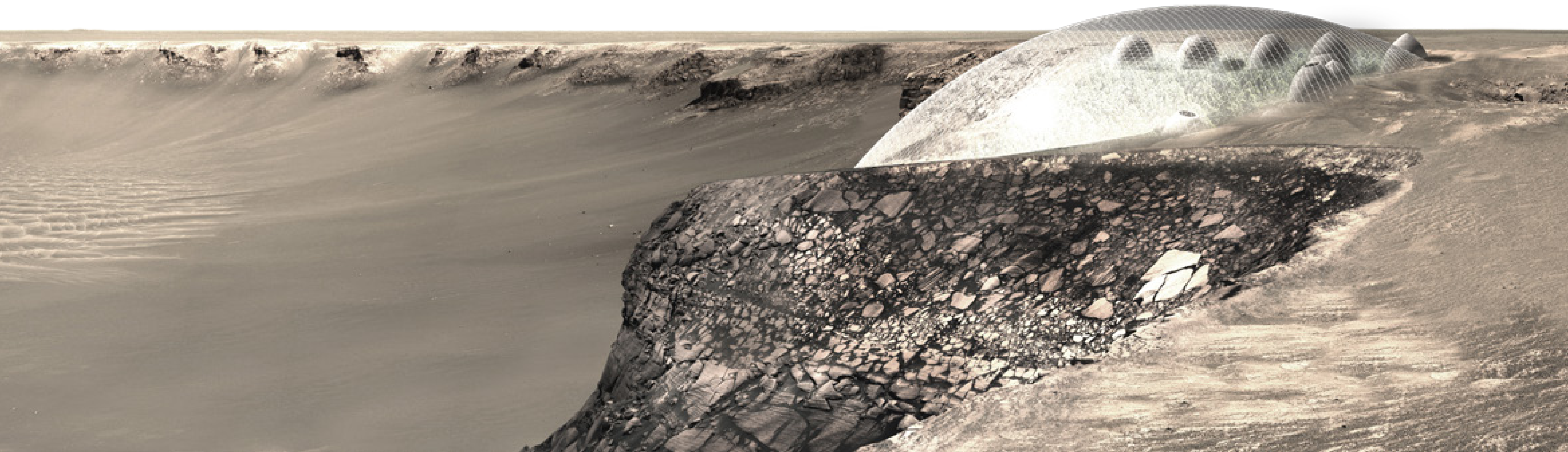
NEXT GIANT LEAP



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ABSTRACT

This booklet presents an architectural design proposal for a human settlement on Mars. The aim of the project is to combine technical values for surviving with soft architectural values for living. This by amplifying local materials, the atmosphere of the site and the building methods in this new context.

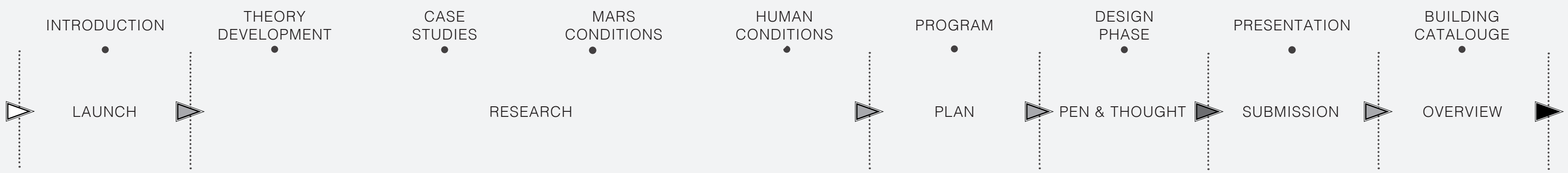
Analysis of vernacular building methods and utopian architectural ideas sets the frame for the project and is the foundation for a new theory focused around the terms ‘Tradition and Vision’. Tradition in the sense of learning from the structural principles of vernacular architecture and defining what spatial gesture arises from these building methods. And vision in the context of renewing and rethinking the way we live and build, to set the frame for a more sustainable future.

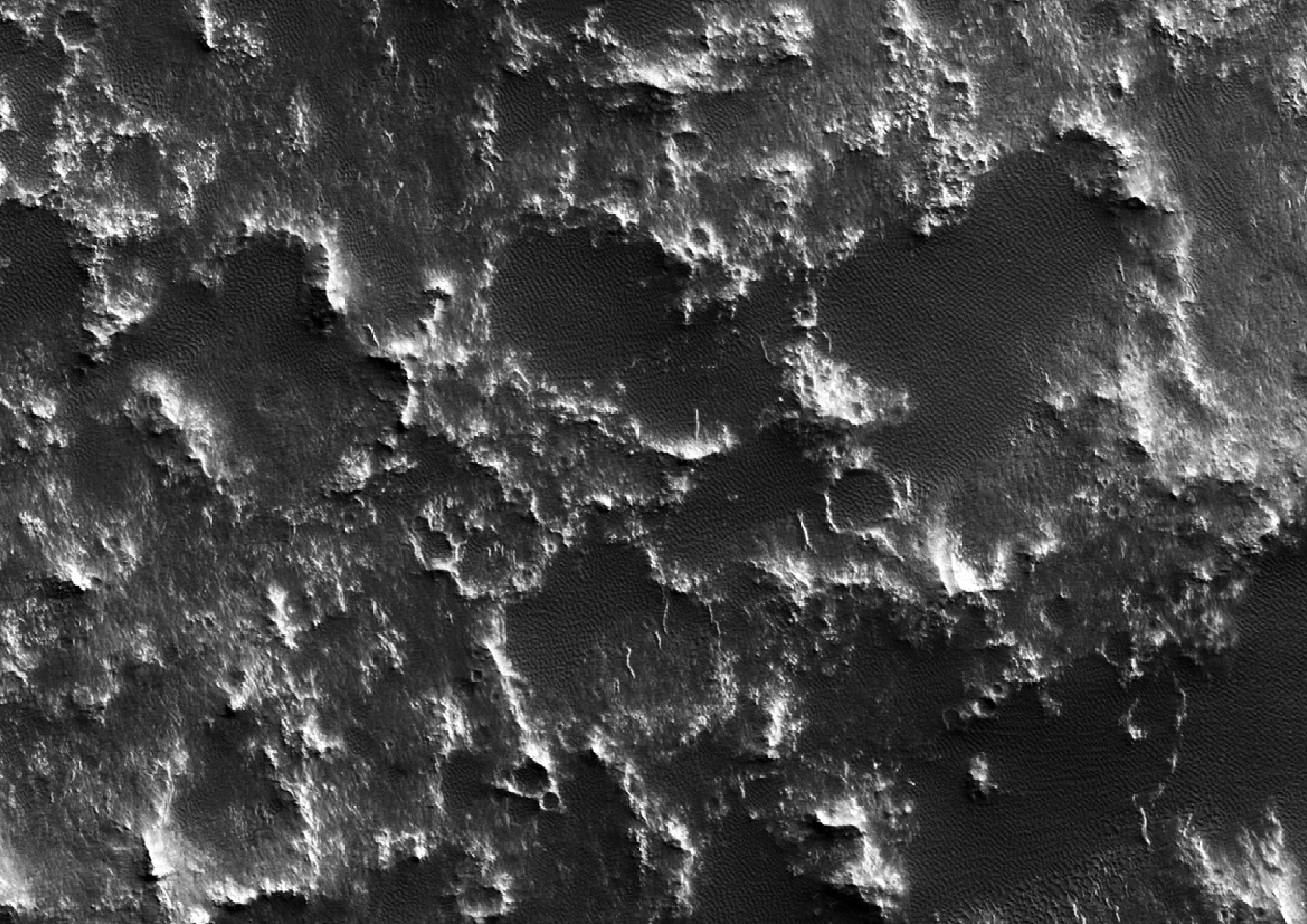
As a result of this theory a small community of approximately 200 people is designed with a focus on the structural membrane to obtain the possibility for life, and additionally a more profound design of a housing complex and a cultural center is developed - a product in the light of the theory ‘Tradition and Vision’.

TABLE OF CONTENT

READERS GUIDE

This Master Thesis booklet is divided into nine chapters. Every chapter is built up by an introduction with a simple table of content, to give the reader a simple overview of the chapter. The illustrations throughout the booklet is indi¬cated with the current page number and a letter following the alphabet, while the written content is referenced according to the Harvard Method. [Harvard, 2015]. Calculations and technical iterations to support the content are attached in a separate appendix.

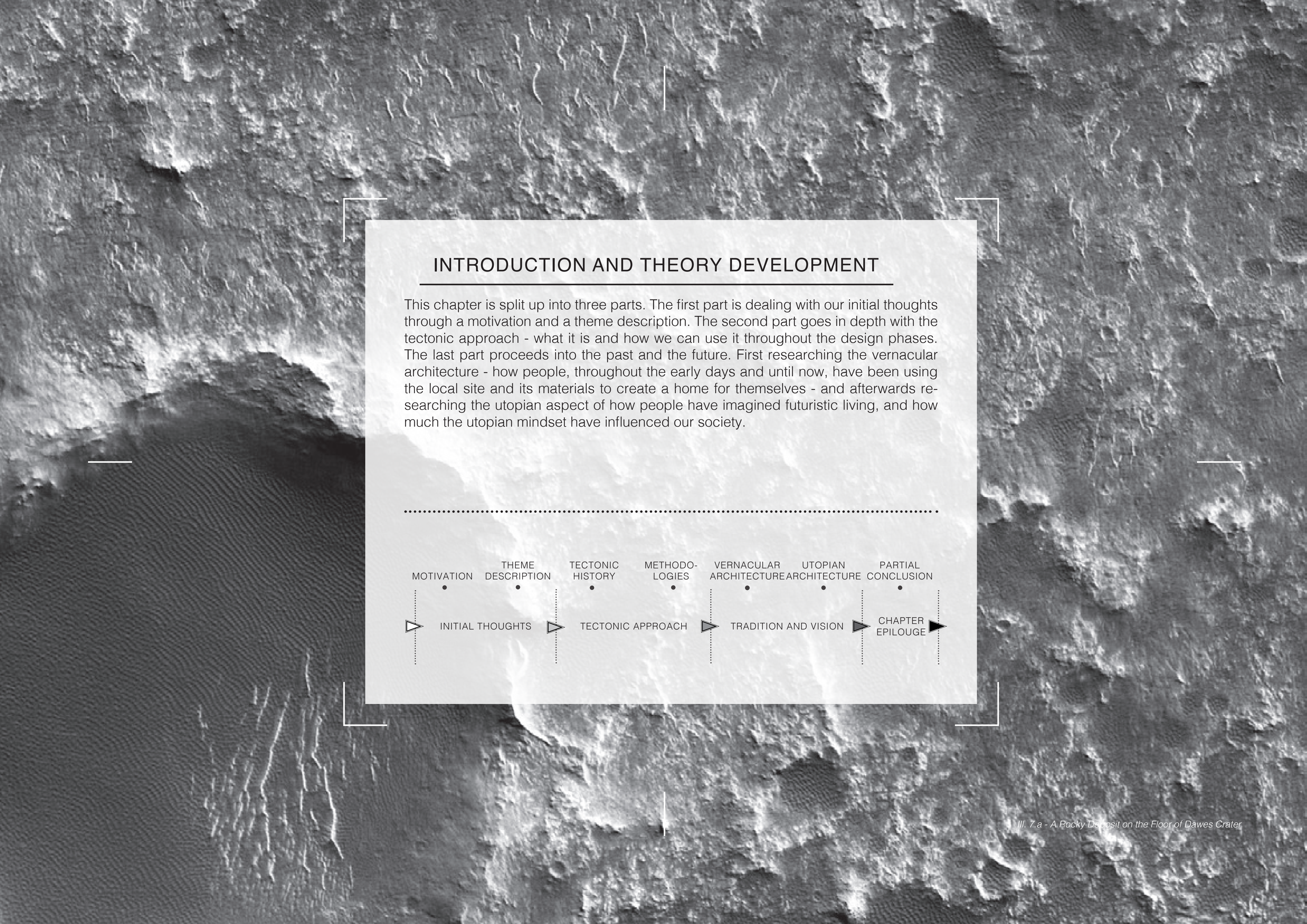




INTRODUCTION AND THEORY DEVELOPMENT

This chapter is split up into three parts. The first part is dealing with our initial thoughts through a motivation and a theme description. The second part goes in depth with the tectonic approach - what it is and how we can use it throughout the design phases. The last part proceeds into the past and the future. First researching the vernacular architecture - how people, throughout the early days and until now, have been using the local site and its materials to create a home for themselves - and afterwards researching the utopian aspect of how people have imagined futuristic living, and how much the utopian mindset have influenced our society.

MOTIVATION
THEME DESCRIPTION
TECTONIC HISTORY
METHODO-LOGIES
VERNACULAR ARCHITECTURE
UTOPIAN ARCHITECTURE
PARTIAL CONCLUSION
INITIAL THOUGHTS
TECTONIC APPROACH
TRADITION AND VISION
CHAPTER EPILOUGE



Ill. 7.a - A Rocky Deposit on the Floor of Dawes Crater

MOTIVATION

Throughout time the human species has adapted to extreme living conditions around the planet. Initially with the essential goal of surviving in new conditions - and with this goal fulfilled - a new ambition of making a home and focusing on the psychologically needs to create welfare. If the space agencies around the world is to fulfil their next giant vision - the following extreme conditions for the human species to overcome, is the ability to survive on the surface of the planet Mars. This is a challenge that addresses the physical needs of the human biology and just as much the psychological needs of the human mind. Together this is a design task that requires all the knowledge gained throughout the last five years of studies, from parametric additive architecture, self-sufficient sustainable architecture, site-bound local architecture to sensational psychological architecture. All elements should work together to create a new holistic Martian typology, making the place suitable for living and not only visits - generating conditions for the inhabitants to feel free even though they will be living inside an enclosed biosphere.

Together we find this new topic attractive to pursue, and the challenge is a big driving force for us throughout the project.

The project hovers in-between a utopian dream of exploring how far the human kind can reach, and a dystopian scenario of needing to leave this planet due to overconsumption and abundance. In both cases people will be placed on Mars to live the rest of their life. Their children will be born into an artificial biosphere with a natural dream of experiencing Earth. Due to these issues it is important that the architecture does not facilitate the feeling of being trapped but the ability for having sensational experiences inside the limited space.

It is a motivation for us to learn from the architectural experience developed here on earth. To find the good examples of how people built in the past, how architects create poetry in the contemporary architecture and take inspiration in how people visualize the future. It is our vision and a great motivation to bring all these qualities together towards a bright future, and push the Martian vernacular in the direction of a sensational and human-oriented typology, with great understanding and respect for the untouched location. It is a motivation to inspire and be a reference for future buildings on other planets, pushing the boundaries for the nearly impossible, with the people in focus, not only to survive - but to live.

THEME DESCRIPTION

The rise in sea level, the increased global temperature and the growing amount of human inhabitants living on earth has an impact on this planet and could potentially force humankind to seek residence elsewhere in the cosmic. More than six different space agencies have in the past few years planned and publicized their future human Mars mission. Including both governmental and privately funded brands as; NASA, ESA, CNSA, Boeing, SpaceX and Mars One. All of these with the same goal - To make humans a multi-planetary species within the next two decades. [Wilson, 2018] Martian architecture is a complex concept to realise, it questions absolute banal elements of surviving such as sustaining water, nutrition, oxygen and temperature? Furthermore, general terms normally taking for granted have to be re-examined, such as daylight cycle, gravitation, radiation, daily routines, seasons and temperature. Two main themes is selected, with respective subthemes: “How would mankind survive on Mars?” and “How would mankind live on Mars?”

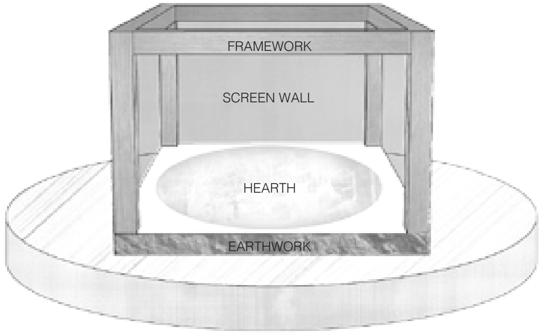
How would mankind survive on Mars?
The human body have specific conditions for survival, the essential the human biology is nutrition, water, oxygen and a temperate climate. These are the main and first priorities for survival, and should be researched in order to be able to design a proper habitat.
An architectonic habitat which house an artificial biosphere with a temperate and pressurized climate inside, but as well protected from harsh environments and radiation from outside. This approach could be designed modularly, allowing for urban extensions in a parametric sense.

How would mankind live on Mars?
The thesis is based upon a population which has arrived on Mars, it is a post-arrival project. The general concept of this project is to create a proposal for a self-sustaining community on Mars, a place where people give birth and live a lifetime, a place to call home. This part of the thesis will go in depth by investigating different modern opportunities of building the artificial biosphere, which need to house both agriculture, homes, working spaces, functional- and recreational spaces and as well focus on the human sensations.

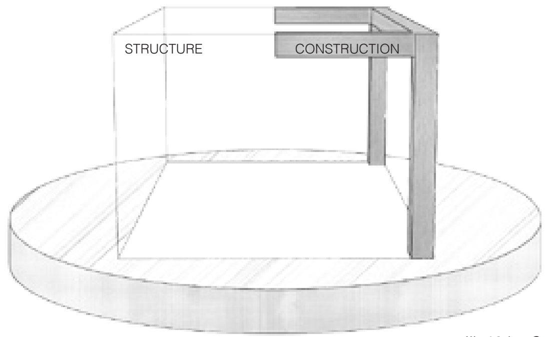
Vision
The vision of the project is to create a Martian typology, with the desire to design a comfortable habitat on Mars, for a small self-sustainable community. A typology where we work together with the site conditions and use the local resources. This community should function inside a pressurized biosphere, where the everyday life should be reconsidered and optimized to create a comfortable human living - giving atmosphere and human sensations to Mars without a feeling of imprisoning. The vision for the project is furthermore to serve as an inspiration for future habitat projects on Mars, and to accelerate the process of making humankind a multi-planetary species.To make all these elements come together into one symbiose, we think of this as a great tectonic challenge of combining technical parameters with architectural qualities. To really understand tectonic here on earth and use it as a fulcrum in the project on Mars, the tectonic history is studied.

THEORY DEVELOPMENT

TECTONIC HISTORY



Ill. 10.a - Semper



Ill. 10.b - Sekler

Before creating a vision for a future tectonic approach to Martian architecture, it's important to understand tectonic and its influence here on earth. What is tectonic in architecture? Tectonic is by many architects referred to as the utmost a building can achieve, a symbiosis of the technical and aesthetic, gathered in the structure of a building, but is it more than this? Does it also have a cultural or a spatial element? And can we, by learning from the tectonic history and development, improve our methodology mindset in architecture?

The notion of 'Tectonic' origin from the ancient Greek - referring to a carpenter or a master builder - unfolded from the word 'téctón'. The first reference to this word was through Homer's writings in the ancient Greece. Where it was alluded as the 'art of construction'. And again, later in the same period by the writer Sappho, where she refers to a téctón as a craftsman assuming the role of a poet. [Frampton, Frampton and Cava, 1995]

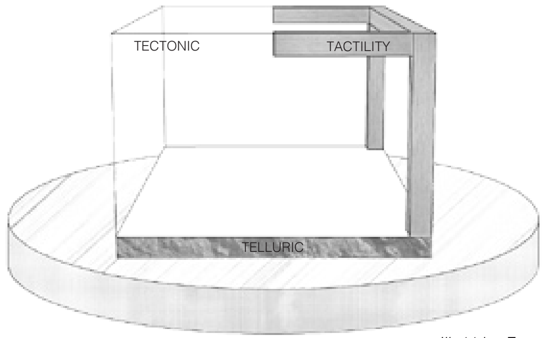
The first person to define the word tectonic as a blend of art and practical matter was German Karl Otfried Müller during the 1830's, where he relates tectonic to all architectural aspects from utensils to dwellings. Later, also in Germany, Karl Bötticher further develop the definition from Müller. He divides architecture into two aspects, core form and art form. The core form could be seen as the structure of the building and the art form as the ornament. The art form should never obscure the core form, but rather emphasize or underline the structure for achieving true tectonic. [Frampton, Frampton and Cava, 1995]

Later in 1851, tectonic was provided with an anthropological socio-cultural aspect by Gottfried Semper. He segregated the primordial dwelling in four elements through his book 'Four Elements Of Architecture'; Earthwork, Framework, Hearth and Screen Wall [Semper, G. 1851], as illustrated in Ill. 10.a. The first two representing the ontological or technical elements of architecture and the latter being more representational or symbolic. These elements were not an attempt to specify a specific typology of architecture, but more an attempt to create a general theory of architecture.

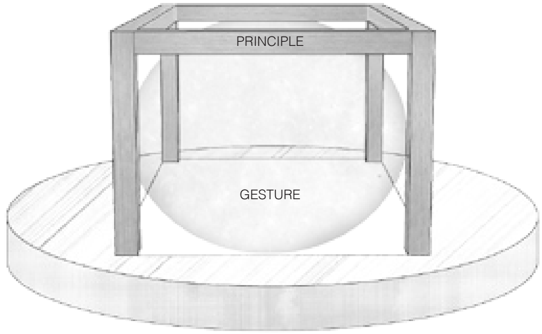
In 1965 Eduard Sekler wrote the essay ´Structure, Construction, Tectonic´ in which he specifies that there should be a strong relationship between the artistic expression of a building, and the constructive logic. [Sekler, 1965] These together should highlight the space and function in architecture. Sekler, just as Bötticher, emphasize the importance of clarity in architecture, he separates the concept of structure and construction into two different elements; The structure is the overall static system of a building, the construction is the elaboration of this system, dealing with detailing of the joints and the materials as illustrated in Ill. 10.b.

A decade later Vittorio Gregotti picks up Semper's social aspect of tectonic, he clearly emphasizes the importance of bringing the context and nature into interpretation when designing architecture and tectonics where he states;
"Before transforming a support into a column, a roof into a tympanum, before placing stone on

Ill. 11.a - Nordberg-schulz



Ill. 11.b - Frampton



Ill. 11.c - Hvejsel

stone, man placed the stone on the ground to recognize a site in the midst of an unknown universe: in order to take account of it and modify it." [Frampton, Frampton and Cava, 1995, p.8]

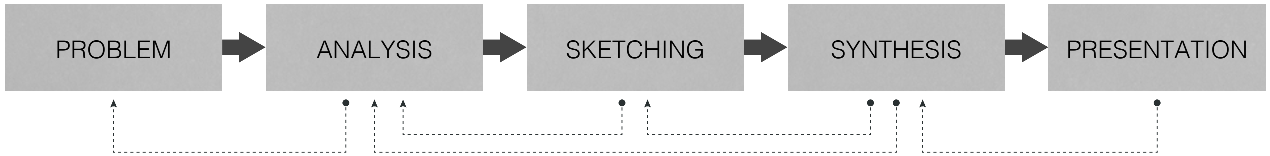
In the same decade Christian Nordberg-Schulz writes a book 'Genius Loci (towards a phenomenology of architecture)' concerning the spirit of the place and the interaction between the natural and the manmade. [Nordberg-Schulz, 1996] He describes a location or a place out from tangible phenomena like; Earth, Light, Shadows Trees and Stones and intangible phenomena - feelings and atmosphere - perceived through these tangible phenomena. Emphasizing the importance of caring for- and using the context and the local resources to influence the manmade spaces. Ill 11.a.

Around the same period Kenneth Frampton repositioned the tectonic theory through his writing ´Towards a Critical Regionalism, 1983´ and book ´Studies in Tectonic Culture, 1995´, he applies tectonic as a tool of architectural criticism and analysis. Frampton's work is in some part a countermovement to the modernism, and he places architecture in the intersection between human realization and technology development. He refers to Sappho's statement of architecture being poetry and that architecture should contain three elements for achieving poetic unity; The Tactile, The Tectonic and the Telluric as illustrated in Ill. 11.b.

In 2017, Marie Hvejsel also picks up on the poetry of architecture, through her writing ´Gesture and Principle´. [Hvejsel, 2017] She repositions tectonic a step further from Frampton and applies it as a critical method in architecture. She refers to tectonic in architecture as the unity of gesture and principle – Gesture as the phenomenological awareness of a spatial quality perceived from the architectural form. Principle as the structural system clearly generating this architectural form – seeing tectonic as an interplay between a phenomenological gesture and a technical principle. See Ill. 11.c. By working both with gesture and principle as a critical methodical resource throughout the design process, it enhances the chances of improving the final product and hereby enriching the everyday life of the user.

Analyzing these historical highlighted theorist and their approach to tectonic, we observe that they all work inside the spectra of four elements; Aesthetic, Socio Cultural, Structure and Materials. They also have a common denominator when looking at the importance of the joint in the structure. After the modernist period, tectonic thinking is starting to be applied as an academic tool, and it is probably here the theorist is divided the most, Frampton – using tectonic as a critical tool for analysis – and Hvejsel – using tectonic as a methodological tool for designing. Can we, by applying this knowledge to our design process, create Martian architecture with our own interpretation of tectonic and use it as a generator?

METHODOLOGIES



Ill. 12.a - Integrated design process [Knudstrup, 2003]

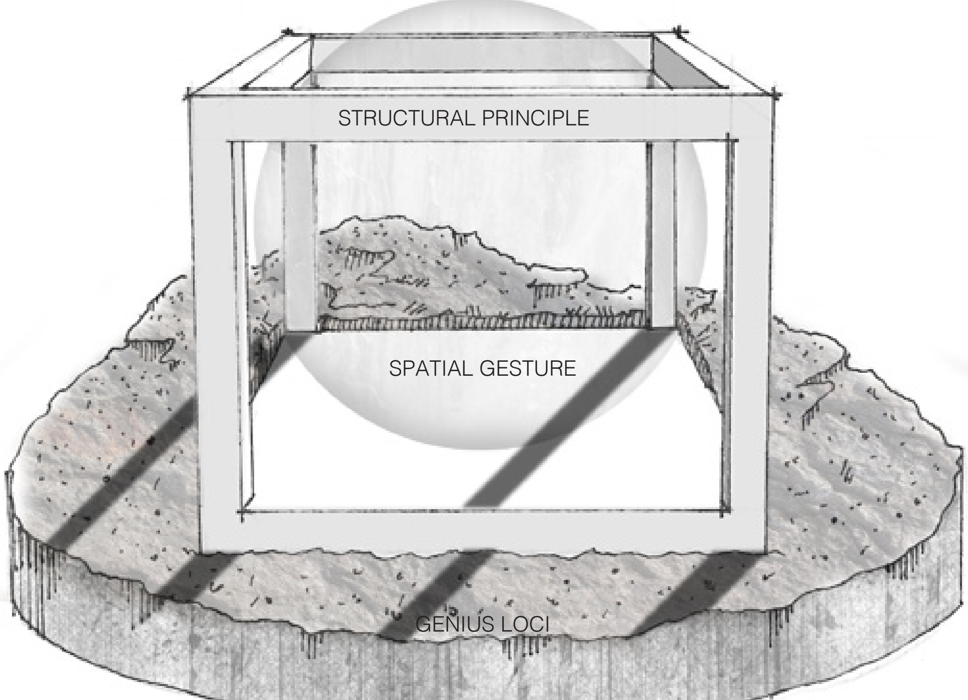
Integrated design with tectonic as a generator

To incorporate the knowledge from the tectonic history into our design process, the process of contemporary design is investigated. The process of designing a building today is very complex, demands in the building sector is increasing as a result of the technology development and higher legislative demands. Due to more complex buildings, it is important for the engineer and the architect to combine their knowledge early in the design process. In 2003, Mary Ann Knudstrup wrote an essay on this uniting process between the different professions called ´The integrated design process´. [Knudstrup, 2003] This is an iterative process with the purpose of creating a holistic approach between the engineering knowledge and the architectural practice. The iterative process is built up of five phases; Problem, Analysis, Sketching, Synthesis and Presentation as shown in illustration 12.a.

In this integrated design process, we sometimes find a gap in-between the analysis and the sketching phase, kind of a missing part to kick start this next phase of the design process. In the book by Bryan Lawson, ´How designers think´, [Lawson, 1997] Jane Darke writes about having a generator in the design process. This generator is an aspect of the problem, used to keep the project in a certain direction and used as a guide line to maintain the project on a chosen course. The risk in this method is to choose a too complex or concrete generator, for then to create more obstacles than necessary and hereby slow down the process.

We propose to implement a selection of elements from the tectonic readings into this integrated design process - the principle and gesture as described by Hvejsel, combined with the focus on the environmental aspect described in Gregotti's quote and in the book from Nordbjerg-Schulz's 'Genius Loci'. To then use these as a primary generator, to ensure that we retain the poetry in all elements of the project and hereby incorporate both the principle and the gesture in the general concept, as well in the joints and detailing part of the project. It is difficult to imagine the genius loci of a place no man has ever visited, but it is important for the design to try and emphasize the phenomena of the place and the local available materials. To take the local resources into considerations could be an essential factor, when the building is located on a site with limited imported means.

In our methodological approach we propose ´Gesture´, ´Principle´ and ´Genius Loci´ to be the fulcrum in this integrated design process. To function as a generator and keep the project on track. To fully understand how to use the environment in a place as a structural principle - generating spaces full of gesture and poetry – vernacular architecture is investigated.



THE STRUCTURAL PRINCIPLE
GENERATES A SPATIAL GESTURE
WITH USE AND INFLUENCE FROM NATURAL PHENOMENA

Ill. 13.a - Tectonic elements as generators

VERNACULAR ARCHITECTURE

Vernacular architecture is based on local needs and the materials available in the building area. The building fulfils the fundamentals of surviving in the given area and society, and therefore the architecture varies a lot over the world, according to climate, culture, tradition etc. The building methods are based on local traditions, and the skills of the locals, and are evolved through generations constantly improved towards the optimal.

Many societies have therefore achieved a sublime ecological balance, between the available resources and their consumption of them. [Oliver, 2006 p. 3-16] According to building in a new undiscovered environment such as Mars clearly demand an investigation of vernacular architecture, its tectonic in form of the principle, the gesture, the use of materials, simplicity and the ecosystems.

"Where did it all begin?" is a question asked many times through history and in architecture. The search for the origin in the vernacular architecture, is first described in 1753 by Laugier, in his "An Essay on Architecture" where the primitive hut appears as a place of origin, and not as much as an actual building as we know it. Later on, a lot of theorist has searched the origin of the "primitive hut", among them Gottfried Semper who did not agree with the perceptions of Laugier , he wanted to discover the ultimate forming principles in architecture, and if necessary go further back in history in his seek. [Hale, 2005]

He wanted to determine architecture in a new approach where he classified it in functional and material characteristics. He worked from the Vitruvian point of view, were the hut was an effort to protect the fire, newly discovered.
He describes the fire as the first gathering point, which is the hearth, and the most important thing of a settlement, around the hearth the last tree elements are grouped, the roof, the enclosure and the mound. These three elements are the defenders of the hearth against the hostile elements of nature. This is his starting point of his tectonic approach later refined to Earthwork, Framework, Hearth, and Screen Wall, as described earlier. He

Ill. 14.a - Tungkwan settlement under ground

also assumed that the skills of the craftsmen had its starting point from these four elements.
Ceramic around the hearth, water and masonry around the earthwork, carpentry around the framework, and the art of weaving and decorate to make the enclosure. [Semper, 1851].
Many years of improving these skills passing on the experience, has made it possible to make larger societies in what would seem like barren places. It is what Bernard Rudofsky describes at his exhibition at the museum of modern art in 1964, and afterwards in his book "architecture without architects", where he gives a short summary of some of the different types of vernacular architecture.

