48.
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- Fig.13 James Brett, Looking into Houses (New York: Watson Gupstill Publications, 1976), p. 159.
- Fig.14 Ibid., p. 24.

Fig. 15 Ibid., p. 175.

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Fig. 17 Myron Goldfinger, Villages in the Sun (New York: Praeger Publishers, 1969), p. 59.

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EXPERIENCING WARMTH IN UNDERGROUND ARCHITECTURE

by

MICHAEL DAVIS GREENE

(ABSTRACT)

Architecture which is partially or totally beneath the earth's surface has the advantage of the high insulative capacity of the soil. As a result it takes less energy to warm an underground building than a comparably sized aboveground building.

However, many people consider underground architecture to be psychologically cold. This thesis shows that there is more to warmth than the much publicized thermal aspect. There is also a psychological warmth which is just as necessary as the physiologically based thermal warmth for the creation of viable underground architecture. Understanding in the areas of both psychological and physiological components of warmth will contribute to the creation of an experience which is holistic in nature.