Building methods:
The simplicity in the design of the nomadic architecture drags clear references to Semper' tectonic theory of Earthwork, Framework, Hearth and Screen Wall. The light framework of wooden sticks, and the woven screen wall makes them easy to pack down, and easy to carry around seeking food or exploring new living sites.

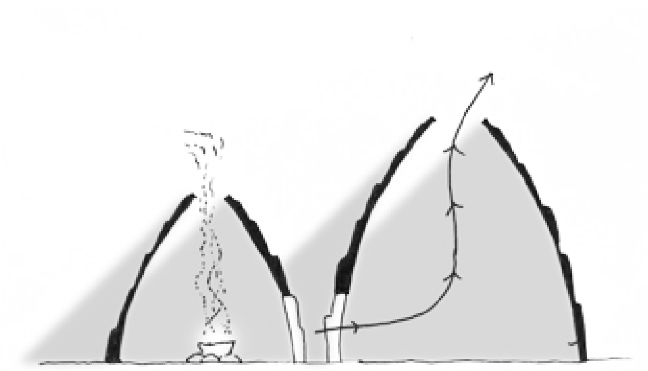
Other cities are troglodyte cities, dug in the ground or carved into larger mountains or valleys, using an already existing structure to build upon. Some of the most extreme underground cities are the large (ten million people) Chinese cities Shansi and Shensi, placed in the Loess Belt. Loess is silt and easy to dig in, this makes it possible to have a community of houses, schools and hotels underground, and fields on top to provide some of the needed food. It minimizes footprint area of the city, and benefits the houses with a comfortable indoor climate with a large thermal mass keeping it cool in the summer and warm in winter. The underground city is lighted with large pits working as staircases to the apartments, and smaller multi functional holes working as light intake and chimneys.

Carving into mountains and using the material to ad buildings outside the hill is an often-used technique in many different areas of the world. [Rudofsky, 1964]

The city Petra, Jordan, the dwellings in Mesa Verde, Colorado and perhaps the most Mars like area to place a city must be the city, Apanomeria, Greece. It is placed on the edge of a volcano crater, and the buildings are all alike with very little variation, this makes the city almost endless to look at. They are made of the materials from the site, and then coloured white, making great contrast to the lava rocks.

Investigating the Mugsung Mud Huts, in Cameroon, in the central part of Africa. (See Ill.16.a and 17.a) We find a clear example of how the shape of the building - developed over centuries by local habitants - is optimized for the different phenomena in the area. The building shape is a compression optimized structure, taking form after a catenary to withstand a high amount of load with a minimal use of material. The material used for the shape is local reeds from the area cladded with mud. The shape of the building generates an aesthetic value. Both in a visual sense and in a phenomenological sense where the structural principal provides an internal gesture for the inhabitants. The form has the ability to natural ventilate the space due to an opening in the top, an opening that also works as a light intake – staging the phenomena of light and shadow and the change in day and night. This opening is also a functional escape route, used when the area is flooded.

Living a simple life in a building like this, with the minimal use of building structure, or digging in ground living the life of a troglodyte, or using old volcanoes as building sites, is a big inspiration to attempt a good living conditions on Mars, they are well known and thoroughly tested housing types using only what the site can offer of building materials. It is clear that these building techniques would cover the fundamental needs of surviving, but what if the new Martians want more than this? Would it be possible to rethink these vernacular methods – emphasizing the tectonic approach of structural principle, spatial gesture and the use of the local phenomena – and bring it into a new almost utopian and visionary future, focusing on a high sustainable living standard and an optimized healthy society. To get an understanding of the utopian mindset, and what influence the visionaries have had on the society, utopian architecture is investigated.

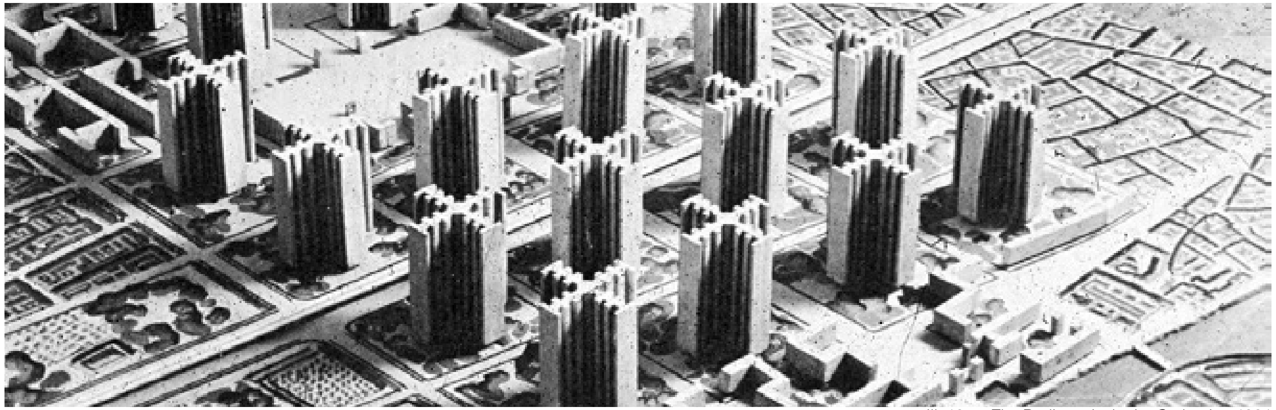


Ill. 16.a - Mugsum Mud Huts, Conceptual Section

Ill. 17.a - Mugsum Mud Huts, Cameroon

THEORY DEVELOPMENT

UTOPIAN ARCHITECTURE



Ill. 18.a - The Radiant city by Le Corbusier, 1924

Building on Mars is a romantic thought scientifically speaking, it seems so distant and surreal. Visionary script- and book-writers have given us their beliefs through time of how the future will be like in both lifestyle, architecture, technology and appearance. They have tried to predict the future for better or worse, through utopian and dystopian visions.

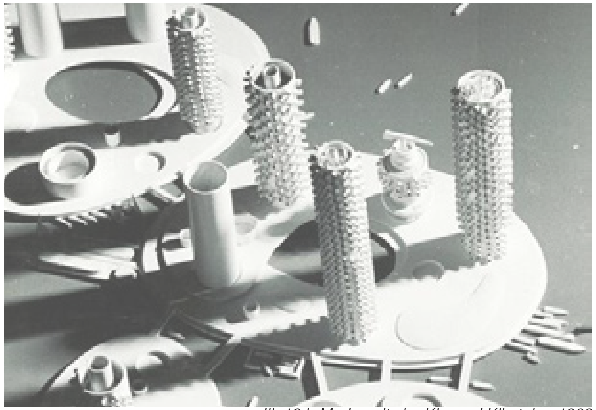
Utopia elaborated by Oxford Dictionary: "An imagined place or state of things in which everything is perfect" and dystopia: "an imagined place or state in which everything is unpleasant or bad, typically a totalitarian or environmentally degraded one". A martian colony is a utopian fantasy, but could just as well end up being a dystopian concept.

Visualizing imaginary places have been done throughout history. Plenty examples lies in observing different religions, they have different views upon the specifics, but the general place of utopian and dystopian afterlife is similar. Thomas Talbot writes how the religion of Christianity allow good people to go to heaven, being rewarded with an virtuous life, while bad people go to hell to be infinite punished.[Plato.stanford.edu, 2018] These imaginary places may have encouraged worshippers to improve in life and therefore strive for heaven, for something better.

The first known man to document a utopian idea is Plato (427 - 347 BC), he called it the "Republic". In it he explains a Greek society which emphasize justice, ethics, equality, political theory, philosophy and moral to help each other, despite social rank. Some of these traits was neglected in society at that current time, and therefore Plato envisioned an imaginary place for the better, a utopian city, explained by Colin Starnes where he partially comment upon the Republic in "The New Republic" 1990. Plato's proposal probably provoked former societies, but at least it ignited a spark for future imagination. [Iep.utm.edu, 2018]

Throughout history great visionaries have designed utopian cities, life and technology. But the manifestation of Utopian Architecture is said to have originated in the period of the Renaissance, hence Fillippo Brunelleschi (1377 - 1446 AD) invented the "Linear Perspective". This technological development in visualization methods allowed designers to challenge the ordinary architecture scene towards a more experimental. [Harbison, 1993] The uprising revolution in different technologies inspired mankind and glimpsed the potential to enhance human life. In the book "State of the Art" Richard B. Halley and Harold G. Vatter mention that:" Technology occupies a central position in the thinking of many futurist" on p. 54 l. 15.[Vatter, 1972]

Ill. 19.a - Stuytown planned by Robert Moses, 1942



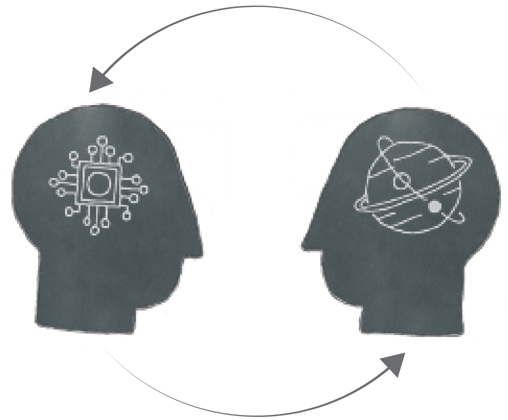
Ill. 19.b Marine city by Kiyonori Kikutake, 1963

Two well known futurist thinkers in the twentieth century was Le Corbusier (1887-1965) and Frank Lloyd Wright (1887-1959), with their respective projects, the “Radiant city”(1924) and “Broadacre city”(1932). Le Corbusier’s master plan was presumed to be built upon the demolished european vernacular cities, in a strict symmetrical system, favourably for efficient transportation vehicle, but as well to make space for unobstructed daylight and plenty of green spaces. [Merin, 2013] While Le Corbusier thought to create one living machine and centralize the city, Frank Lloyd Wright envisioned another utopian fantasy with the implementation of automobiles and telephones. In “Urban Utopias in the Twentieth century” Broadacre city is explained as a decentralized city as a consequence of the technology that either allowed us to communicate or move in space and therefore overcome long distances in brief moments. This should supposedly scatter people and enabled them to require a piece of land for themself and live a more rural lifestyle. [Fishman, 2016] Even though they weren’t realized and didn’t visualize everything correctly, they had the power to provoke the current state of society, enlight problems or inspirere future work. One good example of a work that has taken inspiration from the Radiant city is Stuy Town on lower Manhattan in New York. Dana Schulz writes it was planned by Robert Moses with its 11.250 apartments, in large separated highrise buildings that covered 25% of the site. The remaining landscape has a feeling of countryside with connecting green spaces and pathways, ensuring pedestrians is detached from vehicle traffic. Just as Le Corbusier partially envisioned, since Robert Moses critically took bits and pieces from the master plan and implement them into his own. To critically re-evaluating a utopian idea and maybe also ask what defines one. This approach will be relevant for our master thesis. To ask ourselves what we want to accomplish with the project and as well how the concept should be perceived. Is it an attempt to predict the future? Provoke the current state of society or strive to continuously inspire mankind to proceed towards an exciting future.

Different visionaries in the twenties century tried to predict future utopian concepts, especially one group occurred parallel to first manned space travels (1961)[Rumerman, 2007] which was the Metabolists (1960). The avant-garde originated in Japan at the World Design Conference, which consisted of a young group of architects and designers. The Metabolists manifested themselves by drawing logical comparisons in between metabolism and cities, which they thought should function as a living organism through a constant and dynamic state of transforming and its infinite expanding possibilities developing megastructures. The structures was imaginated to consist of detachable capsules, that serve as minimum dwelling modules and had a clear inspiration towards spaceships for the interior. [Alison, 2007]

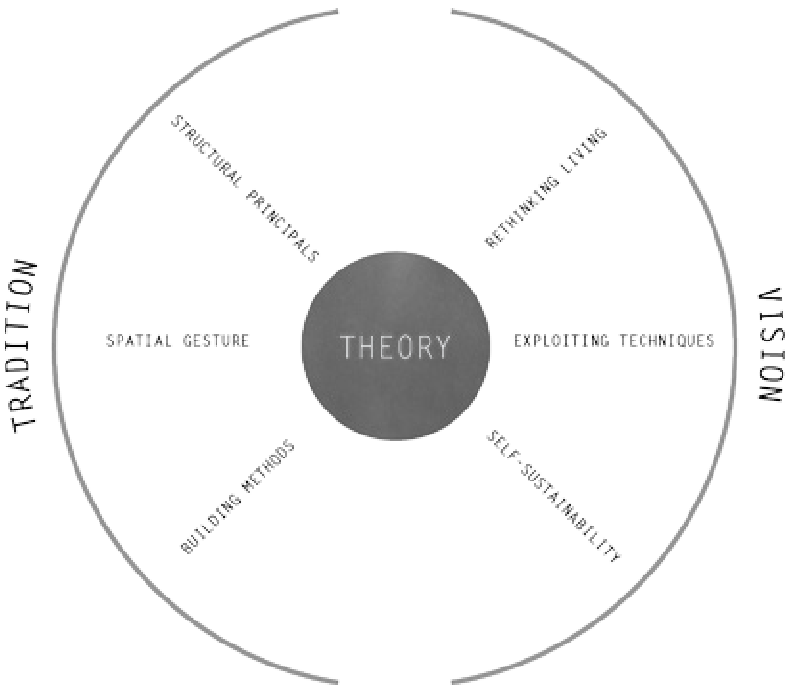
At approximately the same time Roger Anger was working upon a utopian project during the 1960's called 'Auroville - The city of Dawn' (see ill. 19a on page 19), emerged as a countermovement from the present time with global issues. Auroville write themselves it was designed to host 50.000 citizens and the masterplan was divided into different sectors of industry, culture, international, peace, residential with a green belt surrounding it.[Auroville.org, 2018] It launched in 1968 as a new beginning, and new international civilization consisting of 2.500 people with 49 different nationalities concerned with unique values, the citizens is supposedly living by a codex that embrace peace, education, spirituality, progress and exists of one interconnecting self-sustainable city and function as an good example for the future. One could say that the project didn't succeed because of the numbers, but it serves as a inspirational society for the master thesis. The division of the master plan could serve the inhabitant on mars with different spatial experiences, while maintaining effective organization. The metabolism and the Auroville was imagined in the 1960's, so one have to wonder what utopian ideas will happen in our generation?

The purpose of this master thesis' is to evolve into a utopian architectural proposal, which is obligated to move and inspire the ones it reaches, by celebrating those before that walked the unknown as Jane Alison wrote in 'Future City - experiment and utopia in architecture'. Potentially the project should have the ability to change how people think about a Martian civilization. Change their thought from a vivid imagination to an imaginary solutions, into reality. Furthermore, the thesis objective is to enlighten current sustainable problems, both in terms of the global climate, the way we built architecture and our lifestyle today. Present quality of lifestyle should always be challenged and pushed for improvement. Technology have the power to enhance daily quality, but what does utopia? Can it enhance new technology?
Inspirational elements through this chapter have sparked a curiosity to be implemented into the Martian settlement. Several examples is verdant green spaces and rural areas which should be a tremendous part of the living situation for the inhabitants, which should live in larger communities divided into minimum dwelling units. The design needs to emerge from a sustainable scheme as a living machine, which is a complete interconnected self-sustainable and recycling system, with a focus on human welfare, in term of both the physical and psychological qualities.



Ill. 20.a - New technology breed Utopia, but can Utopia breed new technology?

Ill. 21.a - Concept of Auroville by Roger Anger from 1966



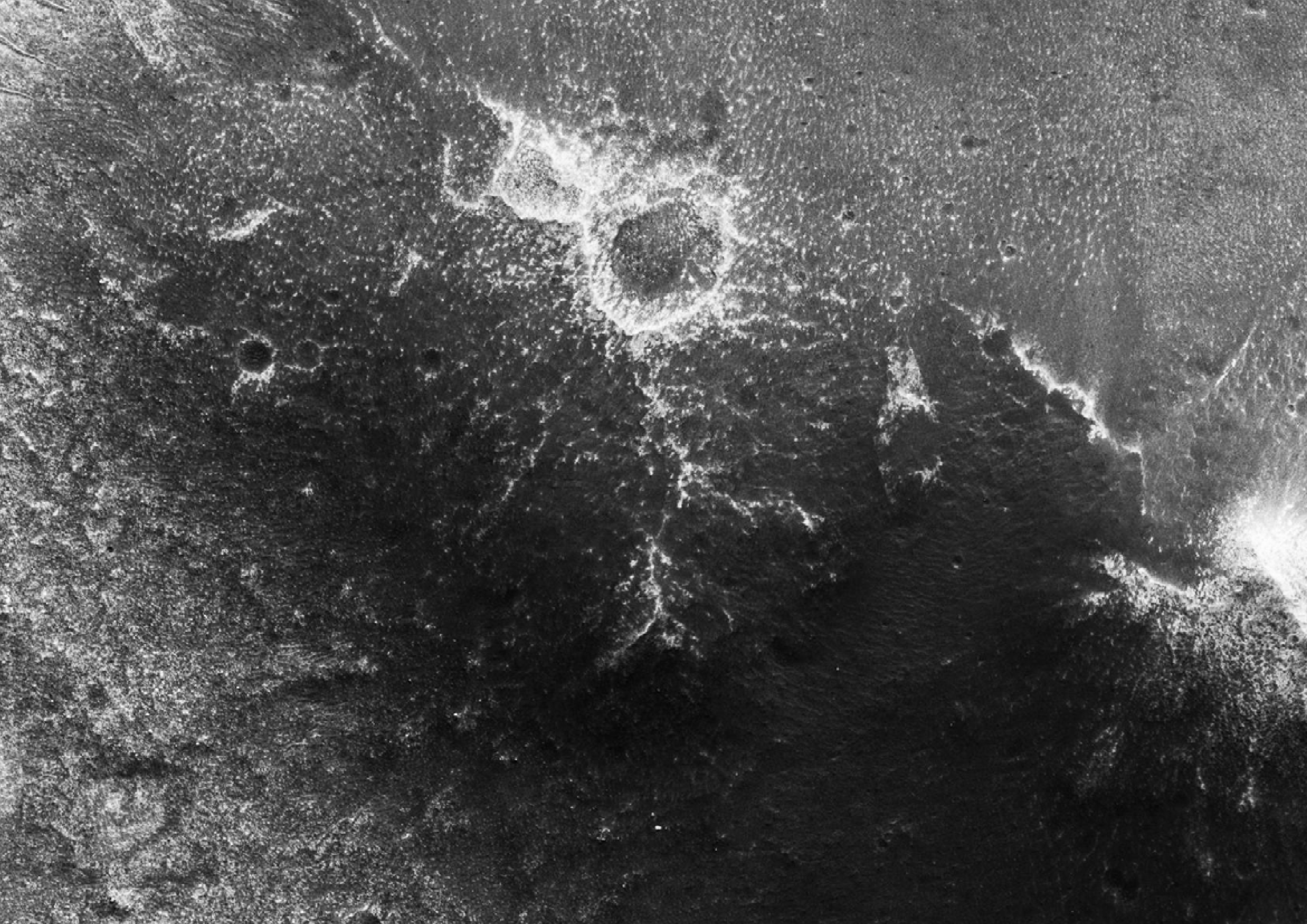
Ill. 22.a - Concept diagram of the theory 'Tradition and Vision'.

PARTIAL CONCLUSION

In the initiating motivation for the project, we describe it as a great tectonic challenge to get all elements in a new design on Mars, to interact as a whole. To understand this challenge, we begin studying the tectonic history. In this investigation of the tectonic history, we discover a focus point throughout history, on the structural principles and how they affect the perception of the natural phenomena as well as the spatial gesture. Elements we wish to bring into a contemporary design process, where we investigate the integrated design process and incorporate these elements from the tectonic history, as generators and pivot for this design process. To use these natural phenomena, spatial gesture and structural principles in an interaction, we search knowledge in vernacular architecture.

In the investigation of vernacular architecture, we discover traditional building techniques, passive strategies, multifunctionality, simplicity, spatial gesture and structural principles. We also discover a lack in incorporation of contemporary techniques and materials, adaption of new technologies and visions for developing the community. This generates an urge to investigate visionary architects' way of thinking - to acquire an understanding of how we can use these traditional technologies in a new mindset. In the study of utopian and visionary architecture, we discover specific common denominators concerning; rethinking the society, exploiting modern techniques to its limit and the creation of a self-sustainable community.

This traditional knowledge, originated from ancient vernacular architects, in a collaboration of a visionary mindset from the utopian architects, is attempted united into one theory – which will be the foundation for the design process – a theory regarding 'Tradition and Vision'.



CASE STUDIES

Assimilating the previous chapter's essence, can be simplified into two words: Vision and tradition. By seeking backwards and beyond in human history, an extensive overview according to the two words, have been found to form a general unifying approach towards a Martian settlement. To convey the words; vision and tradition into examples, two case studies have been chosen to both elaborate the meaning, but as well inspire the master thesis project itself. They are both selected as great examples of contemporary architecture, they both dig deep into their respective traditions and culture, while at the same time being visionary for their time. Parallels can be drawn in between them, while they represent two very different utopian ideas. The analysis are built up by an initiating introduction of the projects genesis, afterwards the projects are analyzed through our interpretation of the words: 'Vision and Tradition' in a story of pursuing each projects essence. Eventually completing it with an epilogue upon the project itself and its potential relation to a martian scenario.

CAN LIS
TIETGEN COLLEGE
PARTIAL CONCLUSION
TRADITION AND VISION
CHAPTER EPILOUGE

Ill. 25.a - Mounds West of Schiaparelli Crater

CASE STUDY

CAN LIS

Can Lis plan drawing Ill. 26.a

The phenomenological experience of being present, in a minimal residence on the southern side of Mallorca, allows moveable emotional reactions to come forth. The use of light, views and the absence of light, in a tropical environment with the necessity of shade, harmonize in the small summer retreat designed by Jørn Utzon.

The building is made of a stone on stone technique - a Spanish tradition that can be traced back thousands of years before common era, where the Spanish people built temples on their islands with local stones. Jørn Utzon used this tradition and hired local craftmen to cut stones out of the site, placing the stones on top of each other, and hereby making the ground rise up and form the space you live in. By using this building technique, the building naturally fits into the surrounding area. Utzon used the stone as the structural principle for the building – each stone cut out and carefully placed, to create a gesture inside the built environment.

All the furniture inside the building is built by Utzon himself together with a local Spanish artist. The furniture is built up of the same sandstone and covered with local tiles. This is also a traditional way of working in Spain. The furniture emphasizes Utzon's vision about the architecture and nature and his vision about the simple life. Utzon's vision for Can Lis was to go back to the simple life and move away from the busy everyday life. To create a house filled with traditions through contemporary means.

These local sandstones that Can Lis is built by is giving tactility to the different rooms – rooms that are arranged to follow the typography of the landscape and orientated to frame the unspoiled view of the ocean. It's a house designed for the senses, with a close relationship between the interior, exterior, the culture and the nature. The design is filled with small details, bouncing light and emphasizing the sensations and atmosphere of the small island, where the house is located. [Weston, 2001]

When Weston is describing bouncing light, a house with the movement of the typography and a relationship between interior and exterior, it can easily be related to Nordberg-Schulz earlier mention of the tangible natural phenomenon affected by the man-made in such a way that it starts to affect the intangible feeling of the place. The emphasizing of the sensations and the atmosphere. A great example of how the structural principle, in interaction with the genius loci, generates a spatial gesture when experiencing the room.

"...A HOUSE UNMISTAKENLY MODERN IN TECHNIQUE AND SENSIBILITY YET SEEMINGLY AS NATURAL AND ORDINARY AS THE SUN, STONE AND SEA WHOSE INTERCOURSE IT CELEBRATES." [WESTON, 2001]

Ill. 27.a - Can Lis

Ill. 28.a - Can Lis living room

Ill. 29.a - Interior detail

Can Lis can be seen as a great example of Critical Regionalism created to oppose the lack of identity or the placelessness of the International Style and at the same time dissociate from the Post-Modern architecture. Architecture should – according to Kenneth Frampton – pay attention to social value, create an understanding of both the cultural and the contemporary means and create harmony between the built environment, the context and the nature. [Frampton, 2001]

Again an example of the importance of the site, but also an example of Frampton seeing Utzon and Can Lis as a countermovement to the international style, a visionary act of pushing architecture against a more phenomenological site-bound position. Frampton find it important to create an understanding of the contemporary means. Which can be seen as not only following the vernacular construction methods of the site, but bring them into consideration, modify them according to the time we live and bring them back into the structural system.

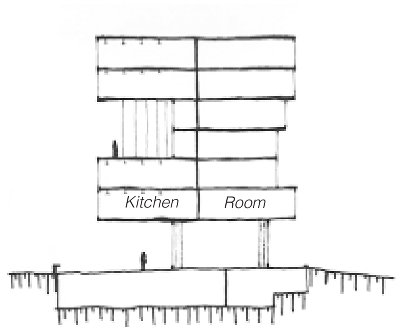
One very clear example of this gesture, created by the structural principle, is in the living room. A small raised window, forty centimetre deep and twenty centimetres wide, makes the sun penetrate the building only thirty minutes each day. Watching this light beam move over the tactile sandstone and highlighting the texture makes you want to rise and feel the building. This half hour movement of light, emphasizes that earth is a spinning globe, and you suddenly feel, that you can see time.

It is a complex paradox to become modern and still return to basic sources, to combine futuristic values with dormant civilization, but it is here – in the contradictions – that we can create moving architecture.

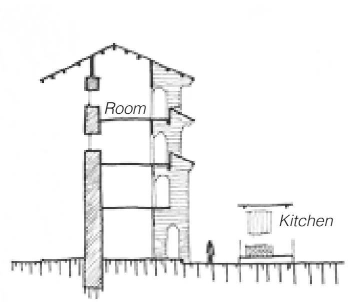
It's important to find the identity of the site and the value of the technology, to then bring both into consideration when designing architecture on Mars – and bring the architecture back to the essential components; the tactility, the natural phenomena like; topography, light and shadow and climate conditions. It's important to understand the spatial created from the structural principal - bringing the essentials together in a holistic design focusing on sensations and people.

CASE STUDIES

THE TIETGEN DORMITORY



Ill. 30.a -Sketch of a section of the Tietgen Dormitory



Ill. 30.b - Sketch of a section of the Chinese Tulou typology

The building is divided into 30 housing groups, each group containing 12 residences, a common room and a kitchen. The common rooms and kitchens are turned towards the centre of the circle and the residences turning towards the periphery, giving the residents the possibility to look out of the small community, having a sense being a part of something larger. The building encircles one large courtyard, working as a transit area where people is meeting when circulating in and out of the dormitory, and at the same time function as one large common room, creating space for larger events. The bottom floor contains all the practical common rooms, such as laundry, bicycle garage, and a courtyard - making the entire bottom floor a place to meet. [LT Architects, 2007]

The choices of interior materials in the dormitory are simple and elegant, gesturing residents with tactile concrete walls and birch plywood storage and varnished oak for the window frames. The smooth concrete walls are working as the buildings framework in the form of a static disc/deck system. Making the large extrusions of the common rooms possible. The integrated storage made of birch plywood, are binding the building together making the rooms seems larger and are easier exploited. The warm light brown oak frames are contrasting the concrete and framing the views.

Right from the start the Tietgen Dormitory was meant to be something special. It is a gift from the Nordea-foundation with the vision of designing the future dormitory, regardless of price. Lundgaard & Tranberg architects made this possible by designing a circular seven stories building, using an old traditional Chinese building typology, combined with modern construction methods. [DAC, 2018]

These round Chinese buildings encapsulates small communities in the center of the 4-5-story outer buildings with diameters up to 75 meters, housing around 30 families - this typology was traditionally created as a defence against other family clans. The families are living together across generation and helping each other through the everyday life. All their common areas are placed on the inside of the protective shell. [Knapp, 1992]

The Tietgen Dormitory drags clear concept references to this vernacular Chinese building typology of the round ´tulou´ buildings or translated to ´earthen’ buildings traced back to the seventeenth century. The concept of both buildings is to create a spatial gesture in the centre of the building where the habitants feel safe and home due to the structural principal surrounding them. Lundgaard and Tranberg have used this venarcular shape as reference and redesigned it for fitting the new context and the modern society and culture, where the building is located. A great example of combining tradition and vision into one building.

Ill. 31.a - Courtyard Tietgen Dormitory

Ill. 32.a - Interior Tietgen Dormitory

Ill. 33.a - Extrution of the common area

Entering the Tietgen Dormitory the inner walls are decorated with prints in different colours and patterns contrasting the clean pale colours of concrete and birch plywood. These prints are individual for each housing group and are not only used as a decoration but also just as much as "tribal" mark dividing the community in small families. It seams like a renewable of the envelope described in Gottfried Semper's tectonic researches, described in the previous chapter, where individual weaving technique and patterns are used in many of the small societies to proclaim status or affiliation to a family.

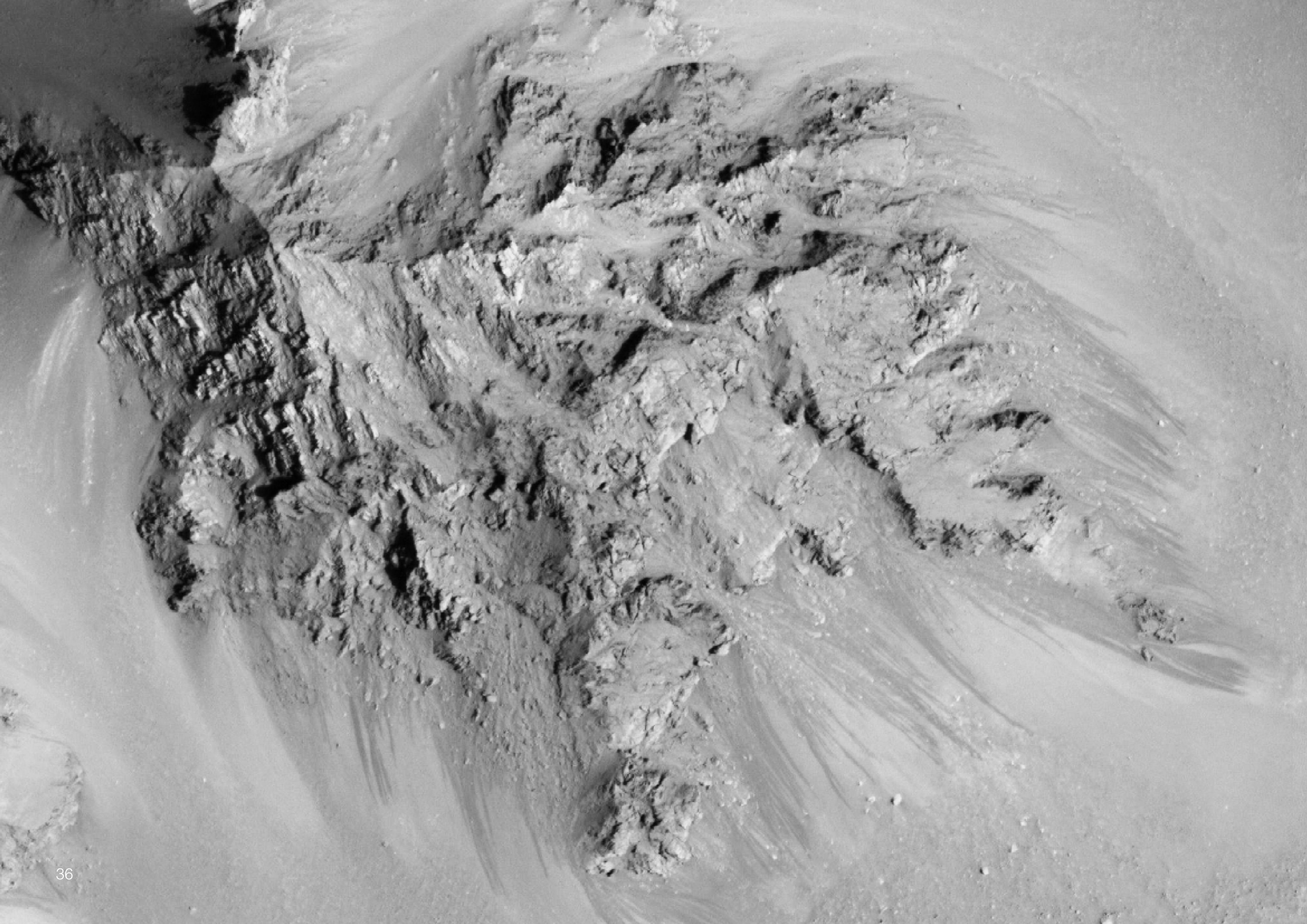
The extrusion of the common rooms from the main building is making it easier to navigate and overview the whole building, and at the same time providing life and fellowship for the ones using the different rooms. At the same time, it provides the facade with a dynamic expression, testing what is static possible, and giving a gesture towards the courtyard.

This building has taken well known vernacular architecture principles converting them into twentieth century architecture. It is combining the visionary thinking of making the future dormitory with old chinese traditions. The concept to make a small community in a larger context, and furthermore dividing the community into smaller "families" are giving the habitants a close relationship. The round shape of the building is furthermore emphasizing the feeling of community and relationship between the habitants – creating a more social gesture.

The Tietgen Dormtory gives inspiration to the importance of creating small communities on Mars, and how the structural principle both can generate a physical gesture and a social gesture in these communities. It is also an inspiration in taking old vernacular methods from around the world and modifying them to fit into a new location and optimizing them according to the environment and the contemporary means available.

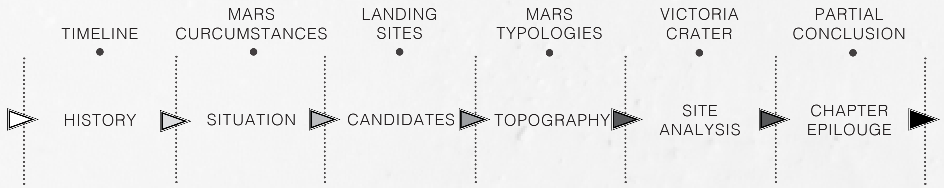
PARTIAL CONCLUSION

The two case studies are very different in shape, function and materials, but they have different elements in common, such as the complex combination of tradition and vision, - the awareness of used materials in the specific context, and the exceptional control of constructing elements as part of the architecture. Can Lis' simple appearance of local stone, used in a modern technique, that construct extraordinary light settings inside, and at the same time let the building grow up from the site, following the topography and becomes one with nature. The Tietgen dormitory has taken inspiration from an old Chinese building design, which as a concept ensure the inhabitants to feel like a community. The chinese concept of community is preserved in the dormitory, wrapped in modern building techniques and materials to achieve modern standards. Designing on Mars will emerge from the same point of view, a concept of uniting visionary- and traditional architecture, using the local materials with new building techniques into a holistic design focusing on sensations and its inhabitants.



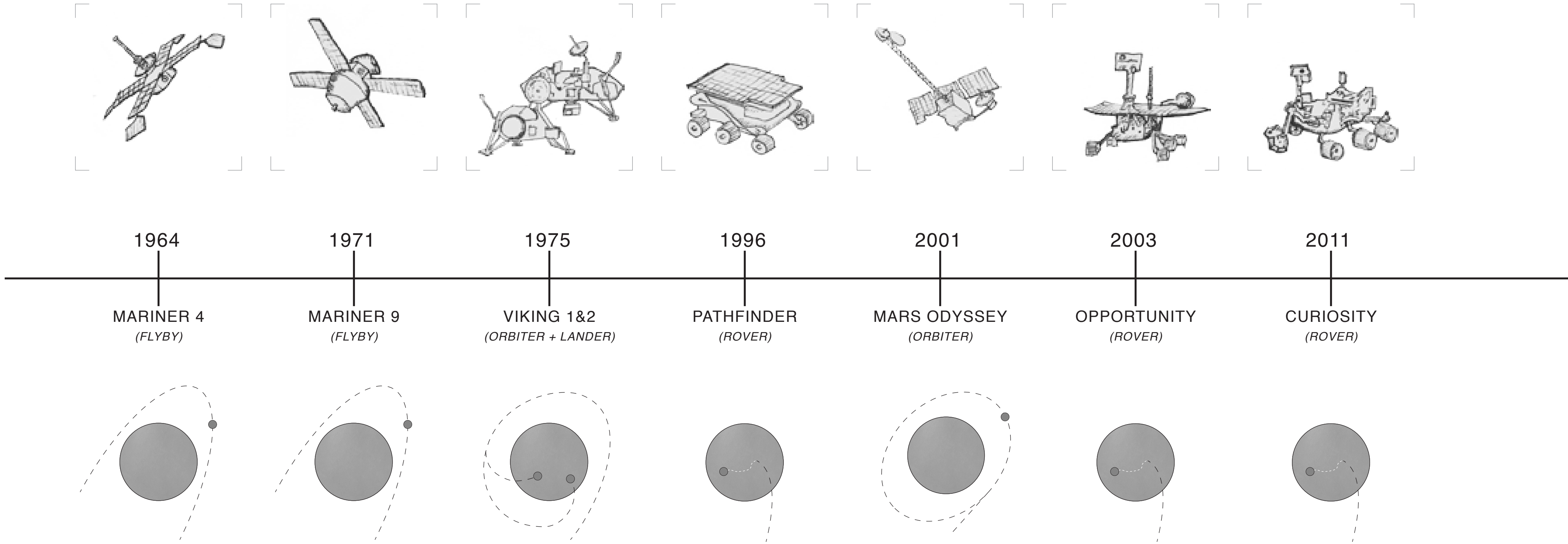
MARS CONDITIONS

Through the report Mars has been mentioned in a context of building a settlement. But how can this be proven to be even possible? One has to investigate the conditions of the planet itself and choose a specific location, in which climatic conditions is most suitable for living. The following chapter will go in depth with the timeline of Mars expiditions and the planets properties, clarify either issues which needs to be solved or finding solutions where this project can work with, and not against the planet.

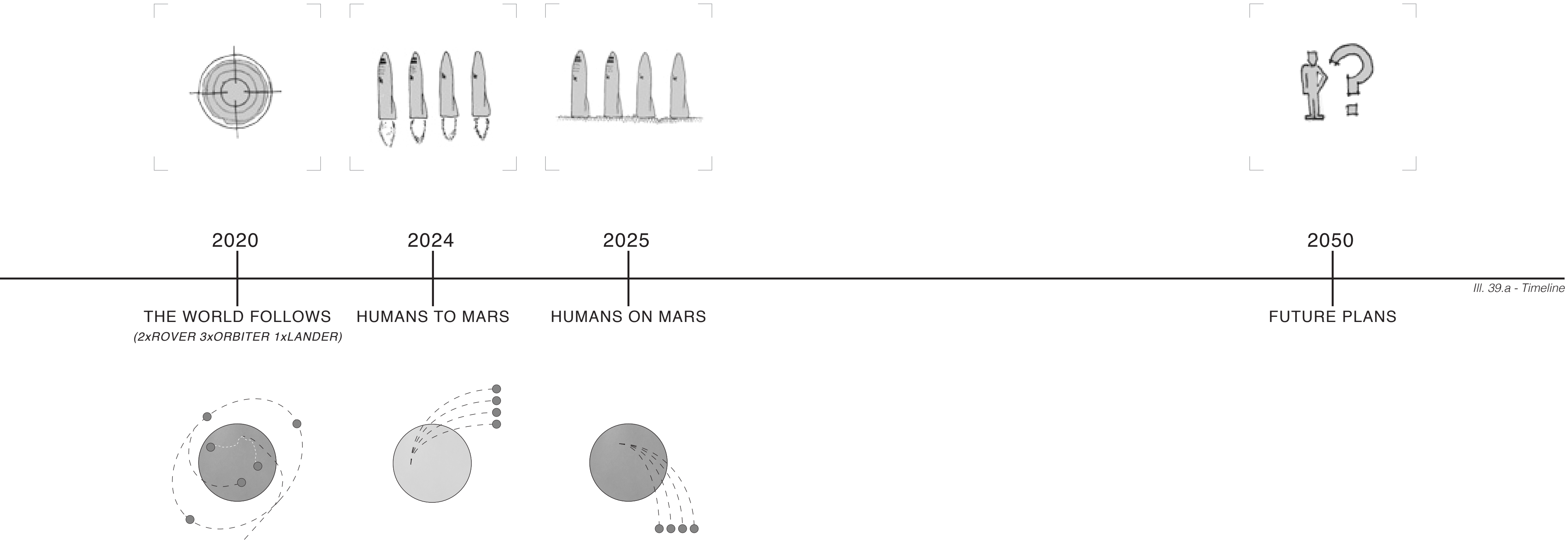


Ill. 37.a - Slope Monitoring in Hale Crater's Central Peaks

TIMELINE



In 1964 the first human created object was sent in the direction of Mars. Mariner 4 went around the planet and brought the first close up photograph of Mars back to Earth. Seven years later, the Mariner 9 made another flyby and discover water, evidence of fogs and weather fronts on the red planet. In 1975 the first two spacecraft landed on Mars, first the Viking 1 and second the Viking two. Viking 1 stayed active for 2245 sols, approximately 2307 days. Viking one made it for 1281 sols and sent photograph of the surface back to earth. 22 years later the first moving object landed on Mars, the pathfinder stayed active for 2 month and discovered that Mars earlier was a warm planet with atmosphere and liquid water. In 2001 Odyssey was sent in orbit around Mars to function as a communication relay for future missions to Mars. The Odyssey created a map with expected buried water and different kind of minerals. Later, in 2003, the Opportunity rover landed on Mars. It remains active (Jan, 2018) and is daily sending geological and atmospheric data back to earth. In 2011 the Curiosity rover joined Opportunity and is drilling in the surface, sending chemical fingerprints back to earth. (NASA's Mars Exploration Program, 2018)



Ill. 39.a - Timeline

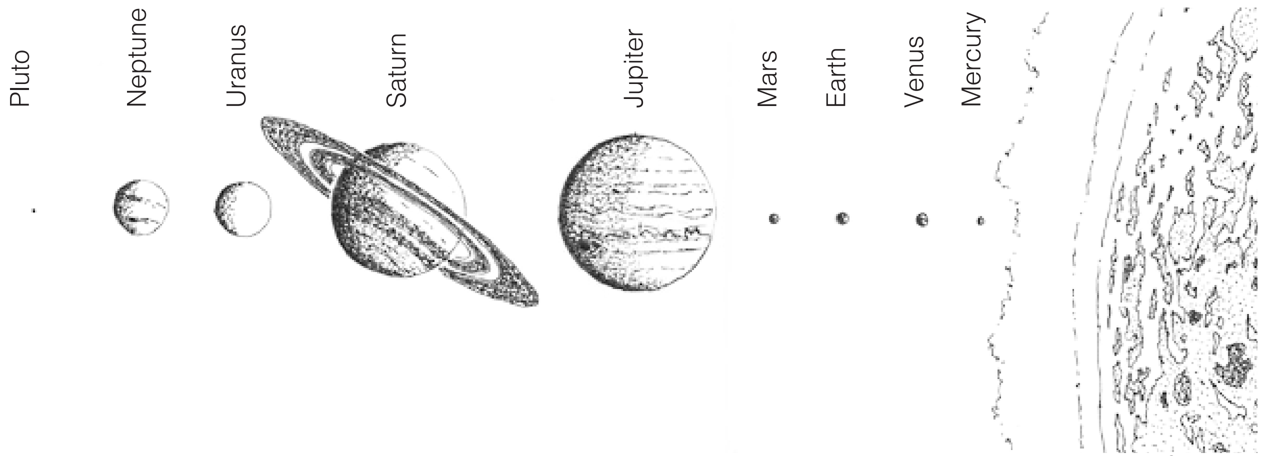
In 2020, the world follows, six different space craft are currently scheduled to launch;
- NASA – Mars 2020 [rover],
- ESA – Exo Mars [rover],
- UAE – Hope [orbiter],
- Japan – Japaneese orbiter,
- China – Chinese rover,
-SpaceX – Dragon Capsule [Lander]. (NASA's Mars Exploration Program, 2018)

In 2024 SpaceX has announced that the first humans are scheduled to take off with the direction of Mars. 2 Crew ships with approximately 100 persons in each ship and 2 cargo ships with equipment and supplies. Each with a capacity of 150 tons. These ships are arriving at Mars the following year and will be the first humans to set foot on Mars. Their mission is to set up a propellant production plant and built up a base for the next ships to arrive. SpaceX expect to send 1 million people to Mars during the following 100 years. (SpaceX, 2018)

This project takes place in the middle of this period, around anno 2050, with the hope of making future Martian architecture a place to live, and not only survive.

MARS CONDITIONS

MARS CURCUMSTANCES



Ill. 40.a - Solar system

In the solar system Earth and Mars travels around the sun as neighbours in a elliptic orbit. Mars has a maximum distance (Aphelion) of 249,2mio km and a minimum (Perihelion) of 206,6 mio km to the sun, and that is approximately twice the distance as Earth's orbit. Earth and Mars distance in between each other various a lot because of the difference i orbit, but there is a 2 year cycle where they have only a distance of 54,6 mio km which by referring to NASA takes month to travel. This is one reason why the martian community has to be self-sufficient to a certain degree, since care packages won't arrive often.

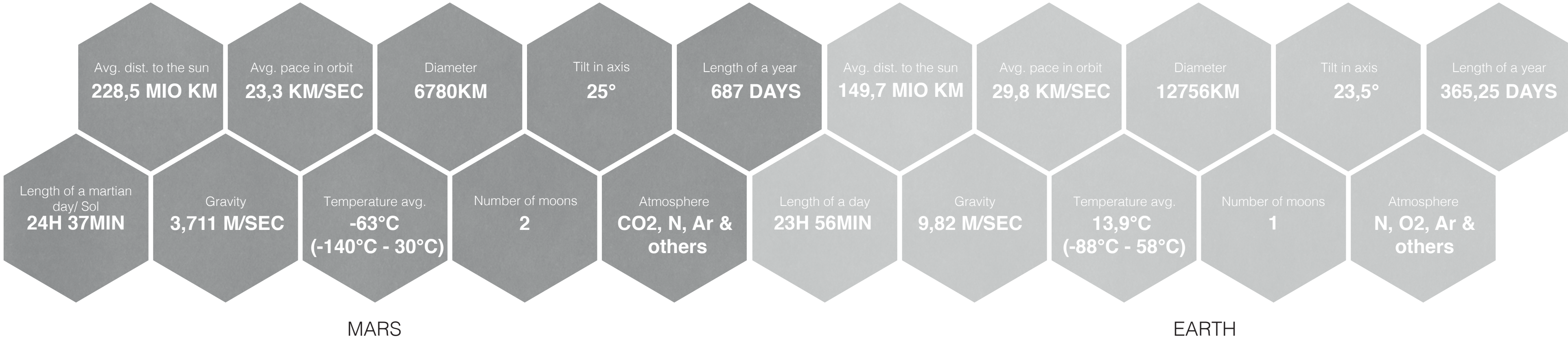
Despite their short distance in a universal perspective, the planets are not alike. Earth has a mass six times greater than Mars, nevertheless if you compared the landmass of Earth and neglect the oceans, it is equal to Mars' surface which doesn't have oceans.

By first glance water cannot be found as a liquid on Mars, but water ice is scattered around the planet and can be seen on the poles. This will enable the inhabitants to extract it to live and water plants for vegetables.

Even though the planets does not look alike, they have similarities such as their tilt in axis. This means that Mars have four seasons just like Earth. The period of each season is longer on Mars due to the size of orbit around the sun, which mean that one year on Mars is almost equivalent to 2 years on Earth. Even though a martian orbit is equivalent to approximately two Earth years, its daily cycle is almost identical, the difference is 40 minutes and one day is identified as one Sol. [Mars.nasa.gov,2018] This enables a recognizable routine and the human body's circadian clock will function, as if it was on earth. [J. Cromie, 1999]

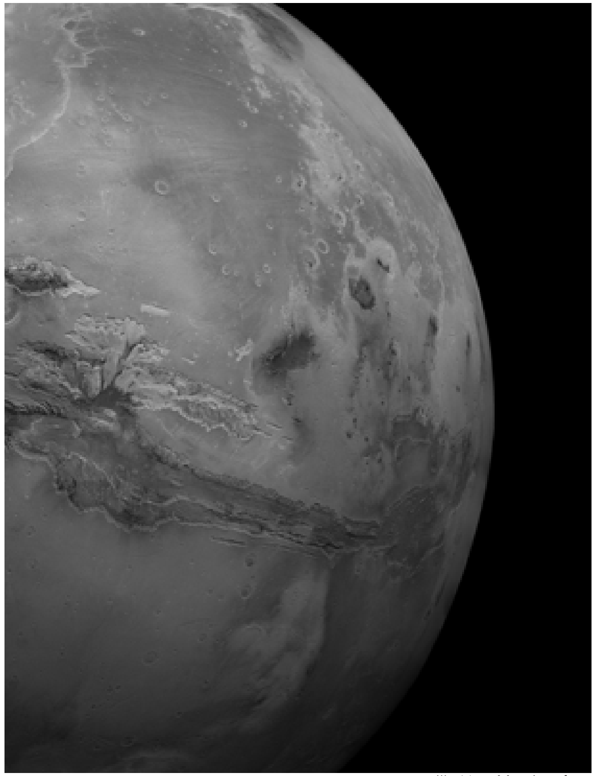
According to NASA the seasons of Mars vary in period depended on one's position of the planet. Being on the northern hemisphere the summer and spring season is extended, while being on the southern part winter and autumn period will. During the season shift, the temperature on Mars change in a range between -140C and 30C for the whole planet, this has to be considered when choosing a location and designing a comfortable climate for the inhabitants. [Mars.nasa.gov,2018]

The inhabitants will experience a gravity of 1/3 of what they are used too, a thin atmosphere which mainly contains carbon dioxide and a low pressure on the surface of Mars. A artificial biosphere with proper atmospheric pressure and inside climate needs to be established, to enable human life, furthermore the martian gravity in combination with the internal pressure of the biosphere, will empower structural and materials properties in constructions, in contrast to what it would have been on Earth. [Mars.nasa.gov,2018]

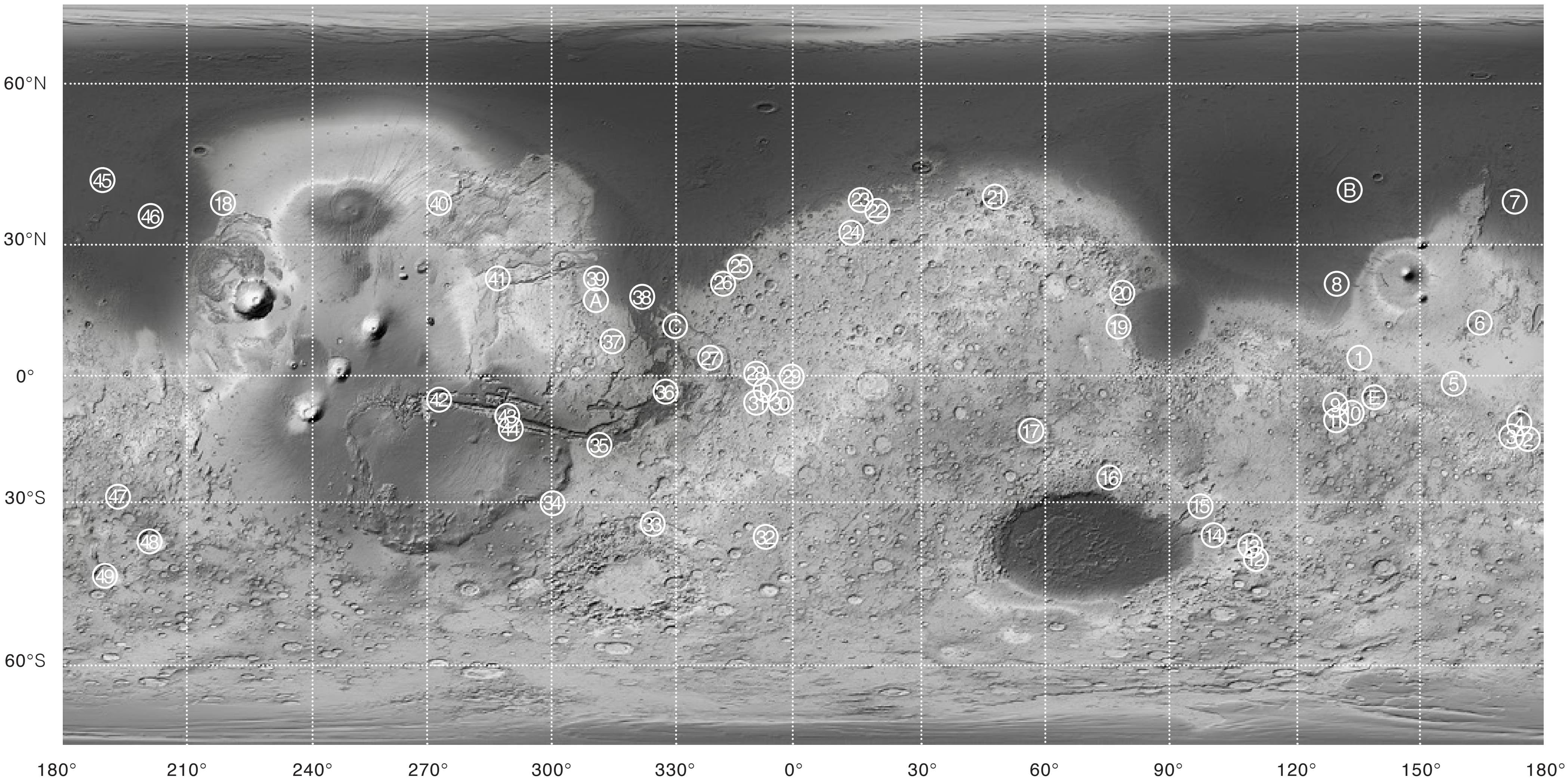


The artificial environment must serve the multi-functional purpose of containing a comfortable climate inside, but as well be resistant to the Martian hazardous weather outside. The low temperature was mentioned previously. But Mars' has heavy dust storms to offer as well, these can last for weeks, and was encountered by a NASA rover that experienced inactivity due to blocked sunlight. So alternatives to solar power and wind loads on the constructions, to ensure the safety of the martian settlement is prominent. [NASA, 2007]

Space radiation is a common challenge among astronauts and space travelers, since as soon one leaves the magnetic field of Earth, exposure to radiation is evident. There is two types of radiation, Galactic cosmic rays (GCRs) and Solar particle events (SPEs), the latter NASA is able to protect humans against, but GCRs travels through all know materials and can damage cellular matter, therefore they are exploring possibilities for new protecting technology solutions. Mars doesn't possess the same magnetic field as Earth


Ill. 41a - Mars' surface

to shield the inhabitants from radiations, therefore solutions to secure a long-term situation on Mars for a healthy human environment is favorable and it might be in Mars itself. If dug deep enough, the martian surface will protect them. [Gushanas, 2017] But by digging down, one would have to consider daylight as well which is essential to human life. The martian wouldn't want to miss the blue sunrise/sunset or the red sky during the day, which is quite unique and opposite of Earth. Another consideration of daylight is the solar impact on Mars, when Mars is at its greatest point, it is equivalent to a spring/autumn day on Earth.



Ill. 42.a - Mars' geographical map

LANDING SITES

Since the discovery of Mars, it has been studied through satellites and rovers as explained on previous pages. Exploring in such a matter is a breakthrough, but as well incredibly ineffective compared to human intervention. Therefore, exploring possible landing sites for future human missions have begun. NASA hosted a conference in 2015, to open a dialogue about Human Landing Sites (HLS), this is no simple task since different factors have to correlate.
The points of interest require different features: The landing site is obliqued to have high scientific research value, natural resources needs to be available to support human survival in order to conduct daily living and work, the site needs to be accessible and climatic feasible.

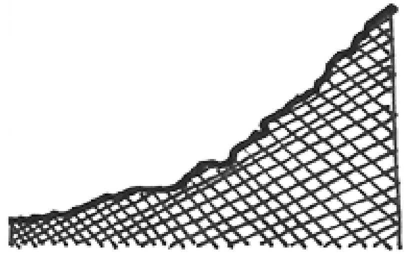
The map (Illustration 42.a) present a simple overview of altitude, where the the colour range of blue indicates lower altitude and possible previous locations of the ocean and lakes. Medium grey indicate the transition from previous thought land to water, and descend to a dark grey for the lowest altitude. Furthermore, the map is marked with points of interest, which indicate where active and inactive human robotics is, while also present future rover and HLS. Letter A to E indicate previous mentioned landings, while 1 is a future planned rover mission in 2020 of Insight, while 2 to 49 illustrate possible Human Landing Sites. [Talbert, 2017]

The forty-eight different HLS' have common features if one look closer. Frequently they are located near the blue border because it is thought that there is presence of ice water, furthermore another common factor between the points of interest is that they are almost all within 30°N and 30°S, and therefore close to equator. This is logical argument of temperature difference, since the fluctuation in celsius degrees is significantly less than if one would travel further North or South.

With these possible HLS' from NASA and the gathered information this utopian vision of settling on Mars becomes more realizable, but referring back to our theory of combing vernacular and utopian ideas into a design, our location has to be thought into a vernacular context. How can we create a settlement which has a sense of genius loci, without ever been used by man? This question might be answered by what Mars has to offer of different landscape typologies, which is described on the following pages.

MARS NATURAL TYPOLOGIES

Ill. 44.a - Flat surface

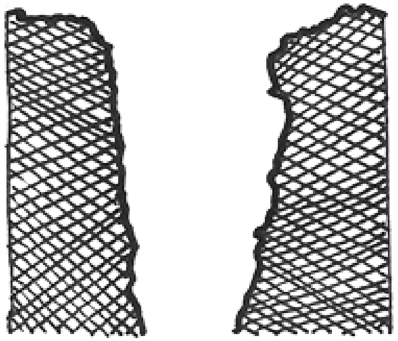


Ill. 44.b - Mountain side

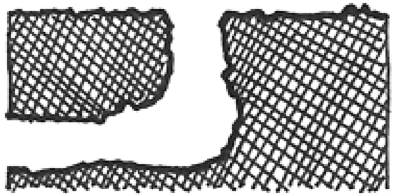
After looking into potential landing sites, another factor for choosing a specific location could be by looking into what the Martian landscape have to offer of different typologies. On these pages, five different typologies of natural landscape is described with disadvantages and advantages. The point of this is to enable a logical argument for choosing a site for the settlement, with a sense of vernacular strategies. One will be chosen on behalf of its natural properties and qualities, while at the same time comparing it with the information gathered in the Human Landing Sites chapter.

Flat surface:
A flat area is easy to mold and form, there is no boundaries and a settlement can be built however. The site would be exposed 360 degrees to the fluctuation of temperatures, wind, sandstorms and radiation which would have to be accounted for, a potential solution would be by digging down.

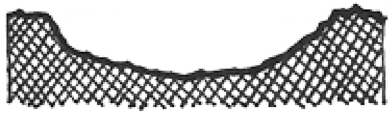
Mountain side:
A mountain side could offer an extraordinary perspective view, while at the same time protect the settlement from the sun and radiation from certain angles, thus exposing the settlement at the other angles to the extreme climate of Mars. The inclination would be a challenges to built on, but at the same time offer different experiences in the cityscape and enable good daylight conditions. [Mars.jpl.nasa.gov, 2018]



Ill. 45.b - Canyon



Ill. 45.b - Lavatubes



Ill. 45.b - Crater

Canyon:
Mars hosts the largest canyon in our solar system, Valles Marineris. It has a length of 3000km and delves down 8km at the lowest points. The canyon could offer decent protective measures in terms of both climatic difficulties on Mars and as well radiation from space. The difficulty would be in building inside a canyon wall, with such a steep inclination. A lot of excavation is needed and daylight might be an issue.[NASA, 2008]

Lava tubes:
The tubes would ensure perfect and essential protection against the extreme fluctuation of temperatures, sandstorms and different kinds of radiations, also in terms of creating an airtight sealing of a quite large space with few materials. A disadvantages would be the amount of daylight that could be attained, and should be considered.[Whittaker, 2018]

Crater:
The iconic landscape of a crater can offer different sheltering option against wind and radiation, while still providing proper daylighting options. Furthermore the enclosure could provide for different experiences along the crater periphery as the sloped hillsides change their inclination. Depending on the size it could be covered and enable of a large area, which could be utilized. [Nasa.gov, 2006]

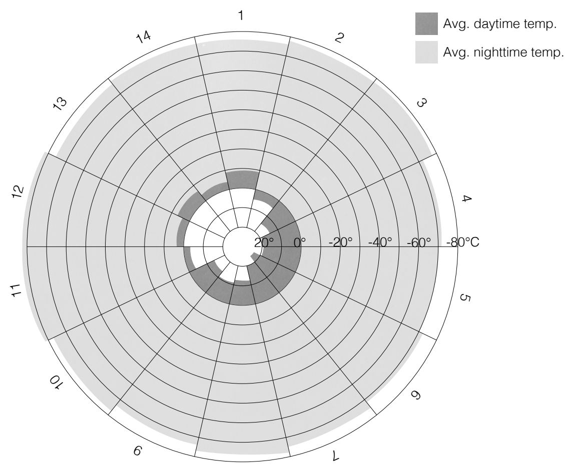
VICTORIA CRATER

The chosen region is Meridiani Planum, which is where the rover Opportunity (Mark D on illustration 420.a) have had is voyage for 5043 sols, equivalent to 14 years on Earth. During its journey it came across Victoria crater, which we have chosen as our project site. The reason why we choose this crater is based upon previous gathered information of Human Landing sites, the iconic shape and proporties of a crater, and the logic derived from this article "Southern Meridiani Planum - A candidate landing site for the first crewed mission to Mars" by J.D.A. Clarke, D. Willson, H. Smith, S.W. Hobbs, E. Jones in 2017. In their abstract on line 13 they state: "Go where you know".[Clarke et al., 2017] The excessive amount of information and pictures already gathered around Victoria crater will benefit the project in the further process of developing a design

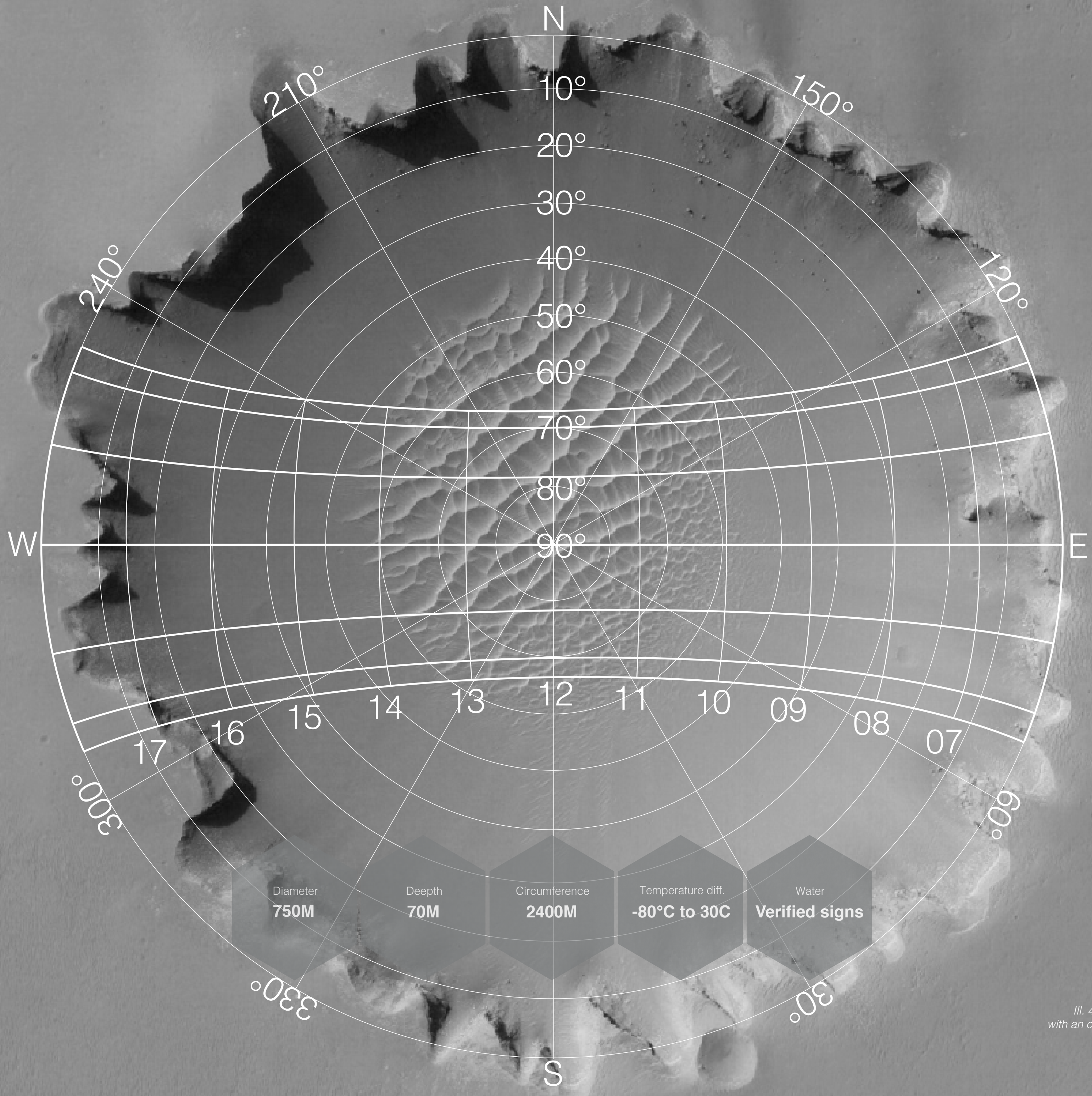
The crater is located specifically on 2.05°S, 354.5°, placed rather close to lower altitudes and close to the equator line.[Mars.nasa.gov,b, 2018] Since Mars' angle of rotation is almost similar to Earth's, we assume the sun's path on the crater is similar to the sun's path near equator on Earth.The crater was formed due to impact of an meteor and formed a circular pit with a diameter of approximately 750m and 70m in depth. The crater differs in steep and sloped edges around its 2400m periphery, which creates this magnificent landscape around the center.[Squyres et al., 2009]
The crater is well documented due to the rover Opportunity's journey there, and it has measured the temperature during a martian year of 687 sols, which spans between -80°C to 30°C in one sol. [Mars.nasa.gov, c, 2018]

This means the search for water will occur in the state of solid ice, and small amounts as vapor in the atmosphere. The reason why water is sought after is because it is essential to life as we know it. For humankind to survive on Mars, a sustainable supply of water and oxygen is uttermost important and therefore should be established and the region should contain potential water resources. Furthermore, the topography of Meridiani Planum is rather flat and accessible, which again is a criteria for the first crewed mission on Mars

Illustration 46.a present temperature during a year on mars, the data is divided in 14 periods, consisting therefore of 49 days each which indicate night and day average temperatures for those periodes.



Ill. 46a - Temperature avg. during a martian year



Ill. 47.a - Victoria crater at Meridiani Planum with an overlay of the sun's path upon the crater

PARTIAL CONCLUSION

By choosing a well documented crater in both pictures, measurements and information a path towards a martian settlement have been paved. By working with Mars and its landscape, we have achieved the first step in the direction of Martian typology. The crater itself is a iconic shape which can be spotted everywhere on Mars in different size and types, so new settlements in other craters could potentially emerge as part of an utopian city development.
It is fortunate to be able to choose your own project site, but by doing it we have laid out a strong foundation for a project to develop upon.

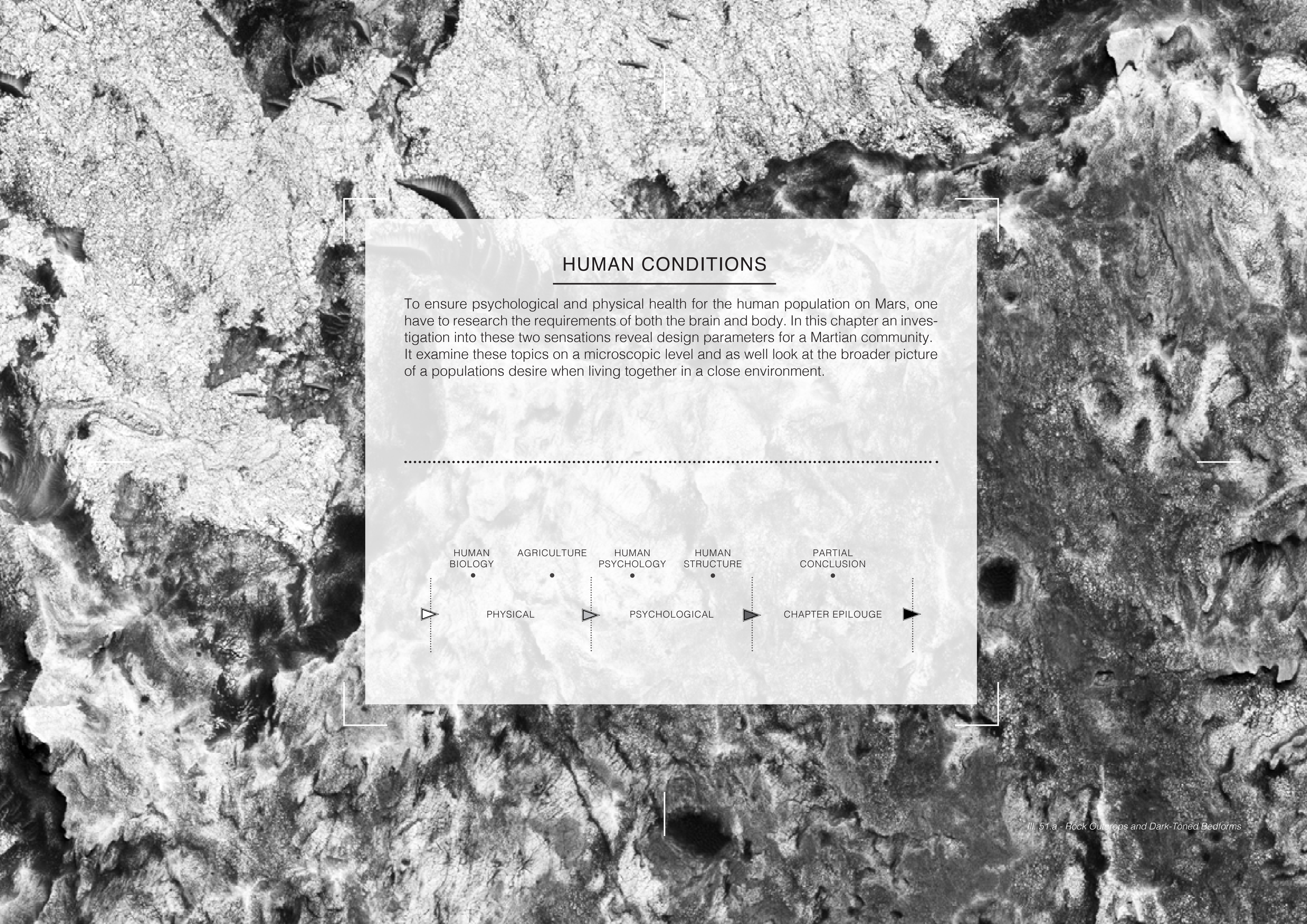
Victoria craters geographic positioning near equator minimizes the temperature fluctuations to reasonable differences for the settlement, while the crater itself enable partially protection against wind, sandstorms, solar and cosmic radiation with natural topographic sheltering. The remaining radiation, the cold temperatures and other issues would have to be solved through technical and integrated design solution, to ensure life inside this utopian settlement. But what is the conditions for life? The next chapter will investigate the psychological and physical needs of humans in small scale and in a city perspective.

HUMAN CONDITIONS

To ensure psychological and physical health for the human population on Mars, one have to research the requirements of both the brain and body. In this chapter an investigation into these two sensations reveal design parameters for a Martian community. It examine these topics on a microscopic level and as well look at the broader picture of a populations desire when living together in a close environment.

HUMAN BIOLOGY • AGRICULTURE • HUMAN PSYCHOLOGY • HUMAN STRUCTURE • PARTIAL CONCLUSION

PHYSICAL ▷ PSYCHOLOGICAL ▷ CHAPTER EPILOUGE



Ill. 51.a - Rock Outcrops and Dark-Toned Bedforms

HUMAN BIOLOGY

Nutrition:
Through daily nourishment, the body acquire essential nutritions for living, such as fat, protein, carbohydrates, minerals, vitamins and water. These enable the metabolism in the body, which is the energy expenditure to sustain vital organs functioning, tissue growth and the body itself. [Web.archive.org, 2006]

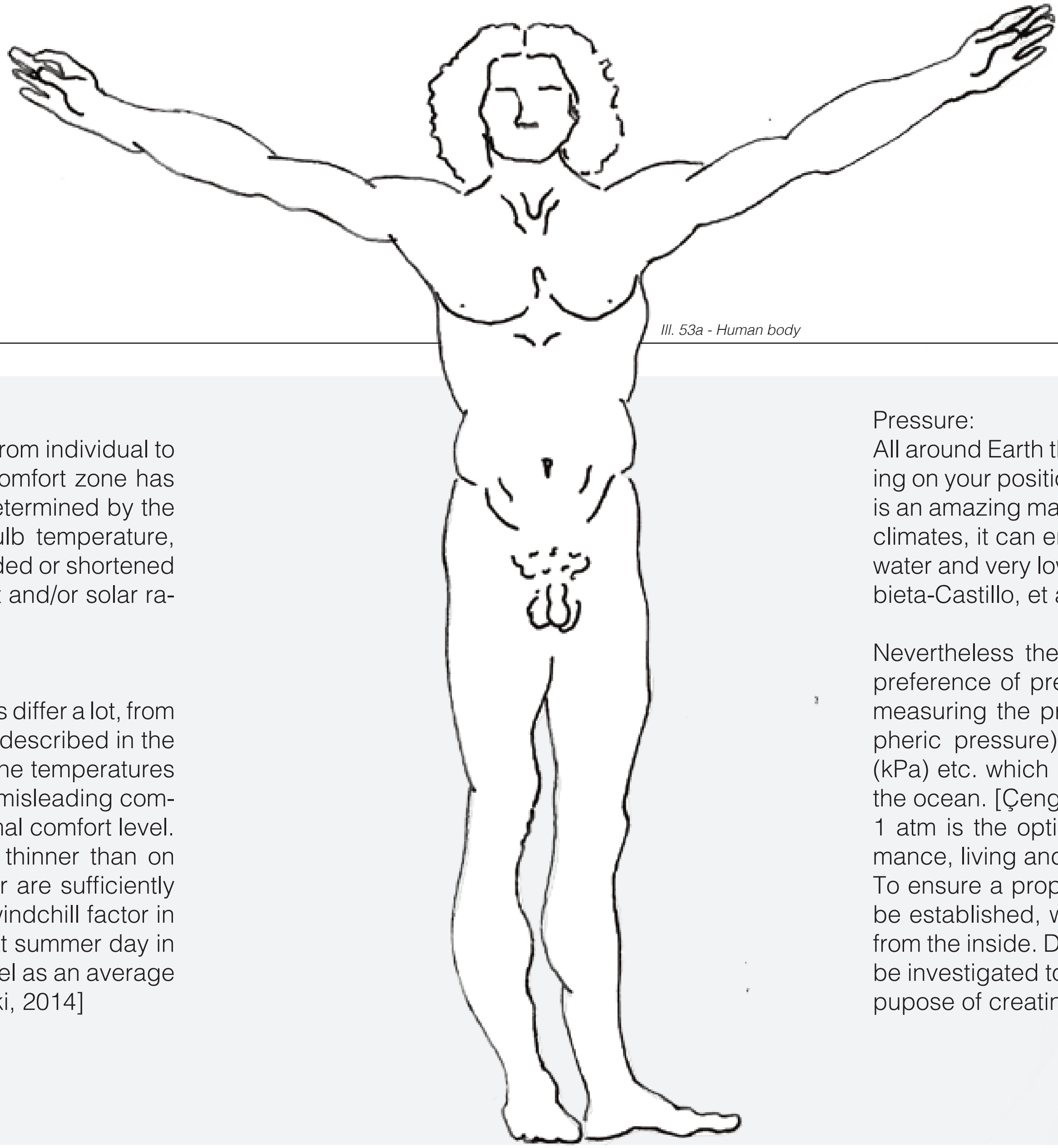
Vegetables will be the food available on Mars, since it can be transported in seeds in large amount without taking to much space. The type of vegetables have different properties in terms of nourishment and space needed to grow, hence different sorts should be brought to Mars. There is different methods of farming: the traditional large fields could be an option for visual comforting effect for inhabitants, while growing in aeroponics could minimize space needed to grow and effectively increase the amount compared to its floor area.

Water:
H2O is important for all life, it can be obtained through consumption of food, but should also be provided otherwise in a certain amount of quantities. For humans it is depended on the climate the person is positioned in and the individual physiological condition. [Reed and Reed, 2011]

A person needs 7,5 - 15 L pr. Person pr. day for purposes like drinking, hygiene and cooking.
The result after multiplying by the number of people, and taken the plants into account would be a massive amount of water that both need to facilitate the inhabitants and be able to recycle it as well. This could be done through naturally with root zone plants and bio treatment. Water is important for living, not only physically, but as well psychologically. The biosphere might contain certain leisure activities including water, for the benefit of the inhabitants.

Oxygen:
Earth's atmosphere is a composition of different gases, such as Nitrogen (78,08%), Oxygen (20,95%), Argon (0,93%) and others (0,04%), which is widely known as air. [Dr. David R. Williams, 2018]

Breathing air is vital to the presence of humans, and a proper supply is to be determined. Oxygen can be produced through a process called 'electrolyte', what it does is it takes liquid water and separate the molecules from each other into oxygen and hydrogen.[Firstbeat.com, 2014] So by extracting water ice from Mars surface, the inhabitant will be able to produces breathable air. This will of course need space for both production, but as well for distribution through mech. ventilation.



Ill. 53a - Human body

Temperature:
Comfortable temperature differs from individual to individual, due too the thermal comfort zone has been established. The zone is determined by the relative humidity and the dry bulb temperature, and the zone can either be extended or shortened with the addition of air movement and/or solar radiation. [Szokolay, 2014]

The outdoor temperatures on Mars differ a lot, from what we are used to on earth, as described in the chapter of Mars conditions. But the temperatures measured by a thermometer are misleading compared to what would be the thermal comfort level. The atmosphere on Mars much thinner than on Earth so the convection in the air are sufficiently smaller. This will also effect the windchill factor in a positive way. This means that at summer day in the middle altitude on Mars will feel as an average winter day in England. [Osczevski, 2014]

Pressure:
All around Earth the pressure is different, depending on your position and altitude. The human body is an amazing machinery of adaptation to extreme climates, it can endure very high pressure underwater and very low on top of mountain peaks. [Zubieta-Castillo, et al., 2008]

Nevertheless the human body have a standard preference of pressure. There is various units of measuring the pressure, such as 1 atm (Atmospheric pressure) ca. 1 bar, 101.325 kilopascal (kPa) etc. which is measured near the surface of the ocean. [Çengel, 2008]
1 atm is the optimal pressure for human performance, living and growth. [Flight literacy, 2015]
To ensure a proper pressure a biosphere should be established, which can contain such a forces from the inside. Different form construction should be investigated to find the best functioning for our pupose of creating a martian community.

AGRICULTURE

One significant thing to obtain life and good living conditions on Mars is after our opinion a functional food production. This means that producing food like we traditional are doing it on earth is not directly adaptable to Mars, because it is a very space-, and water consuming affair. Due to this issue new methods of growing food and furthermore reusing all excess from this production is necessity on Mars - where water and agriculture soil most likely will be a limited product.

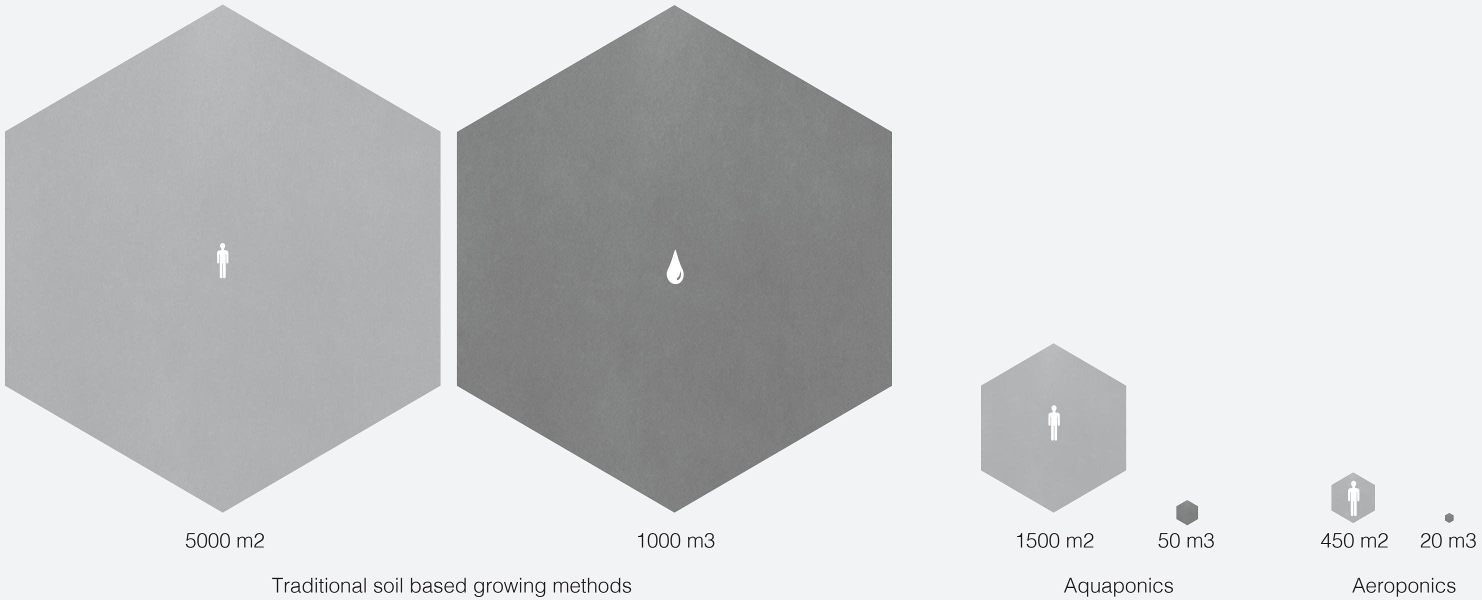
Some of the newest growing techniques are closed loop systems where the production, as the name says, are going in a loop, and furthermore are in a more controlled system where only the necessary nutritions are used. This is making it much more efficient and less area consuming.

An example of this is aquaponics, this form of agriculture are combining the raise of fish (aquaculture) with the growth of soilless plants (hydroponics). These to productions are therefore gaining from each other's excess, the fishes are producing natural fertilizer for the plants, and the plants are cleaning the water so the fish can breathe. This makes it a closed loop system. Hydroponics, are much more efficient than traditional farming, both in the use of nutrition's but also in the use of space, the hydroponics can function as a vertical garden, making the use of land much more efficient. They are so efficient that they can increase the production of certain crops with up to approximately 300%. [Monteiro Corrêa et al., 2008]

Further development of the hydroponic system is the aeroponic system, which sprays the correct amount of water and nutrition's directly on the roots, making it more efficient concerning water use and space, increasing the production up to 277 % compared to traditional hydroponics. [Reza Roosta and Reza Karimi, 2015]

New food production methods is a crucial on earth as well as on Mars, this means that new methods are found on a daily basis. This project are aiming to use methods that, to some extent, could be combined with social spaces making it a visionary strategy for the new Martians.

Three different methods of producing agriculture, (see ill. 55.a). Compared on the amount of space needed [m2/year] and the amount of water needed [m3/year] for one person.



Ill. 55.a - Agricultural methods versus area and water needed to produce food for one person pr. year.

HUMAN STRUCTURE AND PSYCHOLOGY

Human beings are social products, what we would experience as human character is not inborn but acquired through social learning. This means that the truly human in us, are created from the social interventions we have through life. [Eriksen, 2015]

One of the ways to support this theory, is the anatomy study showing that all human are 99,8 % alike looking at the genes. Through studies of different societies also shows that we are all equally cultured but in different ways, and that societies with simpler technologies have a better understanding of the processes of nature. [Eriksen, 2015]

These anthropological statements give us, as architects - designing a new society on Mars - a giant responsibility in choosing the right architecture and the right spaces between the buildings, where social interventions can occur.

To get a better understanding of how and why public urban spaces works, the theory's of the urban architect Jan Gehl, are studied. The life in the city has changed a lot over the last 100 years, going from a trading town to a residential town. This means that habitants are not forced to use the city, there are a lot of other shopping/ trading possibilities, so they have to be tempted with something else, for example quality recreational areas. In the book "New city life", Jan Gehl is making tree subdivisions of characteristics needed in the new form of urban spaces; protection, comfort and amenity. These types of characteristics shown in ill.56.a will all provide quality to the urban spaces. [Gehl, 2006]

In the book ´Living Environment´, Ingrid Gehl writes about the importance of the psychological needs, when designing architecture for people. She split these psychological needs up, into eight categories as illustrated in ill.56.b . Each element has to be incorporated into the design for the user to feel satisfied.
This cannot be measured directly in numbers, but through personal experiences. The architecture has to be inviting and encourages to interaction, positive behavior and retreat when necessary – satisfying the need on the social, psychical, sensational and phenomenologically aspects. The goal is to have these eight aspects in mind when designing, for then to create a social sustainable living through spaces, structure, material, light and form.[Gehl, 1973]

Ill. 57.a - The structural need for the city

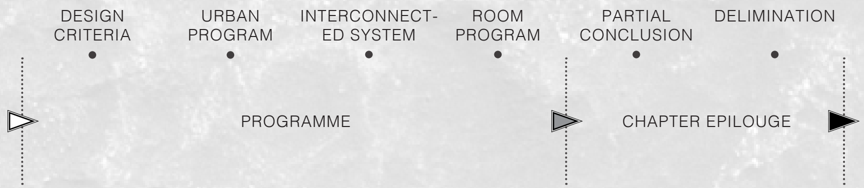
Ill. 57.b - The psychological needs for the individual

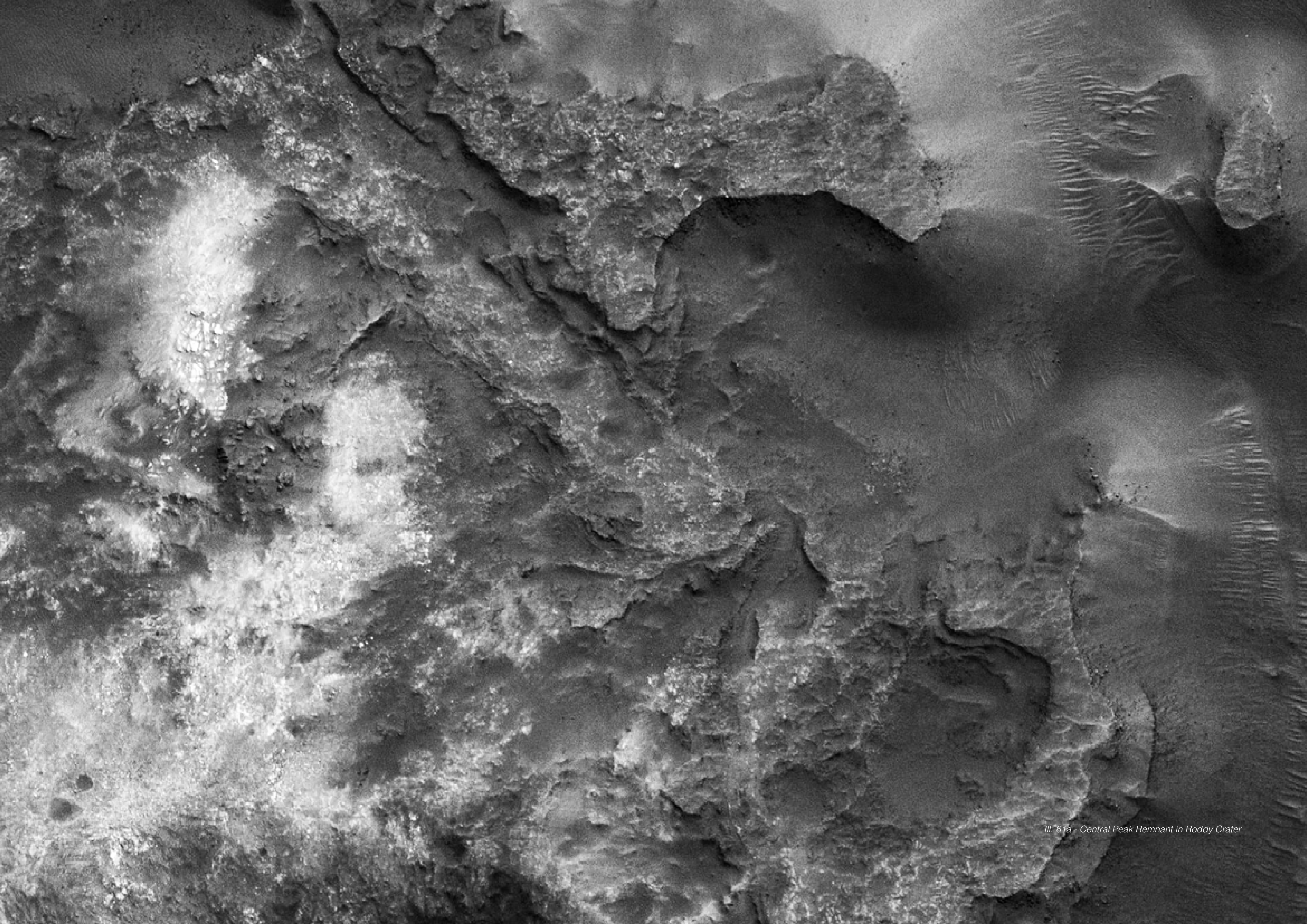
PARTIAL CONCLUSION

The new settlement on Mars should embrace the psychological and physical needs of the human body. Both for the sake of survival but also for the important factor of human wellbeing. Through the research of the human biology and agriculture, it can be concluded that the settlement should be contained inside an artificial biosphere, given a certain pressure and temperature to withhold human and biological life. This will enable agriculture with current technologies to feed the inhabitants, with as little amount of water usage and production space as possible.
Furthermore, the settlement should focus on the individual by making space for social interventions and ensure quality in public spaces. An obstacle of this community will be the feeling of confinement, the limited space under the enclosure with no direct access to the outside. This is a major challenge that needs to be designed with care.

PROGRAMME

In the follow chapter of the programme, it will be illustrated how the areal distribution of the martian community will manifest itself. The quantities is a result of our previous research in both the Theory Development, Case studies, Mars' conditions and Human conditions, and in addition gave both physical and psychological design parameters for residence, structure and the community.



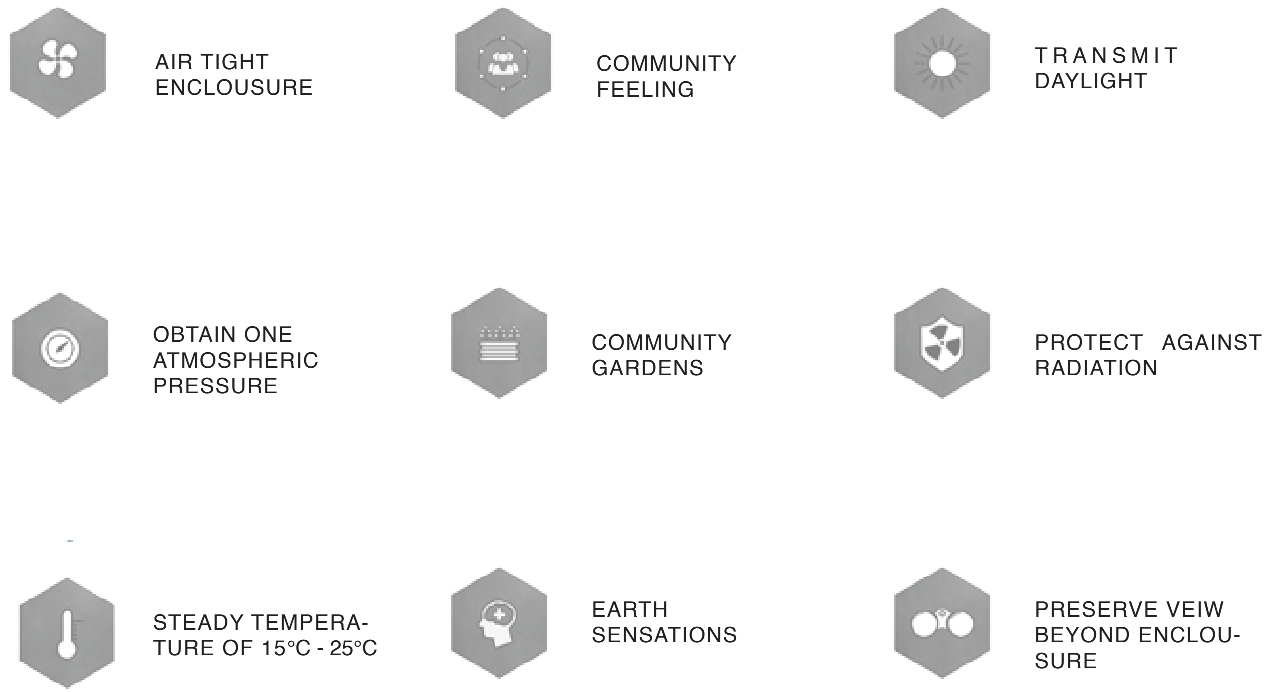


Ill. 61a - Central Peak Remnant in Roddy Crater

DESIGN CRITERIA

Collecting all the information through the earlier research, it have given us some design criterias. They are addressed to first; The enclosure - able to sustain human- and biological life on Mars, and secound to the community inside.

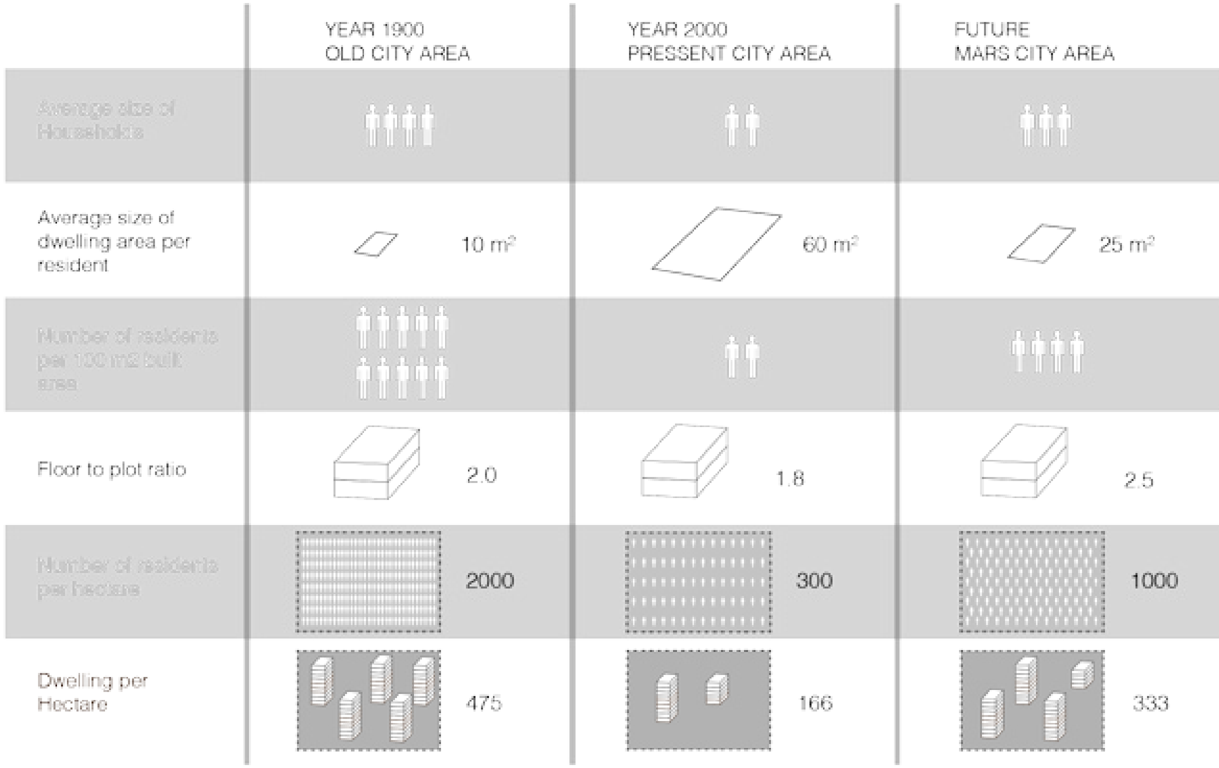
The criterias is derived from purely pragmatic reasons and as well atmospheric, which should end in a harmonic symbioses of shaping each other into the martian typology. The enclosure should be air tight, which then can sustain a preferable pressure at one atm as on Earth. Furthermore, it need to transmit daylight, while protecting against solar radiation. An atmospheric feeling of community should be underlined, with focus on natural phenomena, structural principles and spatial gesture. These design criterias is the initial, and will be supplied with more as the design process proceeds onwards.



Ill. 62a-i - Design criteria

URBAN PROGRAM

The last hundred year urban density, and the use of the cities, has changed a lot. Going from a dense trading center with high population living close together on small areas, to a more open city structure with fewer people that live in in larger dwellings. The function of the city has also changed, going from a necessary place to be, if you wanted to trade, to a were you are not forced to be, and the need of place of recreation are more important to make people use the city. This situation demands city structures to adapt to new functions of the city, and make the public spaces as more residential areas. The new settlement on Mars will in some way go back in time using the city as a place to “trade”, but with a visionary thinking combine it recreative areas with some of the food production. The area of the dwellings will also have to be rethought using the vernacular knowledge gather in combination with visionary ideas developed in the design phase to get the maximum gain of the limited space under the enclosure. The diagram shows a combination of data collected by Gehl architects, and our predictions of the new Martian settlement.

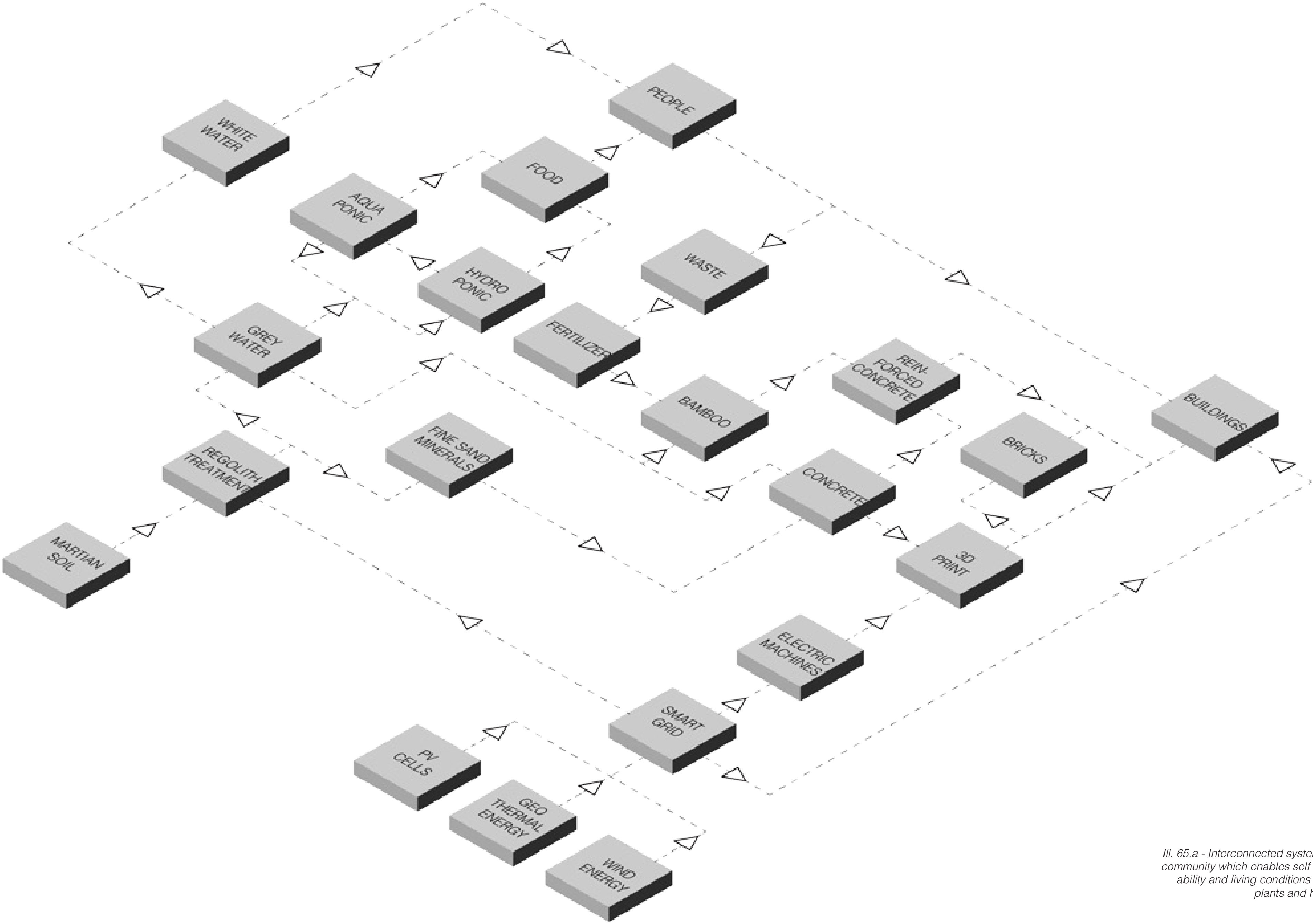


Ill. 63.a - Urban Program [Van Deurs, 2016]

SELF-SUSTAINABILITY

To ensure that the settlement on Mars do not need assistance from Earth in any way it should be as self-sustainable as possible. Delivering renewable energy production methods from Earth, like wind turbines, geothermal heat and photovoltaic cells will make it possible for the Martian settlement to maintain a self-sustainable closed system. Meaning that the everyday resources, such as food production, power supply, waste, etc. has to be rethought into a holistic design under the enclosure. Generating waste for one part in the system into energy or food for another part. Besides energy and food incorporated into the system, materials also a major focus point. The use, reuse and upcycle of on-site materials would be important elements in a closed system like this. Finally, an optimization of the production methods will be a necessity for this system to work. One way to do this is to make incorporated aquaponic systems in the food production and make this take part in the architecture and the everyday life. This will not only minimize distribution but also strengthen the community feeling of being together for a common goal.

The closed loop system is illustrated in Ill. 65.a, showing how the different functions is making a holistic system where everything is used and optimized. The Martian soil is going through a regolith treatment being divided into usable sand and minerals to produce concrete. The sun, wind and geothermal heat are producing energy to the systems smart grid, energizing the entire community. Inside the loops food production is using the waste as fertilizer and the grey water, is rinsed through the aquaponic growth. This system is a simplification on how a self-sustained settlement on mars could work.



Ill. 65.a - Interconnected system of the community which enables self sustain-ability and living conditions for both plants and humans.

ROOM DIAGRAM AND PROGRAM

The room diagram in Ill. 66.a is showing the connection of the buildings and public areas in the community. In general, all of the buildings should somehow be connected, but as the diagram shows some should be placed closer together with easy circulation in between. As well as all buildings and public areas should have a direct connection to a safety room in case an emergency.

The room program in Ill. 67.a is an elaboration of the single buildings technical parameters, regarding daylight factor, size, placement, etc. These numbers are to secure and obtain good indoor qualities in the buildings, regarding to the standards we know from the Danish building regulative.

Ill. 66.a - Room Diagram

Area / Function		Size (sqm)	Daylight factor min.	Artificial light	Temperature	Airchange min.	Room height min.	View	Possible placed under ground
Dwellings	Bedrooms	5	2	200 lux	18-22 C	0,3 L/s	2,4 m	√	√
	Living room	5	4	50-200 lux	20-26 C	0,3 L/s	2,4 m	√	√
	Storage	1	2	200 lux	18-22 C	0,3 L/s	2,4 m		
	Toilet	1	-	200 lux	20-26 C	0,3 L/s - 15 L/s	2,4 m	√	√
	Bath	4	2	200 lux	20-26 C	0,3 L/s - 15 L/s	2,4 m	√	√
	Kitchen	4	3	200-500 lux	20-26 C	0,3 L/s - 20 L/s	2,4 m	√	√
People's house	Sacral place Sport Amphi scene	1200	2-3	200 lux	20-26 C	0,3 L/s	3,0 m	-	√
Agri culture	Aquaponics	1.000	8	-	-	-	-	√	-
	Aeroponic fields/containers	75.000	-	500 lux	20-26 C	0,3 L/s	-	-	√
Recreation	Community gardens Park	5000	8	-	-	-	-	√	-
Research Center	Satelite center Test station Health center	1000	2-3	200-500 lux	18-20 C	0,3 L/s	3,0 m	√	√
Waste center	composting recycle	1200	2-3	200 lux	18-20 C	0,3 L/s	-	√	√
Water and Electricity distribution	Water Electricity Heat	1000	-	200 lux	-	0,3 L/s	-	-	√
Safety zones		500	-	200-500 lux	16-20 C	0,3 L/s	2,4 m	-	√

Ill. 67.a - Room program

PROGRAM CONCLUSION

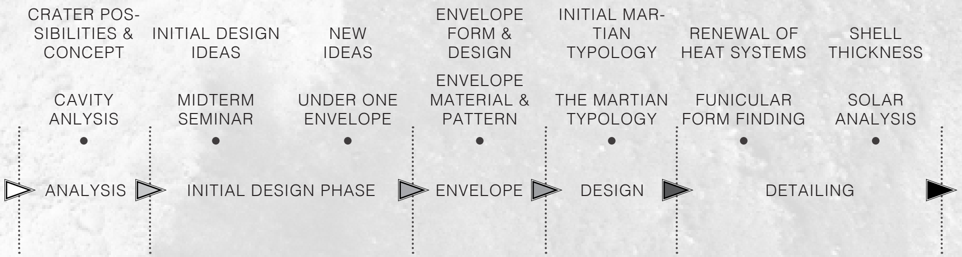
The program has been formed as a clarification for the individual elements in the community. It clarifies how the urban area should be distributed along with a focus on making the community self-sustainable – working as a closed system. Furthermore, it explains a wish for the individual room distribution, with details on the individual requirements for each room. These minimum requirements and distribution thoughts should be used throughout the design phase. But before entering the design phase head on, a delimitation is in order to pave the way for the direction of the design phase.

DELIMINATION

Before the project is proceeding into the design phase, a delimitation is composed to ensure the focus is keept within the limit of what is possible for a small group in a limited timeframe. Even though we wish to design a masterplan for a small community, we will not be going into the details of all the buildings determined in the urban programme. First of all, we need to ensure the possibility for life on Mars, hence a priority on the membrane creating the internal life for the community. A priority in terms of the structural principle, but also on the affect this membrane will have on the internal life and the spatial gesture. Another focus element in the community, will be the housing conditions for the inhabitants. We wish to detail a form for housing complex, with every necessity in an everyday life. Finally, we find it important for the inhabitants to have some kind of cultural gathering space. To arrange events and to create unity and emphasize a higher quality of life. These three elements; A membrane, A housing complex and A cultural complex, will be the focal point when going in dept with buildings in the masterplan, everything else will be on a conceptual level with most considerations in the overall distribution of the buildings in the master plan. Elements such as thermal analysis, building regulations and ventilations calculation will been simplified, where elements as structural analysis and solar exposure will be a priority.

DESIGN PHASE

Initiating the design phase, will have its foundations from the initial created method of genius loci, gesture and principle in combination with the pragmatic information gathered in the chapter Mars- and human conditions. Which is were we lay pen to our thoughts and ideas generated through our research. The chapter is initiated with how to approach the crater and its possibilities, next a initial concept is developed follow up by a more specific location with analysis and the initiating design process. The process is illustrated through different phases and iterations, followed up by additional research, accompanied by that fact of realisation and calculating the designed structures, and investigating the daylight.



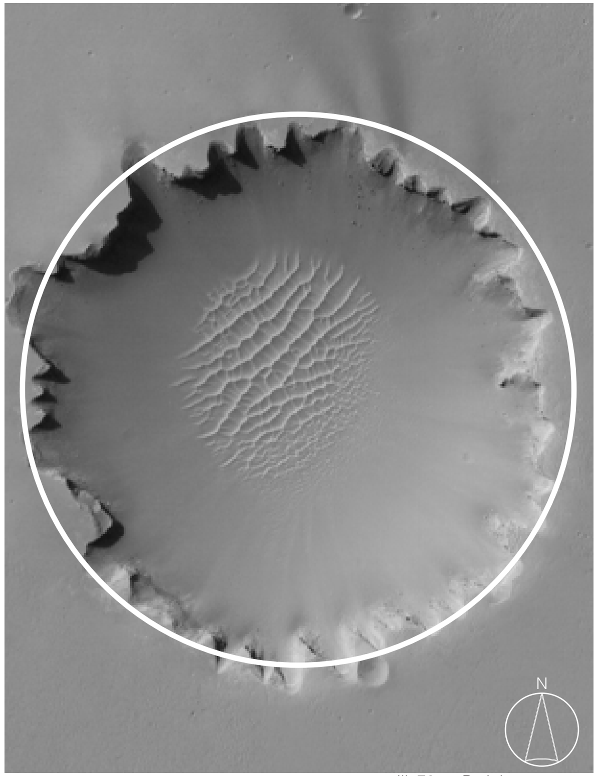

Ill. 71.a - A Crater in Terra Tyrrhena

CRATER POSSIBILITIES

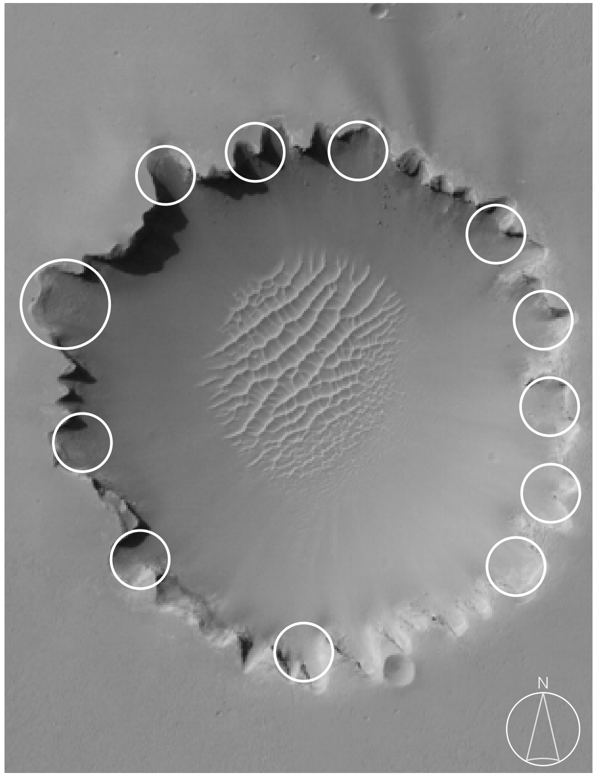
Periphery concept:
Exposing the crater completely and create a settlement on the border, is genuine attempt to preserving and respecting the natural landscape, but will require a large amount of excavating.

Cavity concept:
The small enclosures will have natural sheltering properties in terms of wind, cosmic radiation and for some part of the day also solar radiation. The challenge and benefit will be building on different sloped mountainsides occupied by solid cliff.

A crater posses a lot of different topographical qualities if one look close. Referring back upon the Mars conditions chapter and the program, we state that it would be preferable to work with Mars, rather than against it. Choosing a site of Martian landscape is not only beneficial for pragmatic reasons, but as well in spirit with the method developed earlier with the natural phenomena influencing the gesture of the future settlement.



Ill. 72.a - Periphery concept

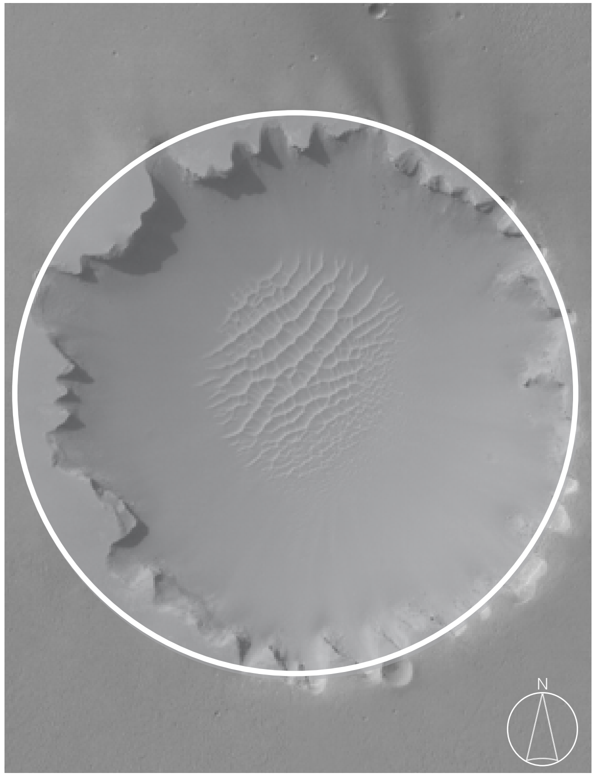


Ill. 72.b - Pocket concept

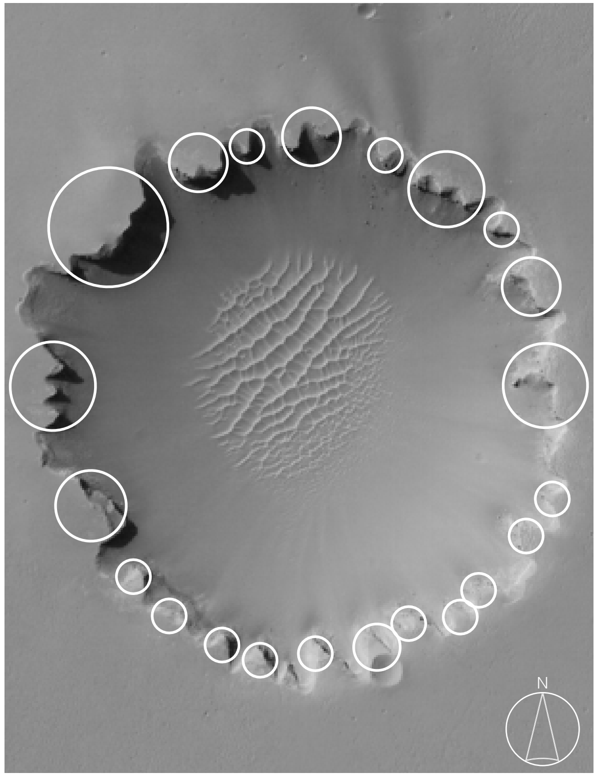
Completely covered concept:
A completely covered crater will ensure a lot of possibilities in terms of building, a disadvantages is that the diameter is 750m and would need support along the span and disrubt the space beneath.

Cliff concept:
Building in the cliffsides will require a large amount of excavating, but without external building material a settlement could be established, with natural sheltering from wind and radiation. Daylight on the other hand would be an issue.

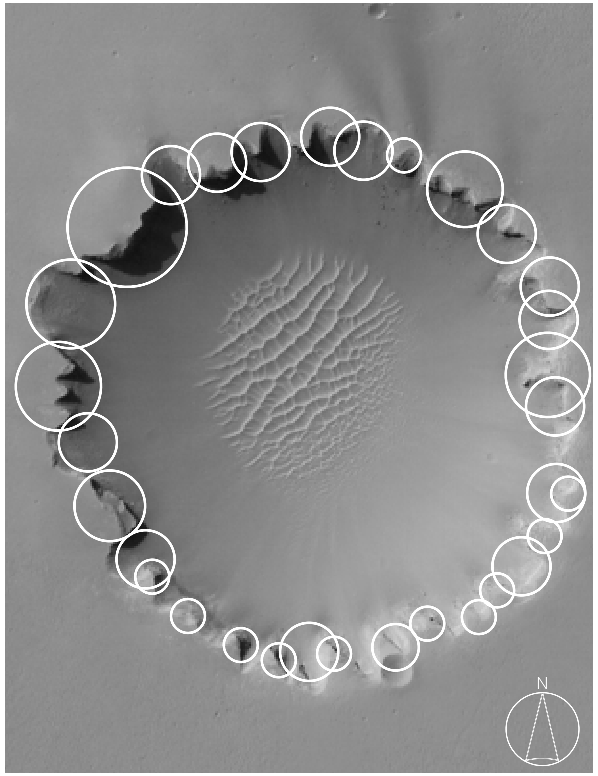
Combination concept:
Building in the pockets around the crater and combining them with tunnels or functional areas inside the cliffs would unify a whole crater into one settlement, while providing different natural sheltering and safety for its inhabitants zones.



Ill. 73.a - Completely covered concept



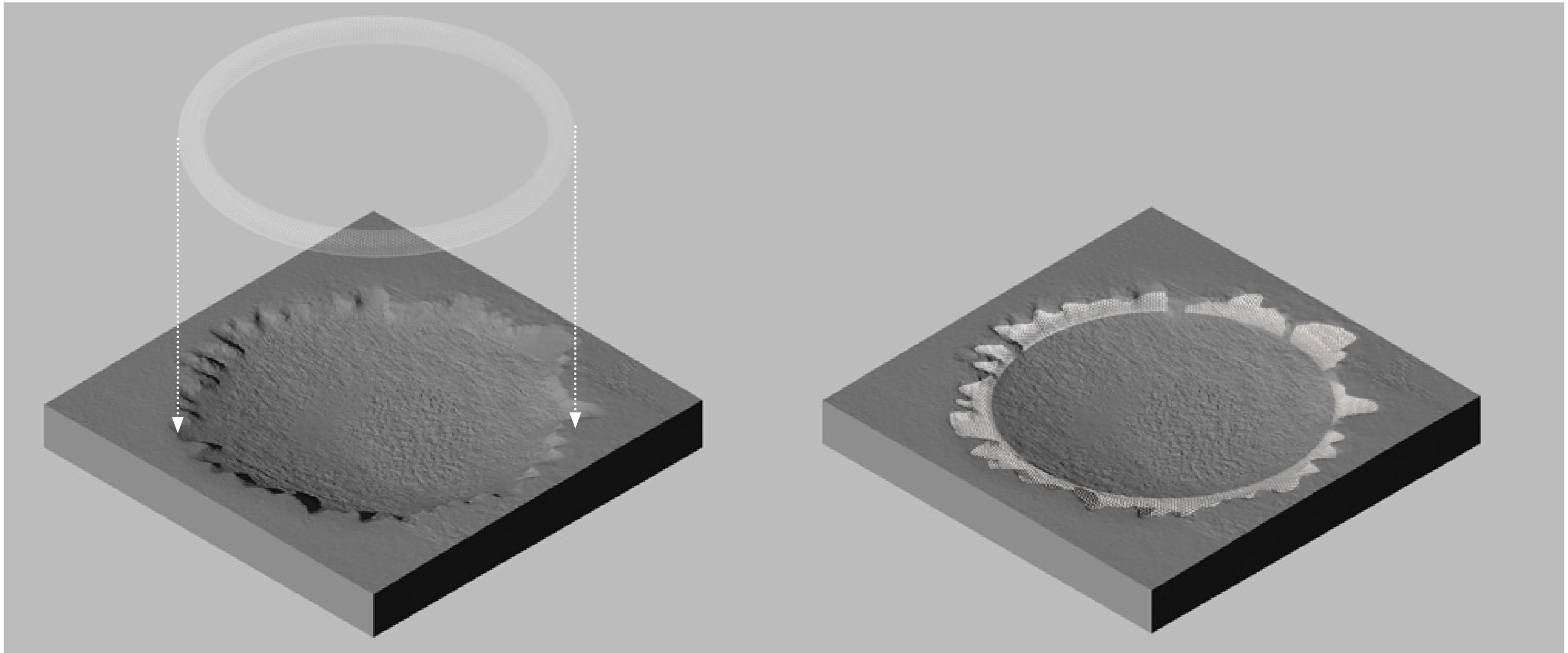
Ill. 73.b - Cliff concept



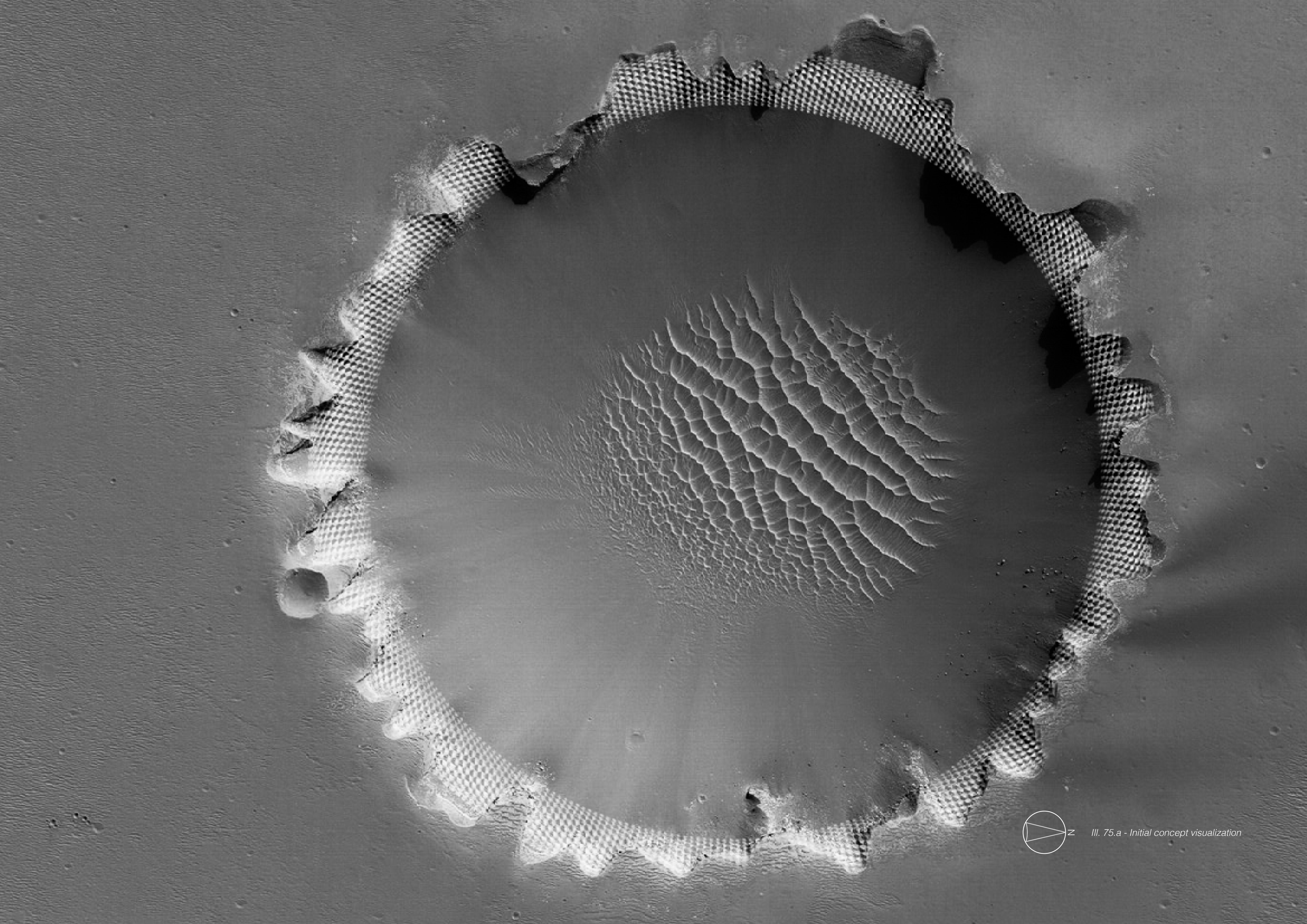
Ill. 73.c - Combination of cliff and pocket concept

CRATER CONCEPT

The combination concept was chosen on behalf of it natural utilization of the site and how it easily could connect the whole crater into one settlement, in a subtle appearance. Furthermore its beneficial properties in respect to sheltering from wind and radiation, while still provide a sustainable amount of daylight. A clear concept is achieved and can be seen on the ill. 74.a & 75.a, where a quick visualization of a torus formed biosphere, is placed down inside the cavities of the crater. These pockets of enclosures will ensure an artificial biosphere and the foundations for life with a gesture of natural phenomena from the site, where different communities can grow separately but as well as one city. For this Master thesis one of the cavities in the crater have been chosen to be detailed further on the following pages.



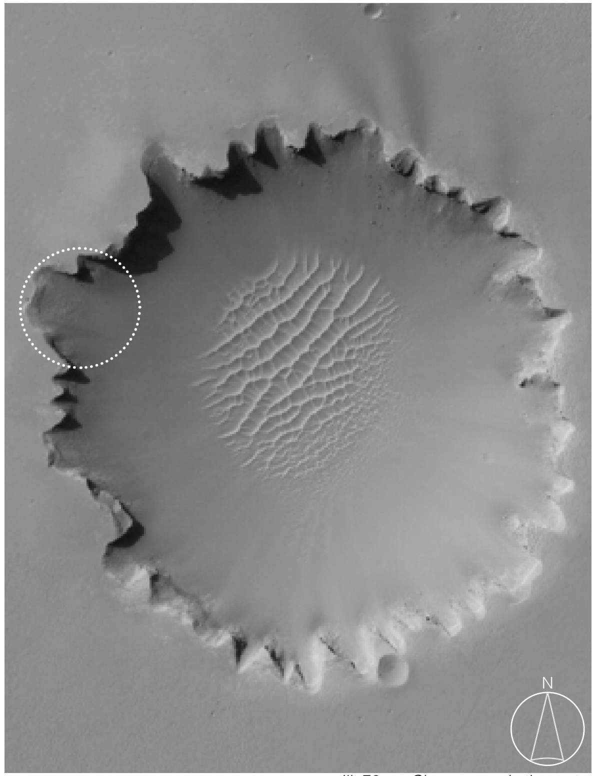
Ill. 74.a - Crater concept



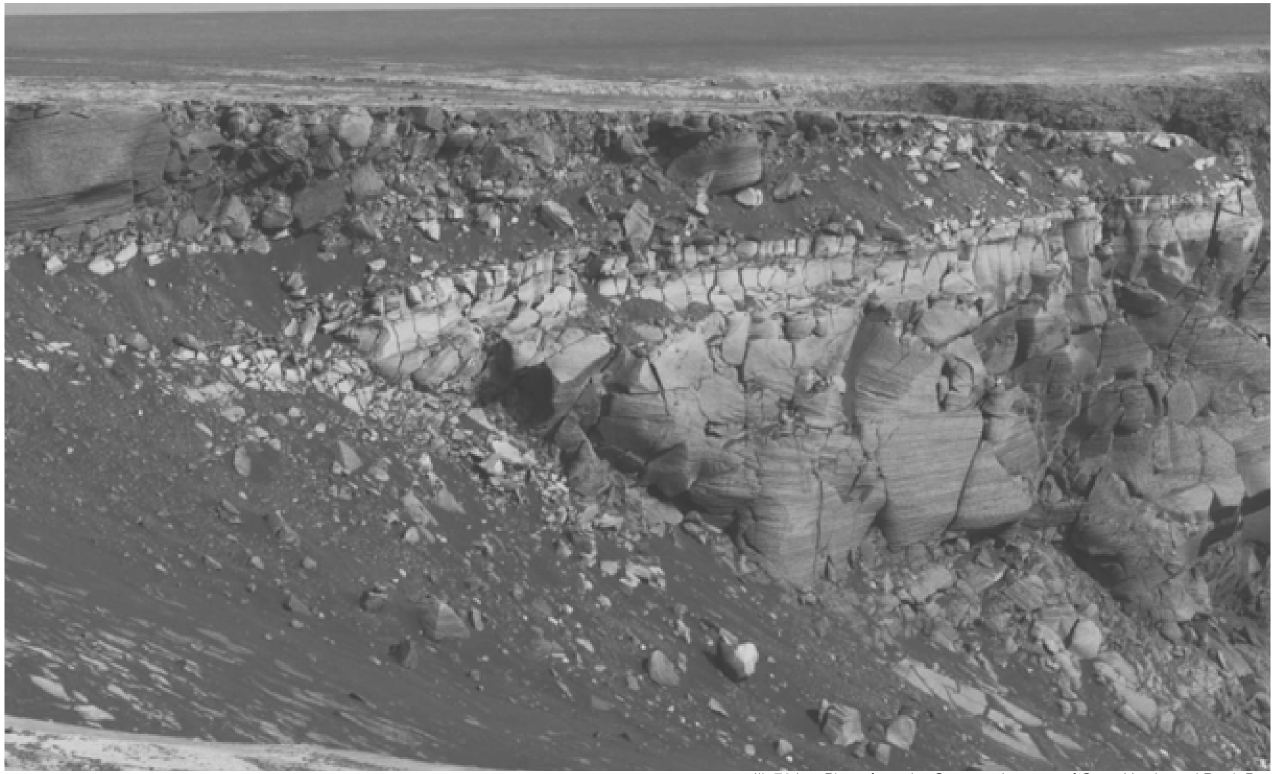
Ill. 75.a - Initial concept visualization

CAVITY ANALYSIS

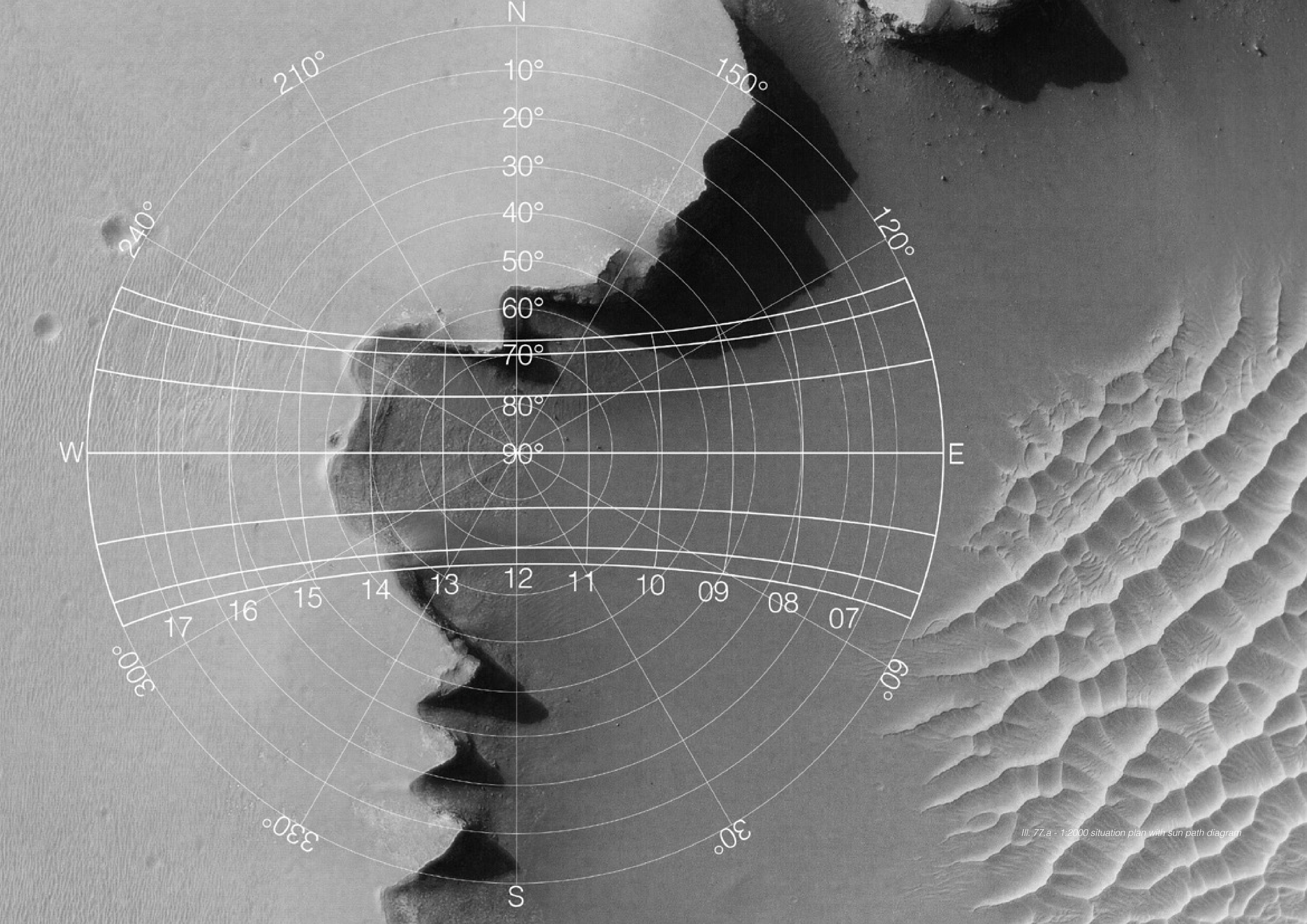
This particular cavity is one of the largest with a width of 117m , and has an almost direct east orientation with sloped hillsides towards the center. The inclination differs from 16° to 90°degrees, as one moves either towards north or south along the cavity edge and start to flatten towards the center of the crater after 30m-40m drop in altitude. The inclination force us to work with the landscape and will ensure different expression and experiences in the settlement development, and could potentially determine the specific function locations. The cavity walls and slope is raw cliff side, with regolith (Mixture of sand and small stones) on top and in between the rock.



Ill. 76.a - Chosen area in the crater

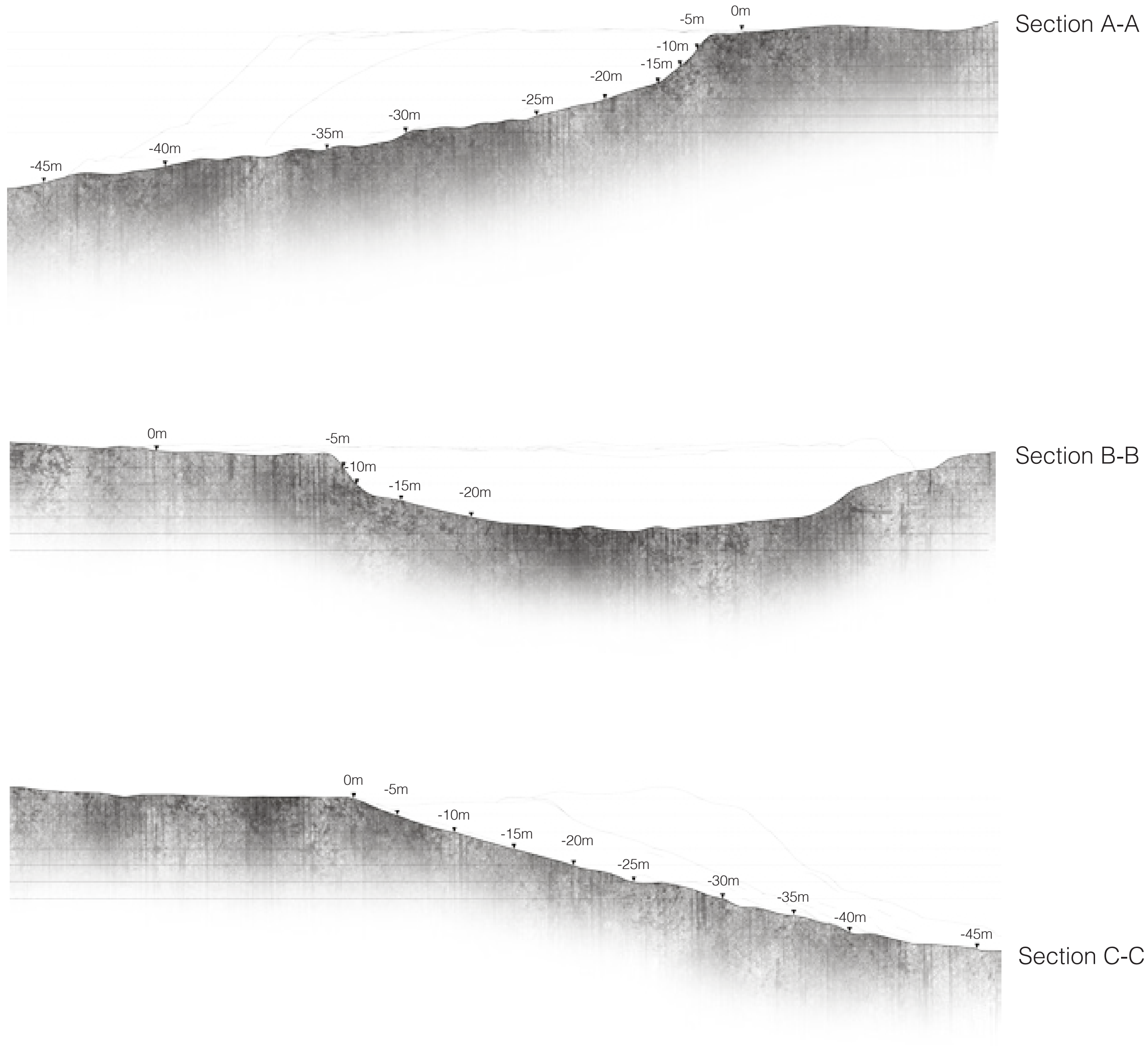


Ill. 76.b - Photo from the Oppertunity rover of Cape Verde and Duck Bay



Ill. 77.a - 1:2000 situation plan with sun path diagram

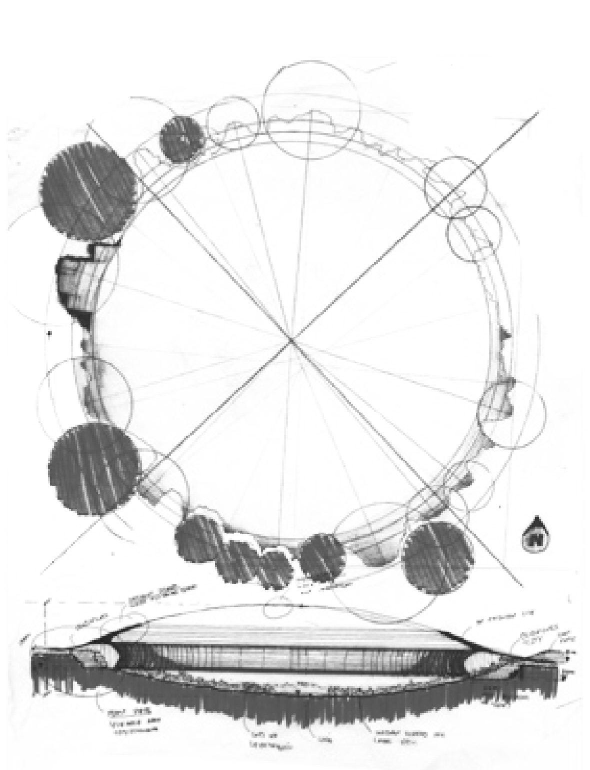
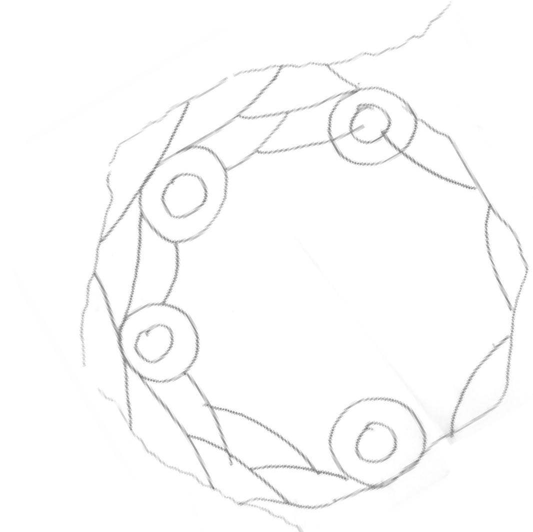
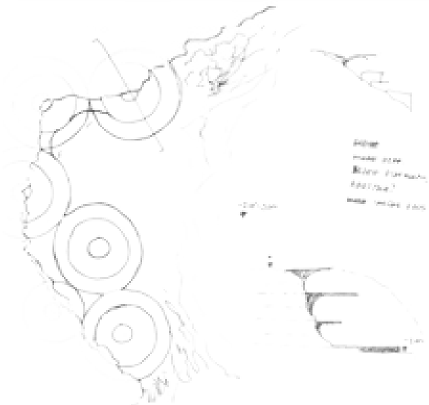
Ill. 78.a - 1:200 Situation plan



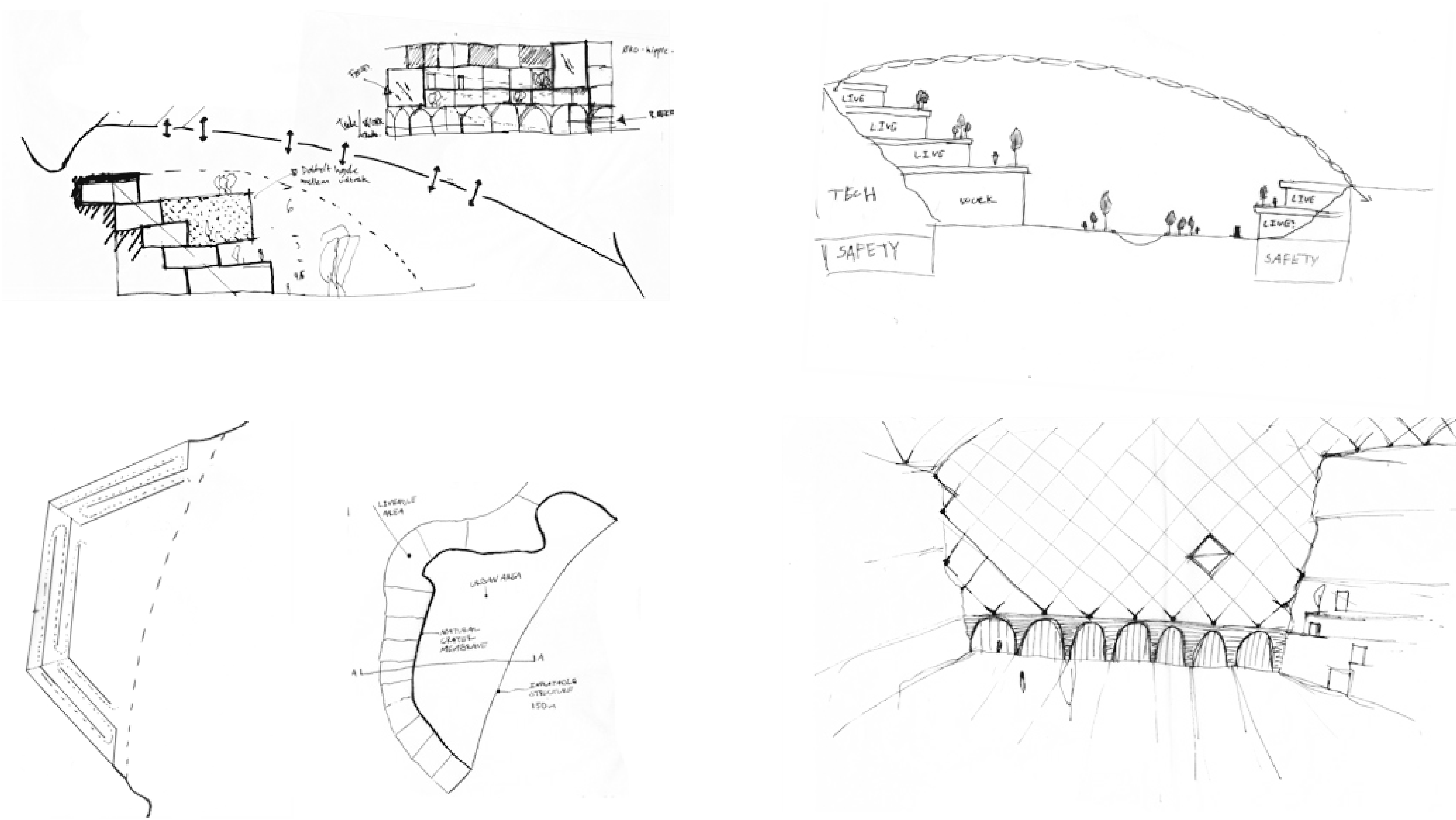
Ill. 79.a-c - Landscape sections in 1:2000

INITIAL DESIGN IDEAS

The site analysis set the frame for the initial design process and key questions started to emerge: How would the settlement function?", "how should it be part of the natural penomena and be influenced by it?" The methodology created earlier was used as a generator and kickstarter for our design phase. The first drawings is mostly master plans and large sections, as an attempt to get an overview of the site, the genius loci, proportions and materials. As the design proceeded, different subjects was discussed, "How would the biosphere be created?", "how should people on Mars live and what happens in cases of emergencies?" These thoughts supplied the project with a pragmatism and functionality, which went on through the project and initially sparked the first idea presented at the midterm seminar.

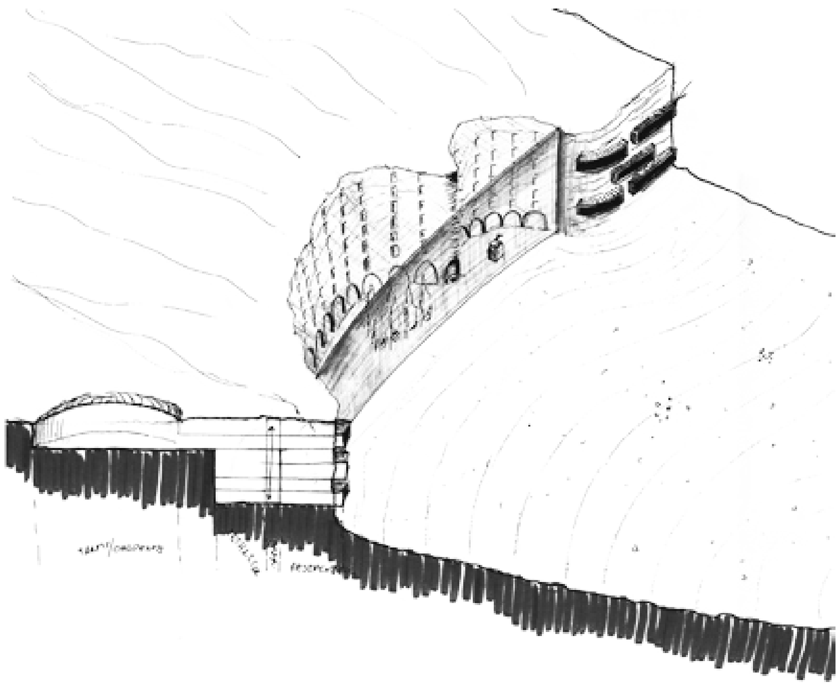

Ill. 80.a-d - Initial masterplan drawings

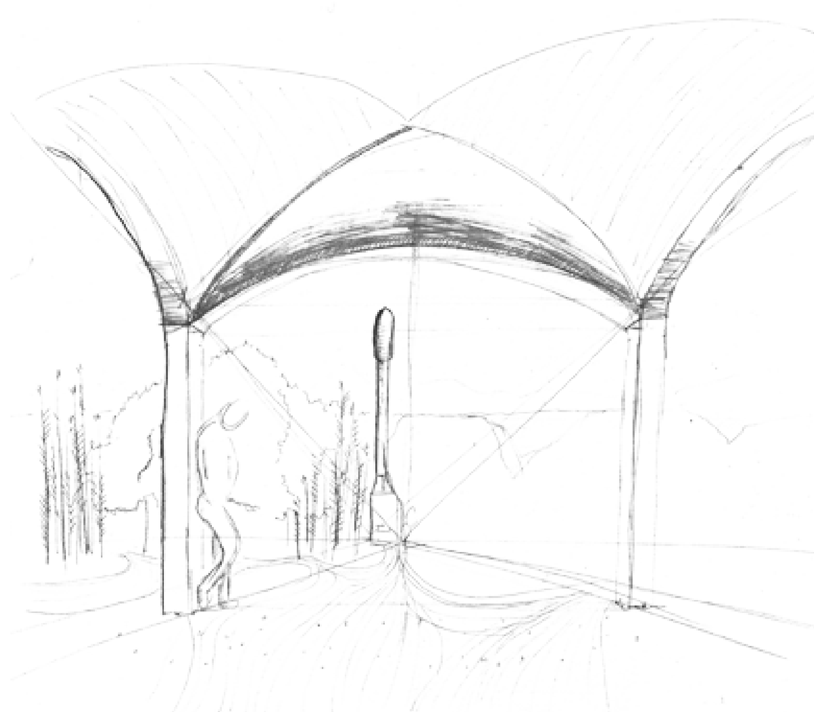


Ill. 81.a-e - Initial concept drawings

MIDTERM SEMINAR

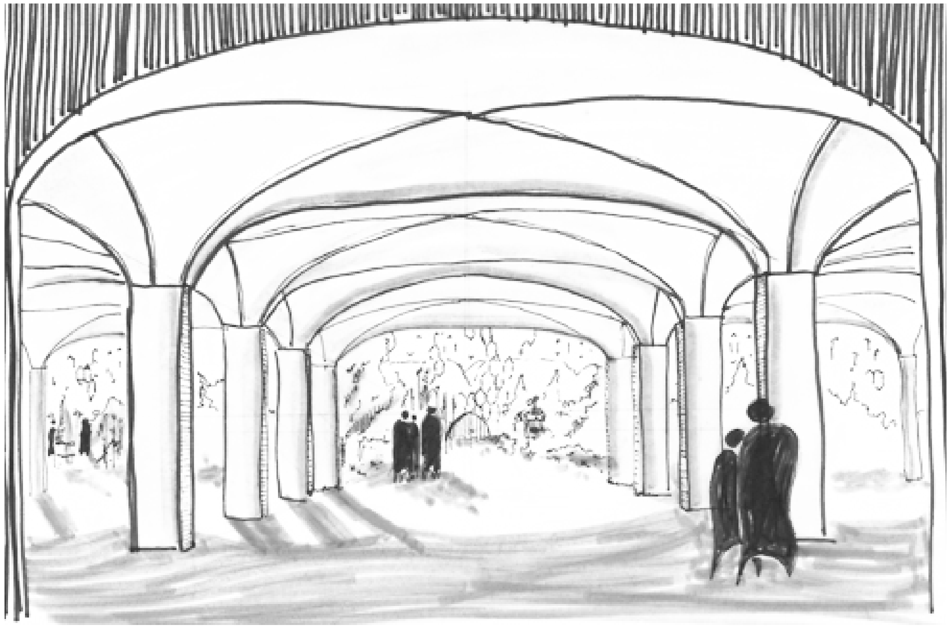
The midterm seminar idea initially started by looking into the site and vernacular architecture. How cultures before have dug inside a cliff side and settled down. The idea is built up by arcades excavated directly out of the landscape, that distribute the forces downwards as in roman architecture. This would ensure a spatial gesture, through the structural principle from the natural phenomena. These arcades would surround an open area filled with vegetation, monuments and earth like sensations. The living quarters was placed from the first floor up and inside the cliffside, common distributional paths with gardens would be placed outside the residences to emphasize the feeling of community.

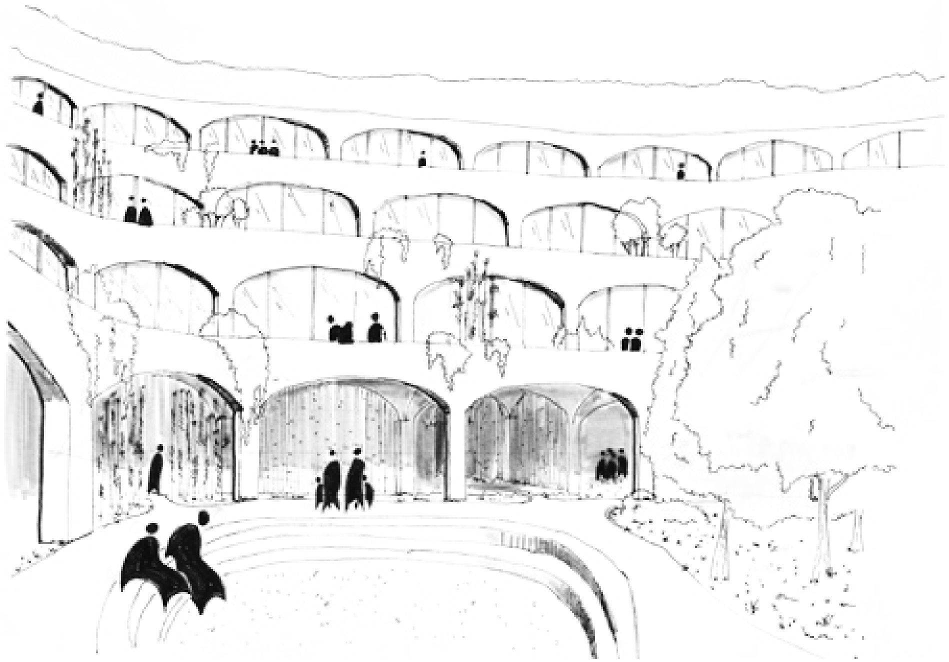




Ill. 82.a-b - Initial midterm drawings

The initial idea was presented at the midterm and was meet with a certain amount of criticism and questions. “Why should people on Mars live in row houses?”, “Why use columns and round arches?” and the spatial experience of being there might be imprisoning. The comments had us rethinking the initial design, and how it should have its foundation in vernacular- and utopian architecture, and not only vernacular. At the same time exploiting new technologies such as 3D printing concrete and inflatable structures.This lead us into the next phase of rethinking our whole approach with a more visionary thinking, rather than solely traditional.

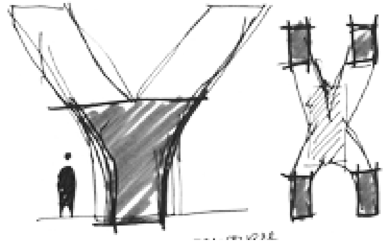


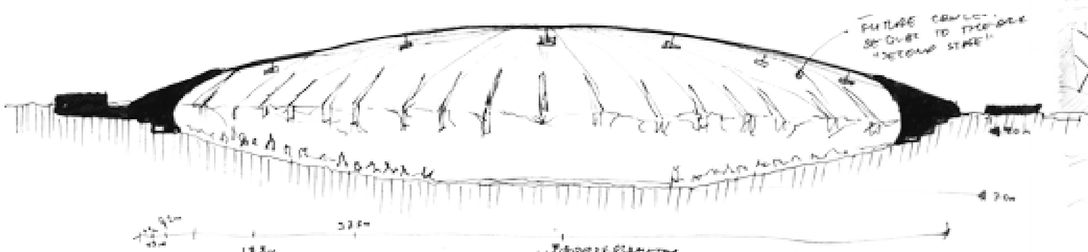


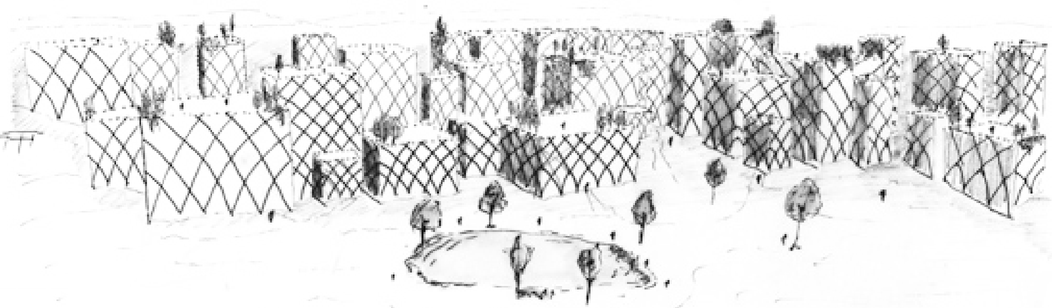
Ill. 83.a-b - Midterm seminar drawings

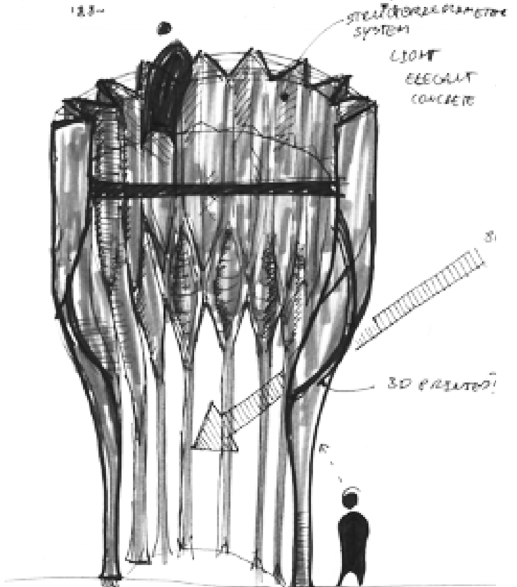
NEW IDEAS

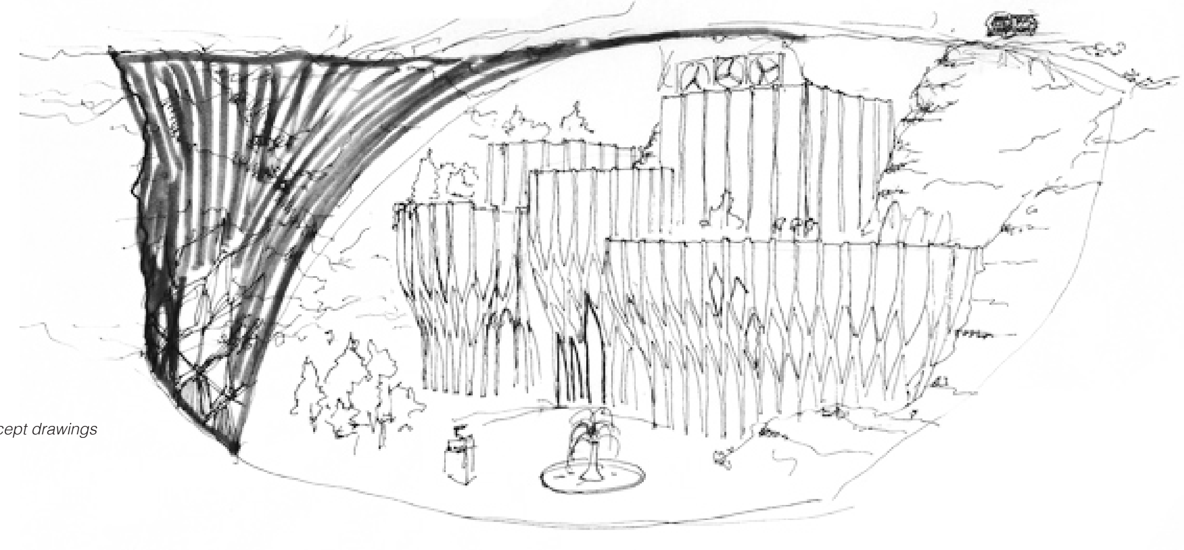
Ideas emerged from the comments of the mid-term and we allowed our self to experiment with new typologies, forms and language. Some more extravagant than others, but the foundation was created at this point. The concept drawing ill. 85a, illustrates how the buildings interact with the cliff side, by utilizing the removed regolith from the landscape and 3D printing the martian typology with it. This strategy was also in the spirit of utilizing the natural phenomena as a principle.



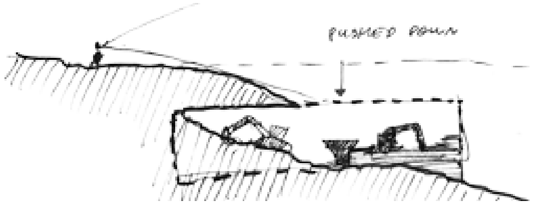




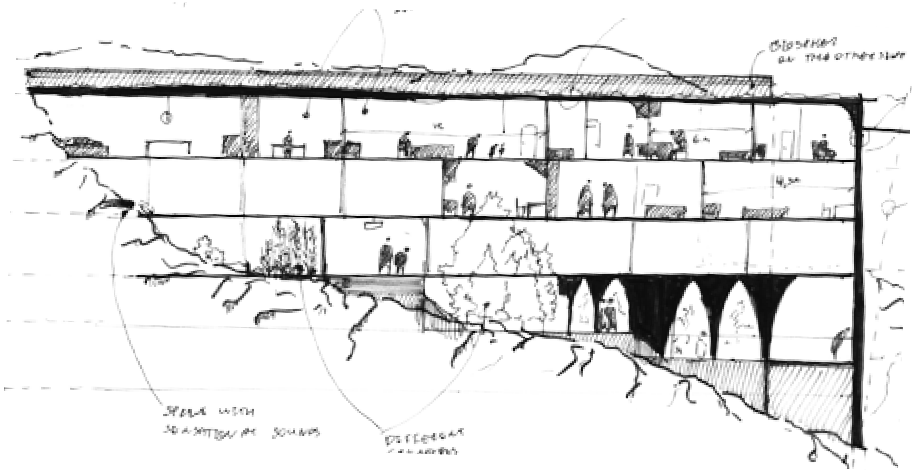


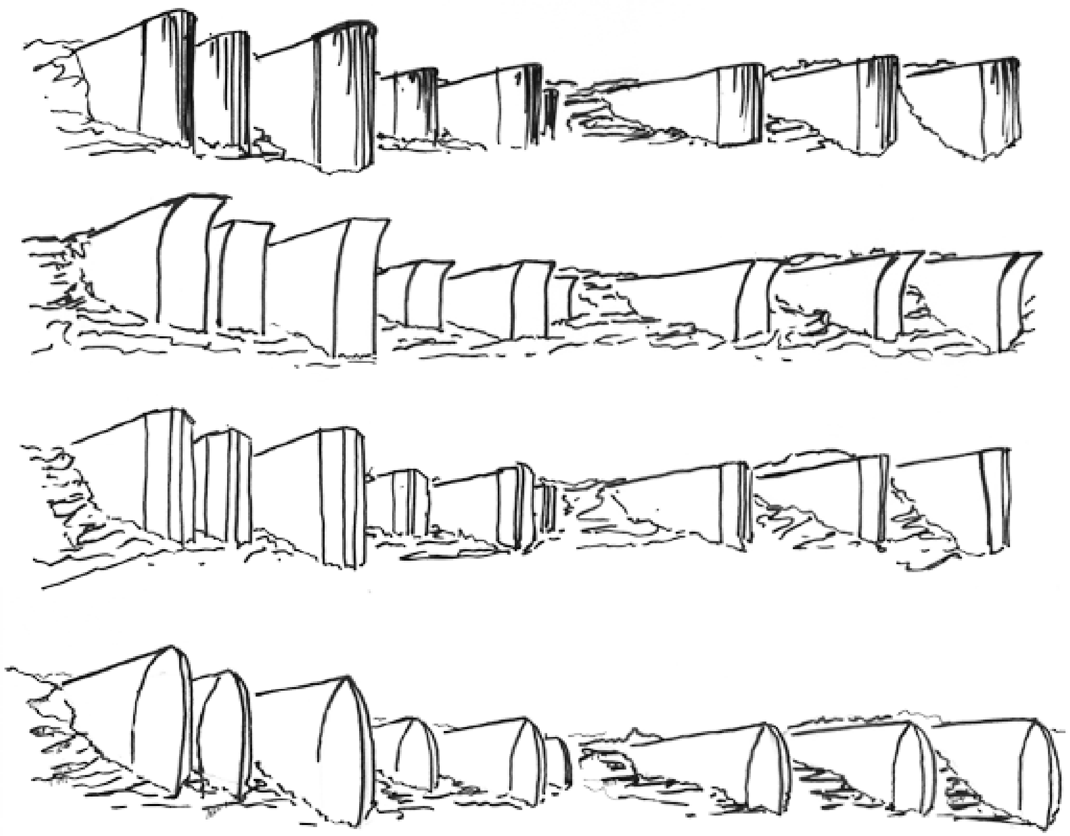


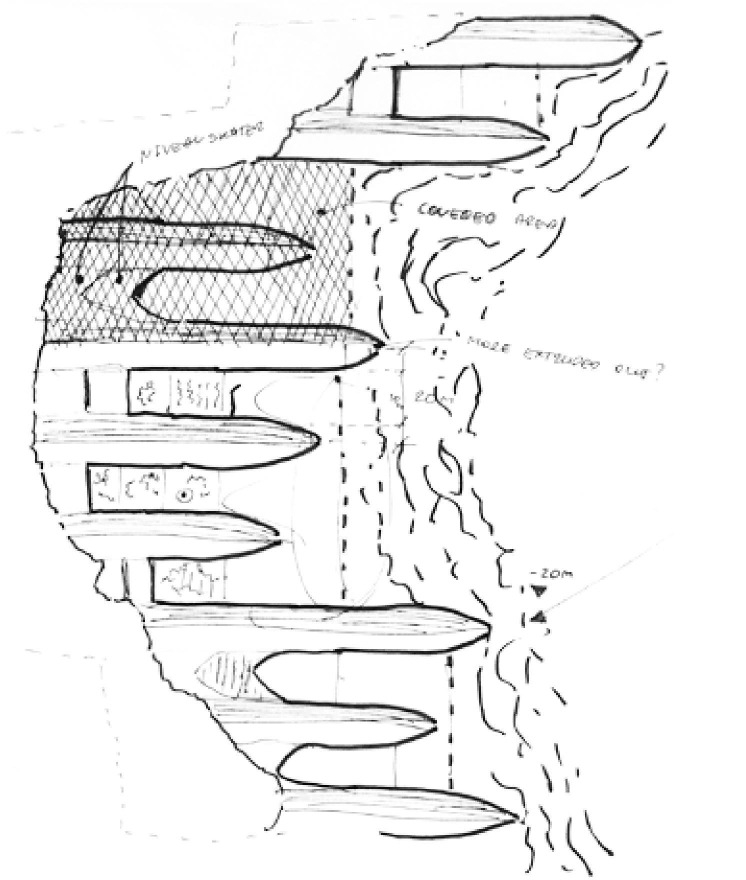
Ill. 84.a-e - New idea concept drawings



Ill. 85.a - Concept drawing



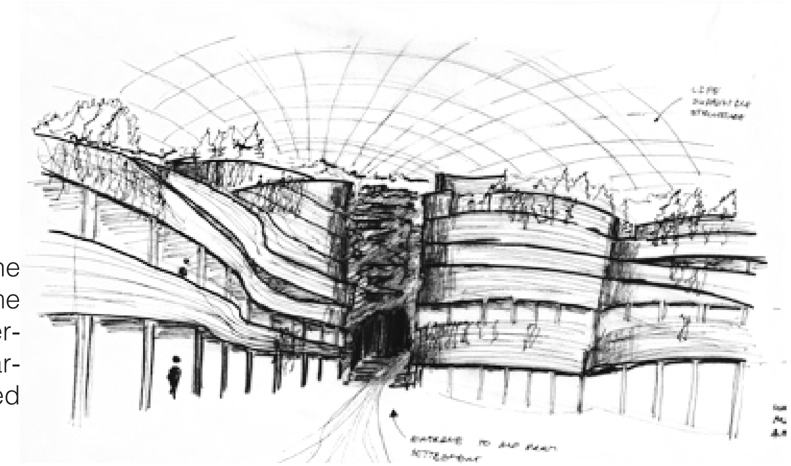


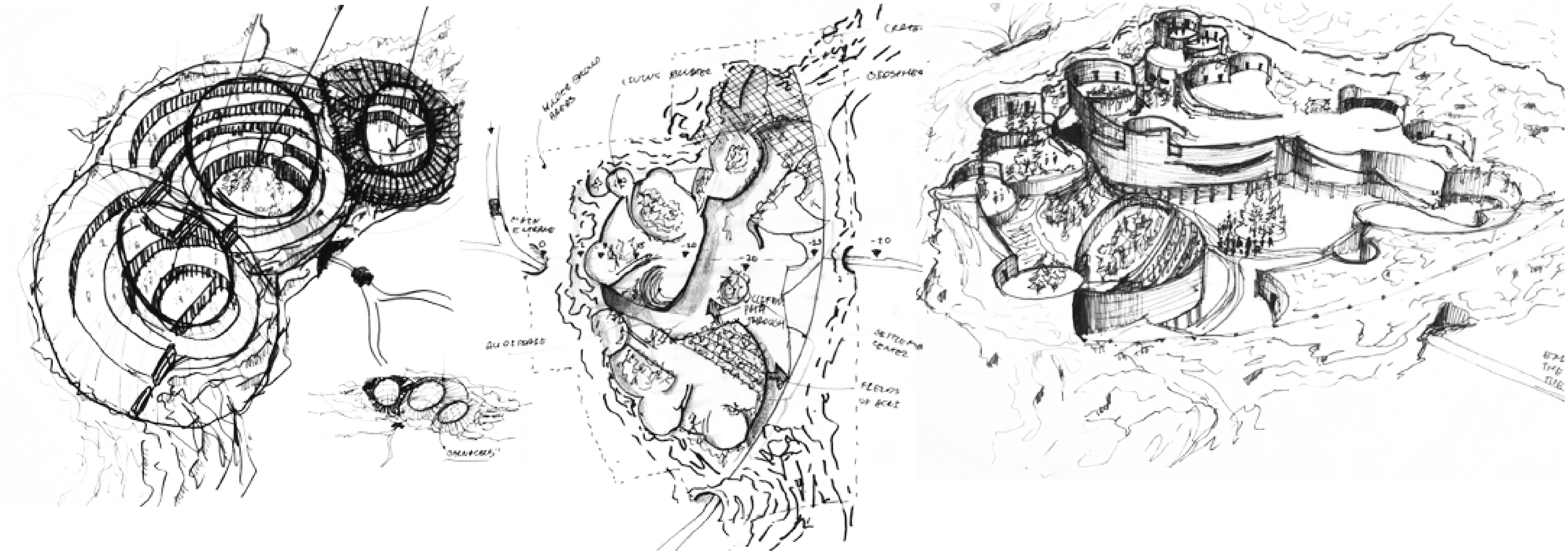


Ill. 85.b-g New idea concept drawings

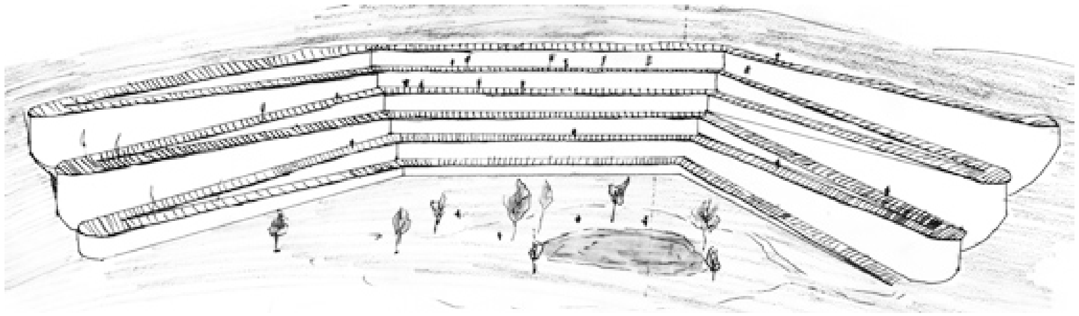
UNDER ONE ENVELOPE

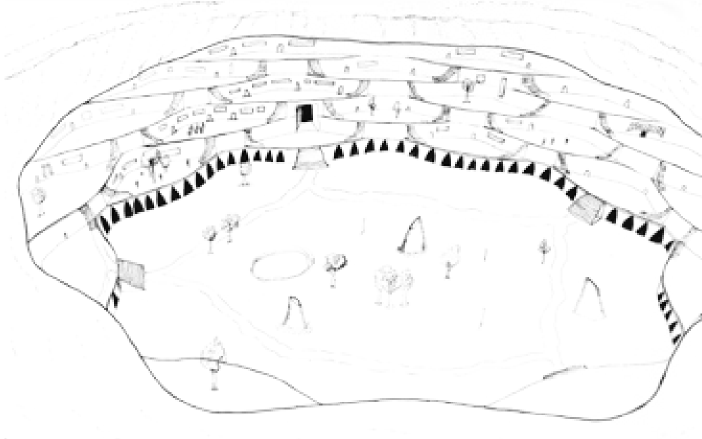
Different new typologies was design from the foundation of “what is taken away, is used somewhere else”. During this process a design criteria emerged as a consequence of previous designs, that the settlements should be covered completely under one envelope and enlarge the livable volume. This was done as an attempt to minimize the spatial gesture of imprisoning at the same time working with Mars’ gravity and pressure difference to span large areas. Setting the inside architecture on a hold, the envelope was designed further.

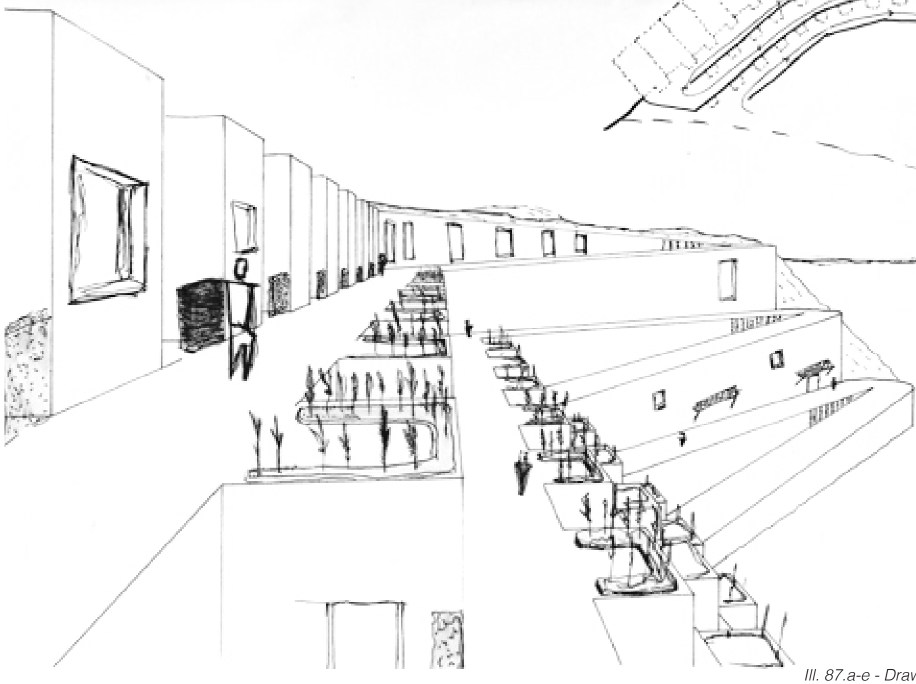


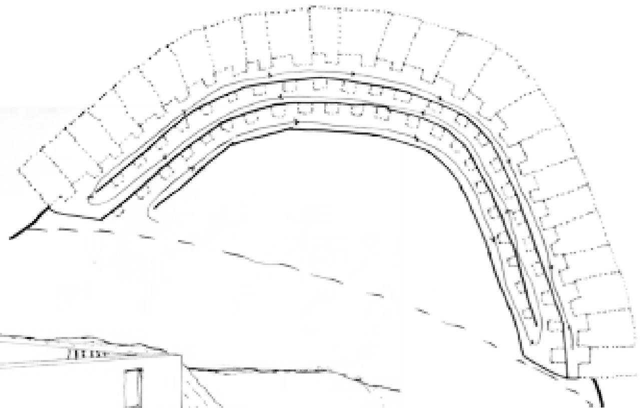


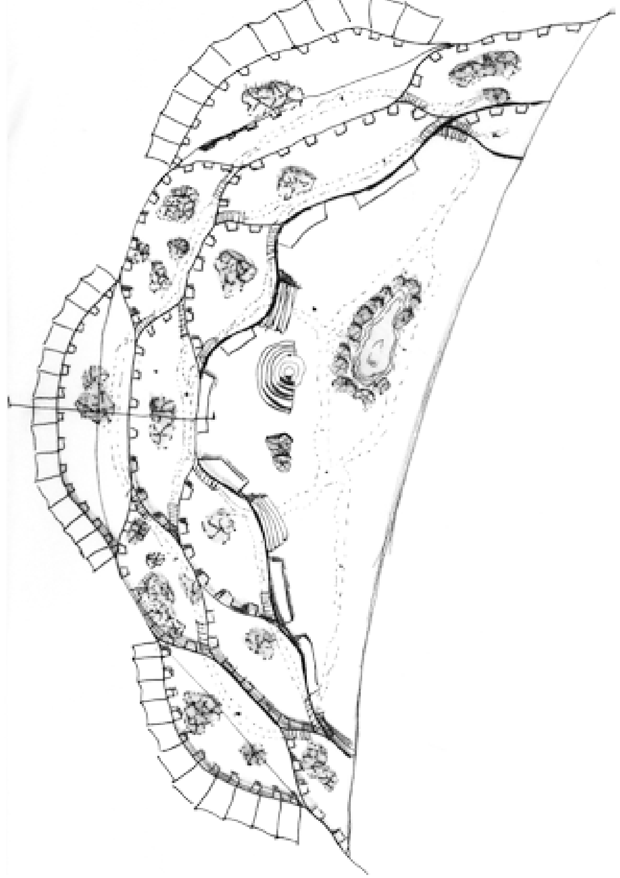
Ill. 86.a-d - Drawings of under one envelope drawings







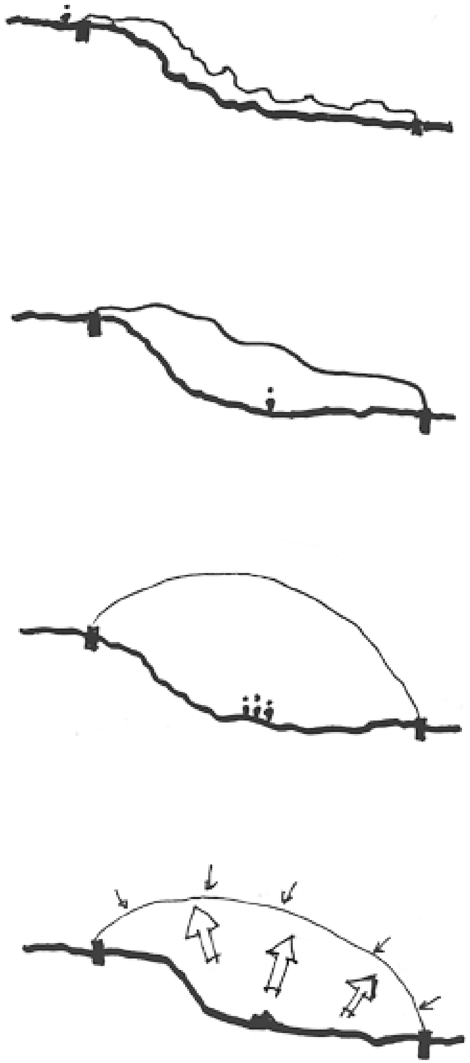




Ill. 87.a-e - Drawings of under one envelope drawings

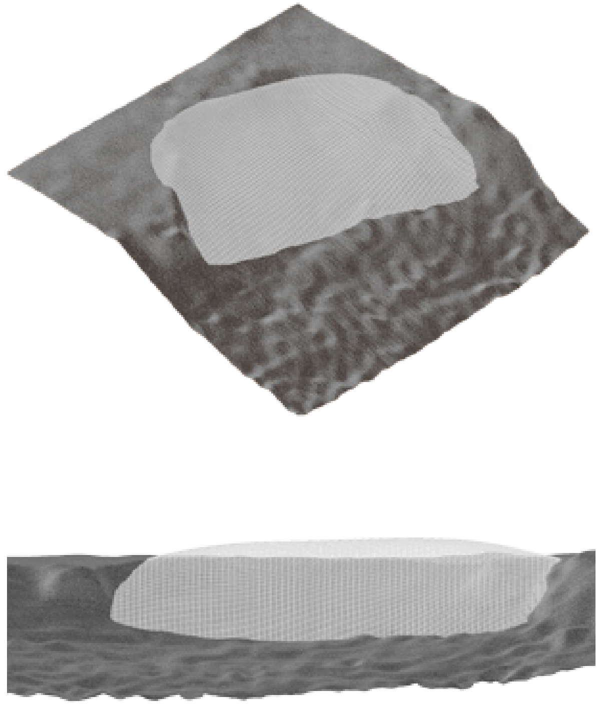
ENVELOPE FORM

After analyzing the cavities size, inclination and deciding upon accumulating the whole settlement under one envelope, it needs to be detailed in order to ensure a artificial biosphere to support biological life. Different forms have been optimized through Kangaroo, which serves as a plug-in to grasshopper. Kangaroo function as an interactive simulation for optimization and form-finding. The inflatable forms is created through a simulation of blowing up the original forms, into a three dimensional form and here by creating a volume for evaluation. The volumes is visually evaluated and later calculated upon.
The reason why a inflatable structure is chosen, is because the martian settlement needs an air tight membrane and we wanted a structure as spacious and as light as possible.
Furthermore an Inflatable structure is an advantage because of Mars' gravity and low density atmosphere. The pressure difference between the inside of the artificial biosphere and the outside martian atmosphere, will have a tremendous tensional force on the inflatable envelope, which will provide structural support and allow hugh spans.



Ill. 88.a-d - Inflatable structure

Torus
The torus is actually part of a whole torus, seen from the crater concept on page 75. Alone the form isn't interesting, and doesn't give enough spacious volume or square meter area.

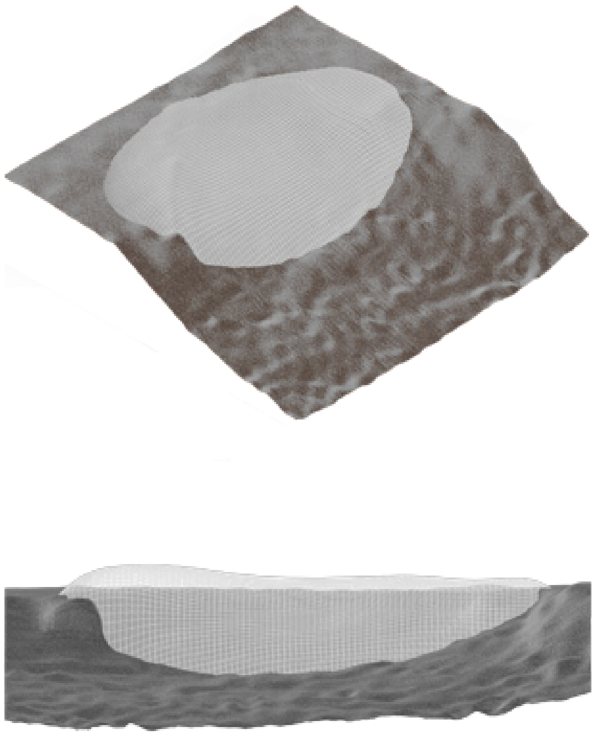


Ill. 88.e-g - Inflatated torus form

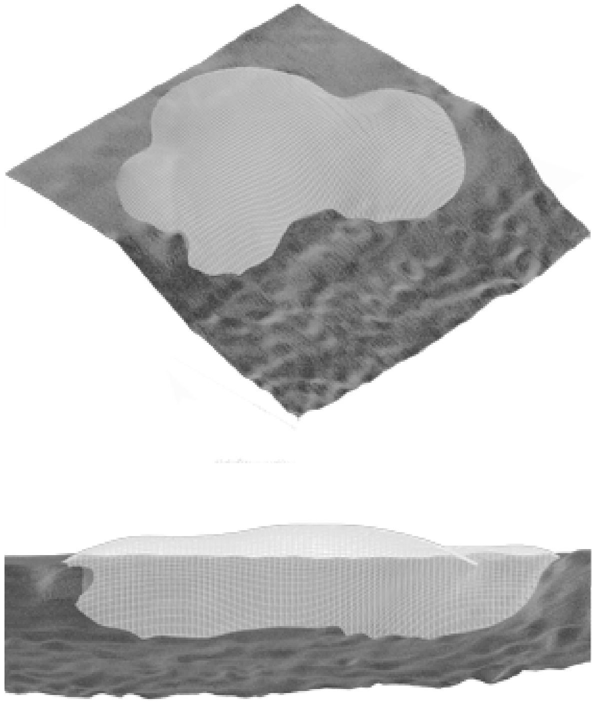
Ellipse
The ellipse form has a more appealing form in plan, but a rather dissatisfied volumetric feeling.

Cluster
The idea of bringing together a group of domes into a cluster will enable a feeling of division inside the settlement. This might be a benefit, but is structurally a disadvantage.

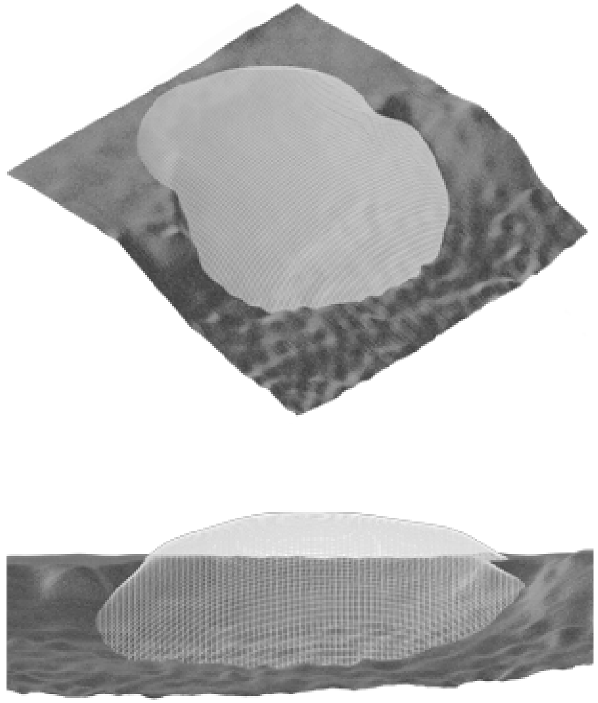
Dome
The form of a dome placed down into the cavity, have shown a massive volumetric space, with a large amount of square meters. The outside appearance seems also grown into the site as a natural part of the landscape.



Ill. 89.a-c - Inflatated elipse form



Ill. 89.d-f -Inflated cluster of smaller domes



Ill. 89.g-i - Inflatated circular form

ENVELOPE MATERIAL & PATTERN

For further development the dome was chosen as the enclosure, both because of is visual appearance, but as well for the spacious volume and square meter achieved.
The inflatable material chosen for the envelope is Bioplast, the reason for this is that the resources for reproduction will occur on Mars in the matter of bio waste and composting from plants.

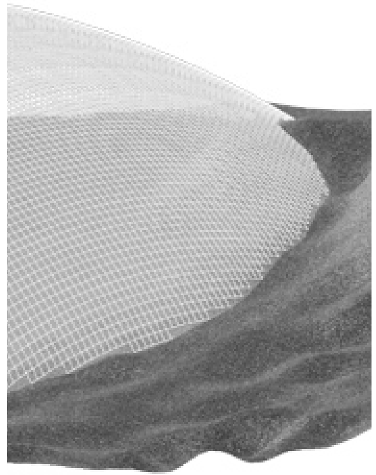
This envelope will function as double membrane, to protect against the martian climate. The envelope will need to be anchored down by cables, and different materials have been investigated and compared upon their tensile strength and density. For this project to success a lightweight but tensile strong cables is needed to withstand the upwards pressure from inside the settlement. Looking upon the different material properties, UHMWPE is clearly the best choice and have been chosen for further development of chosen the structural pattern.

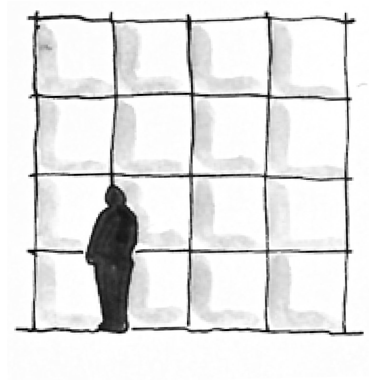
BioPlast
Density: 13,2kN/m^3
Tensile (Yield) strength: 3,4kN/m^2
Young Module: 240kN/cm^2

S460 Steel
Density: 77,01kN/m^3
Tensile (Yield) strength: 33,5kN/m^2
Young Module: 21000kN/cm^2
Thermal Expansion Coefficient: $12x10^{-6}$ 1/C°

CFRP (Carbon Fiber Reinforced Polymer)
Density: 15,7kN/m^3
Tensile (yield) strength: 150kN/m^2
Young Module: 18100kN/cm^2
Thermal Expansion Coefficient: $0,02x10^{-6}$ 1/C°

UHMWPE (Ultra High Molecular Weight Polyethylene)
Density: 9,61kN/m^3
Tensile (yield) strength: 360kN/m^2
Young Module: 11600kN/cm^2
Thermal Expansion Coefficient: $-12x10^{-6}$ 1/C°

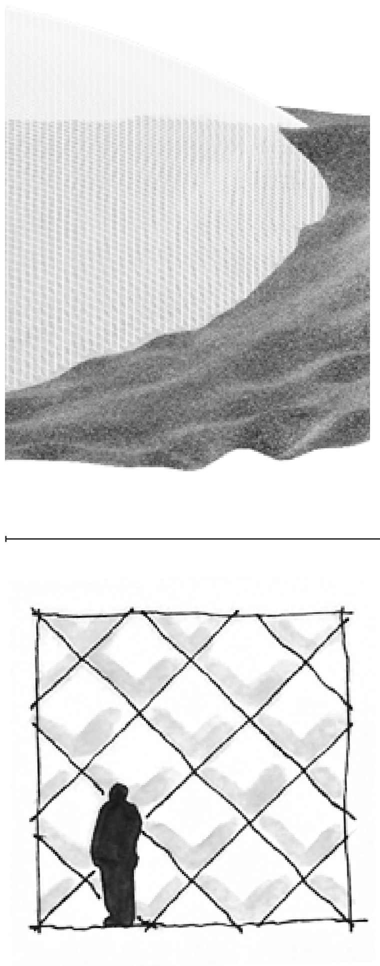




Square grid 1m

Diameter of cable: 10cm
Total weight: 95,4t
Max def.: 57m
Max N: -8763,9kN
Max M: 0,003kNm
Shear force: 0,01kN

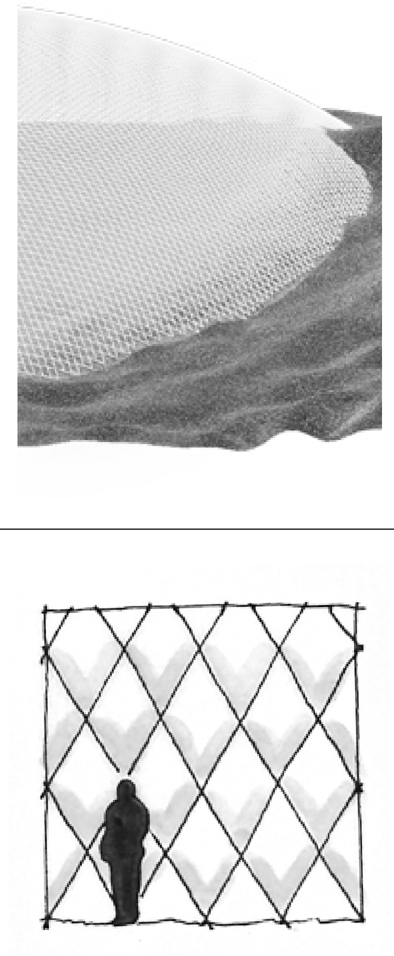
Ill. 90.a&b - Square grid pattern



Square grid rotated 1m

Diameter of cable: 10cm
Total weight: 95,4t
Max def.: 66m
Max N: -8924kN
Max M: 0,002kNm
Shear force: 0,01kN

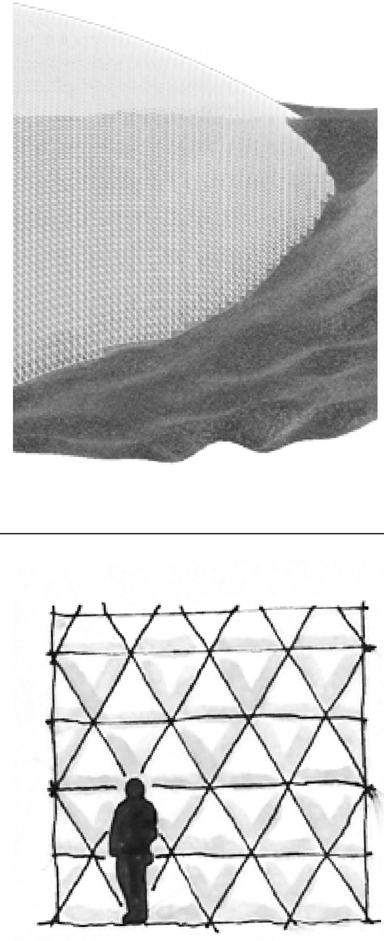
Ill. 91.a&b - Rotated square grid pattern



Diamond grid 1m & 30 degrees

Diameter of cable: 10cm
Total weight: 97,6t
Max def.: 411,9m
Max N: -20353,9kN
Max M: 0,002kNm
Shear force: 0,01kN

Ill. 91.c&d -Diamond grid pattern



Triangular grid 1m & 30 degrees

Diameter cable: 10cm
Total weight: 123,1t
Max def.: 2,2m
Max N: -5103,3kN
Max M: 0,002kNm
Shear force: 0,01kN

Ill. 91.c&d -Triangular grid pattern

ENVELOPE DESIGN

The triangular grid was chosen for both its visual effect and its structural properties. The pattern turn the membrane into a triangle shaped bubble wrap membrane, and to determine the membrane thickness of the bioplast, Barlow's formula have been used. It determine the thickness by combining the internal pressure, the membrane tension strength and the diameter of a pipe. So for this example one volumetric triangle is simplified into a pipe with a diameter of 1m and the internal pressure inside the envelope is found by the pressure difference between inside and outside in the martian atmosphere. Afterwards the membrane is conceptually detailed upon page 93 (ill. 93.a), on how the membrane could be jointed with the ground and ensure and airtight environment inside the envelope.

Barlow's formula: P = (2 · s · t) / D

P = Internal pressure [psig]
s = Unit stress [Psi]
t = Nominal wall thickness [Inch]
D = Diameter of pipe [inch]

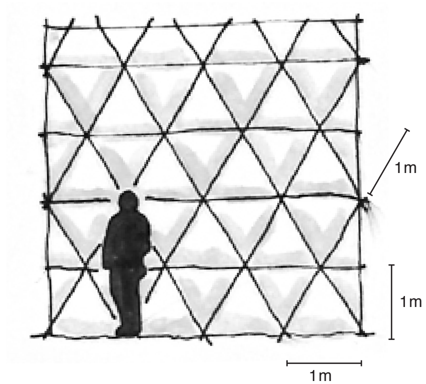
Mars' atmosphere 0,006atm = 0,09Psi
Earth's atmosphere 1atm = 14,67Psi
Pressurized bioplast membrane 2atm = 29,39Psi

Bioplast, tensile strength = 34MPa = 4931,28Psi
Bioplast, D = 1m = 39,37in

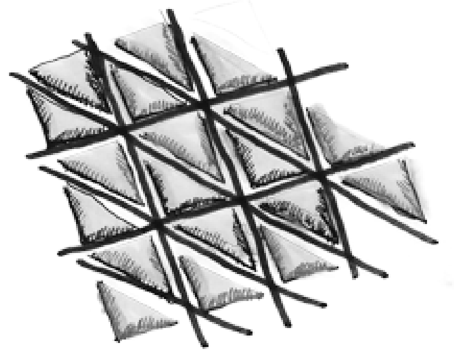
29,39Psig - 0,09Psi = 29,30Psi

29,3Psig = (2 · 4931,3Psi · t) / 39,37in

T = 0,12in = 2.97 millimeter

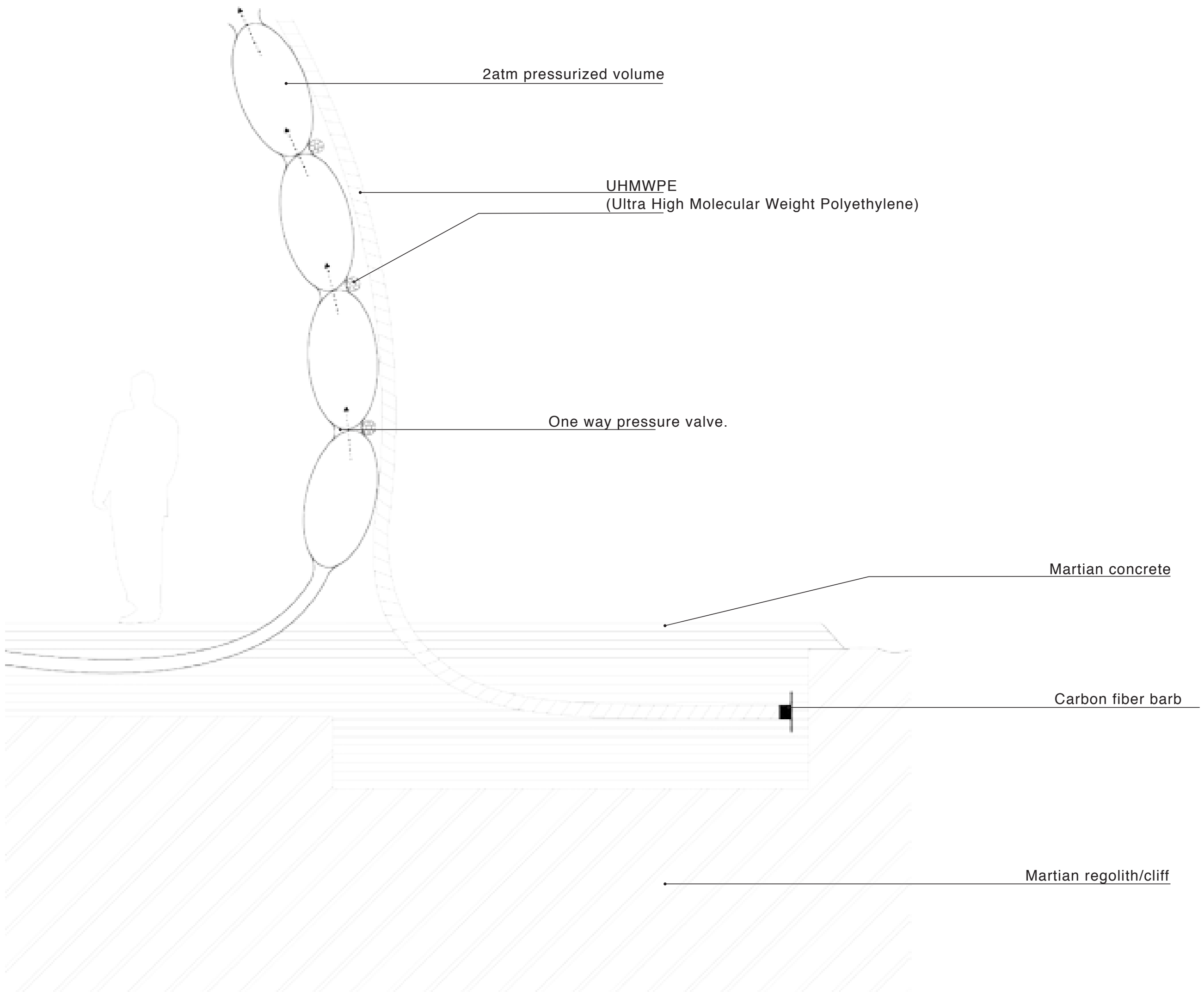


Ill. 92.a - Membrane drawings



Ill. 92.b - Concept drawing of inflatable membrane

The concept detail shows how the membrane is thought to meet the ground and function in terms of reflating punctured volumes. A punctured volume will not affect neighboring ones because the one way valves will lock when pressure is lost. After repairing and sealing the punctured volume, the arrows in the drawing show the direction of which the pressure will move, when applying pressure to the volumes closest to the ground. When max pressure inside one volume is reached, a one way valve opens into the next volume to relieve the excessive pressure.
The pressure inside each volume is estimated to 2atm, the double amount of what is estimated as optimal living pressure for the human body. This is design as such to ensure that every volume is stretched and clearly transparent for the inhabitants to look outside. The higher pressure inside the volumes would normally increase heat transfer, and thereby increase heat loss through the envelope. [Saidi and Hosseini Abardeh, 2010] But referring back to the chapter of Mars conditions of heat loss, this is fortunately not the case.

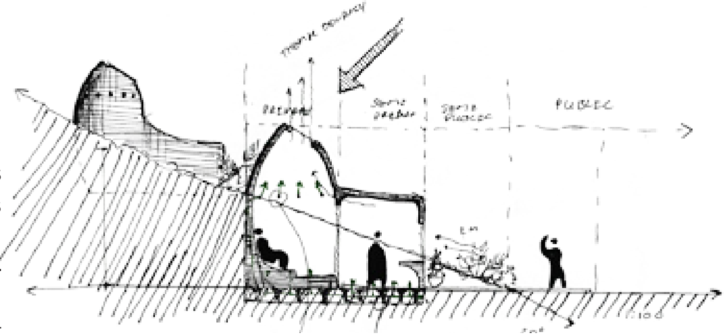


Ill. 93.a - Concept joint of membrane meeting the ground

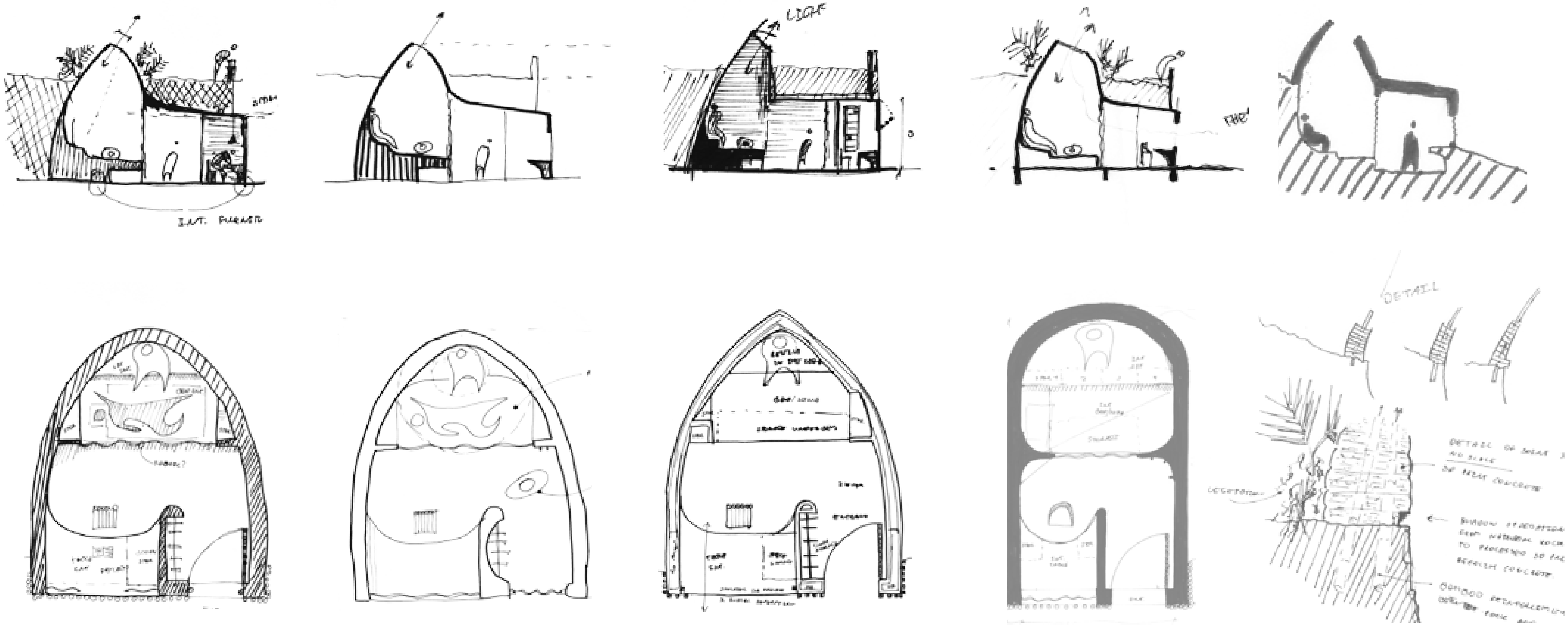
DESIGN PHASE

INITIAL MARTIAN TYPOLOGY

After the life preserving membrane have been detailed our focus orientated towards the actual design of the settlement. The idea revealed itself from scaling our focus down into one living unit and what we thought could be an experiment of minimal living spaces, which was a thought from the program. This idea grew up with curved forms in multiple plan and section drawings with a focus upon minimizing living spaces without neglecting quality, spatial gestures and the influence of natural phenomena.
The minimizing of the living quarters also meant

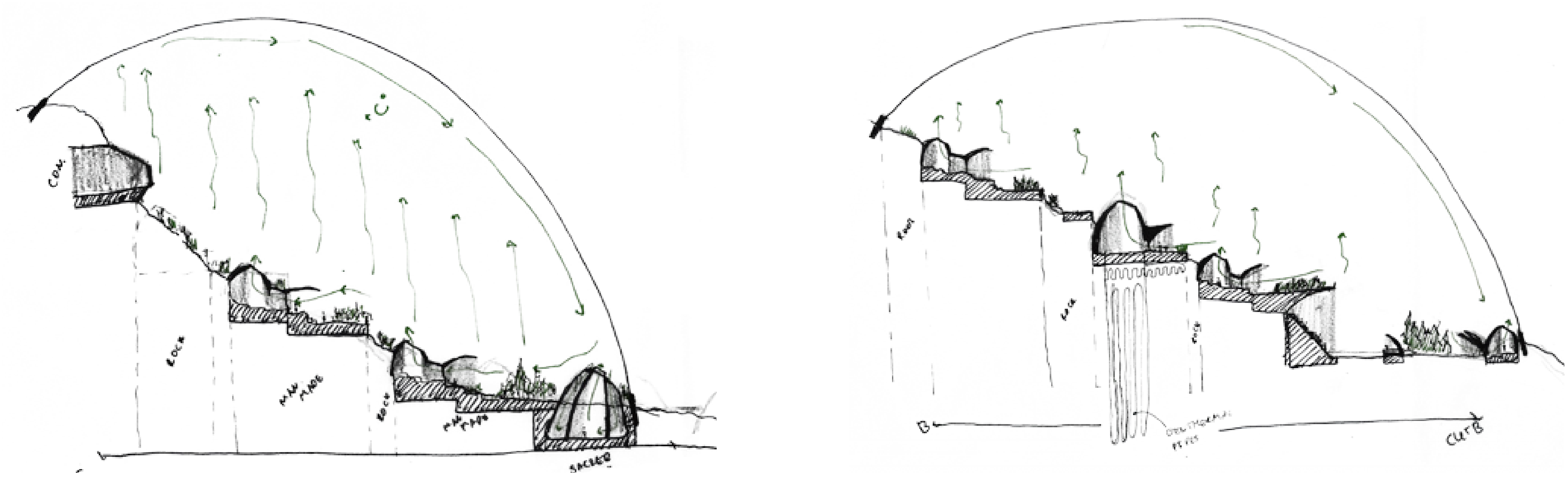


Ill. 94.a - Initial drawing



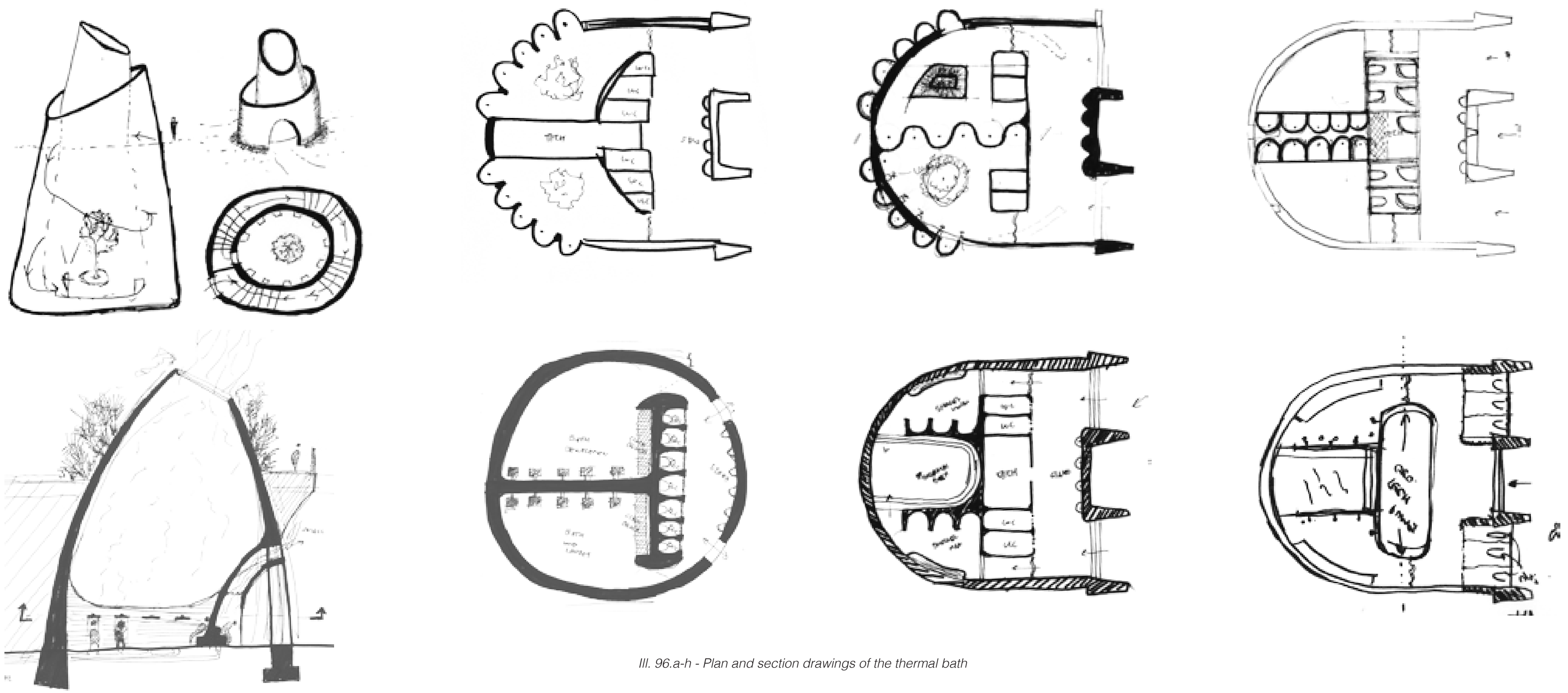
Ill. 94.b-k - Plan and section drawings of a single unit

no water and electricity to really experiment with the thought of purely spartanien living with minimal disturbance. This romantic thinking was a way for us to really reflect upon how we live today, what that distract daily living and what could be changed for the better with of course having the situation and site in mind when designing. So the initial idea was to split such practical function as water and electricity and keep them gathered in one place, to minimize the amount of wiring and piping. This of course seperated the bath from the living units, which was seen as one of these earth sensation we wanted to create an atmospheric experience from



Ill. 95.a-b - Landscape section drawings

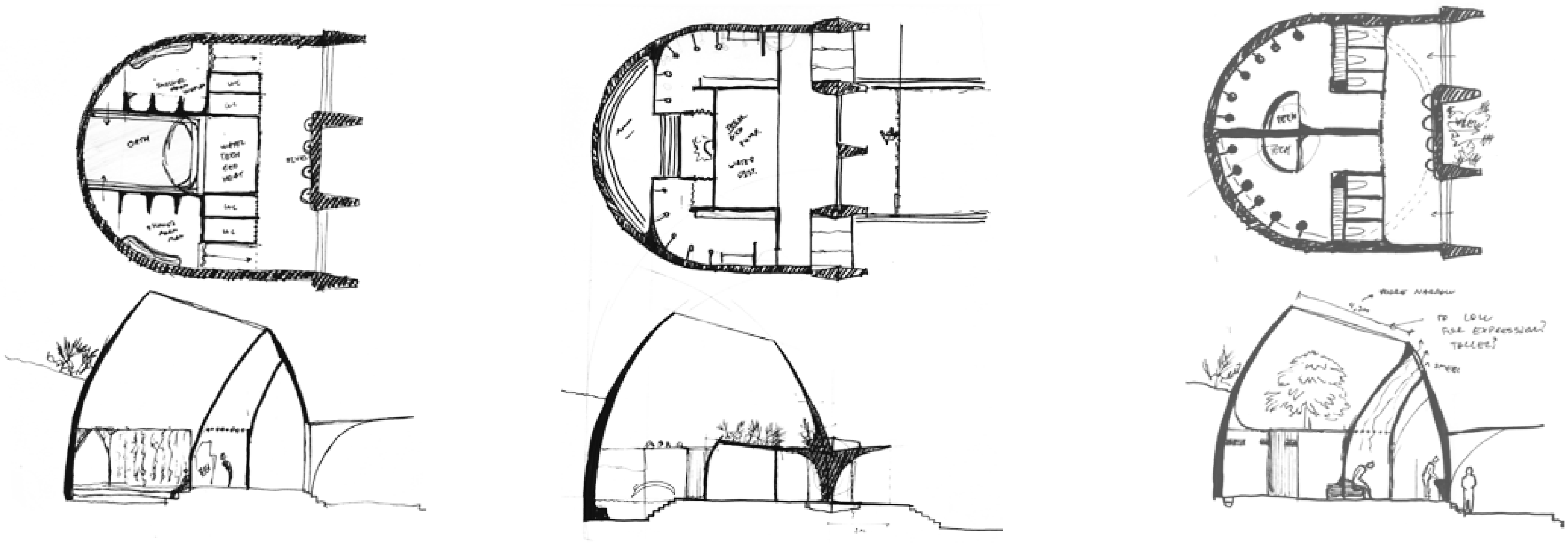
The sensation of taking a bath was designed to emphasized spatial gestures of the tangible and intangible phenomenological experiences, such as tactility, smell, acoustic and visual indication of natural phenomena such as light and shadow. The intention of the structural principle in the bath was a form was to be 3D printed on top of a excavated plateau, that serves as a platform to be printed upon. The bath also work visually from the outside as landmarks, for the inhabitants to guide themself through the principle of the settlement.
During the designing of the martian typology and its interplay between light and shadow, an idea emerged of creating solar shading enabling the inhabitants to move freely during the day, without exposing themself to the harmful direct solar radiation described in the chapter of Mars conditions.
The designing of the thermal bath, the living units



Ill. 96.a-h - Plan and section drawings of the thermal bath

and the shadepath was intentionally good ideas, but needed to be integrated into one holistic design. When designing the three separately it functioned alone, but it was a challenge to chain them together. This initiated the next and last phase of designing towards the final design.

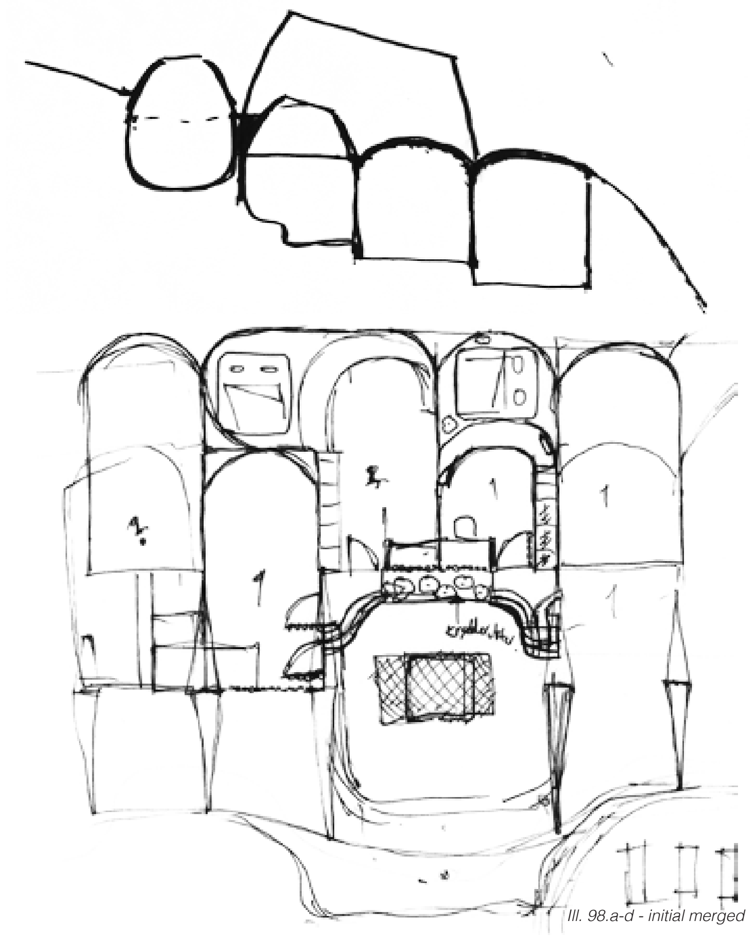
Ill. 97.a-b - Shade path initial design

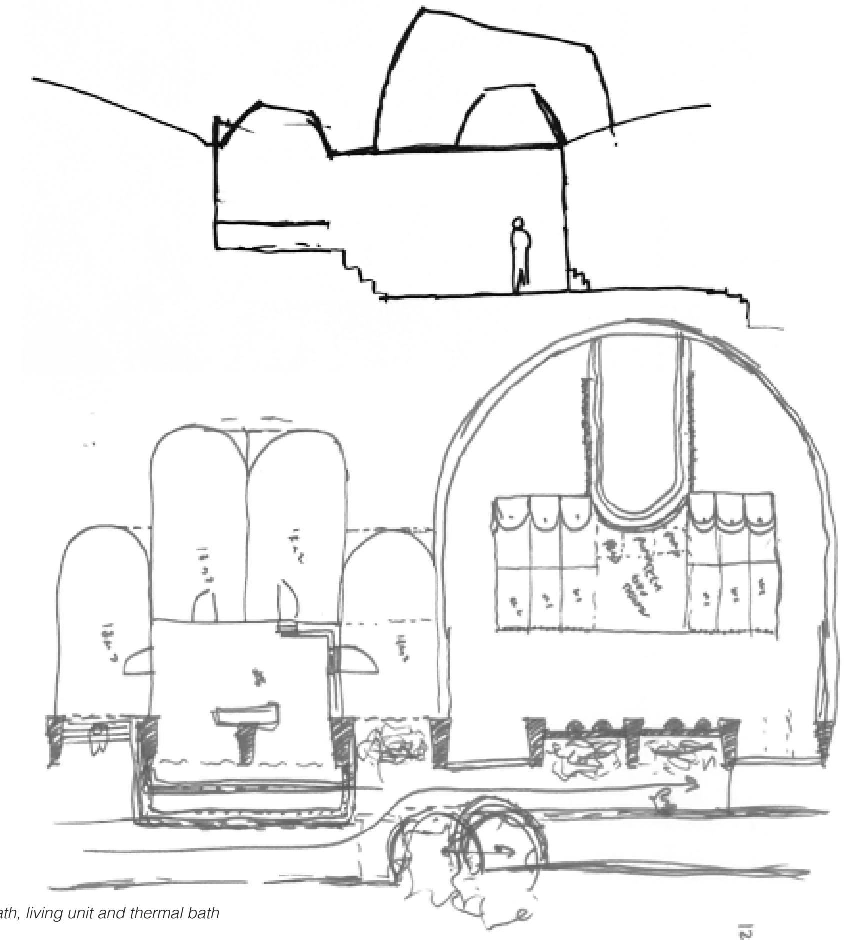


Ill. 97.c - h - Thermal bath sketch iterations in plan and section

THE MARTIAN TYPOLOGY

The martian typology should underline a new way of living, and express community in its language. The new way is a culmination of highlighting the contemporary overconsumption and abduncence living we experience today, in combination with the limited living space under the enclosure. These are rather politically inspired generators, but if we recover and go back to basics we have made an attempt to redefine the way we living by gathering units of living around a common kitchen and thermal baths, to strengthen visual and physical communication and emphasizing spatial experiences.

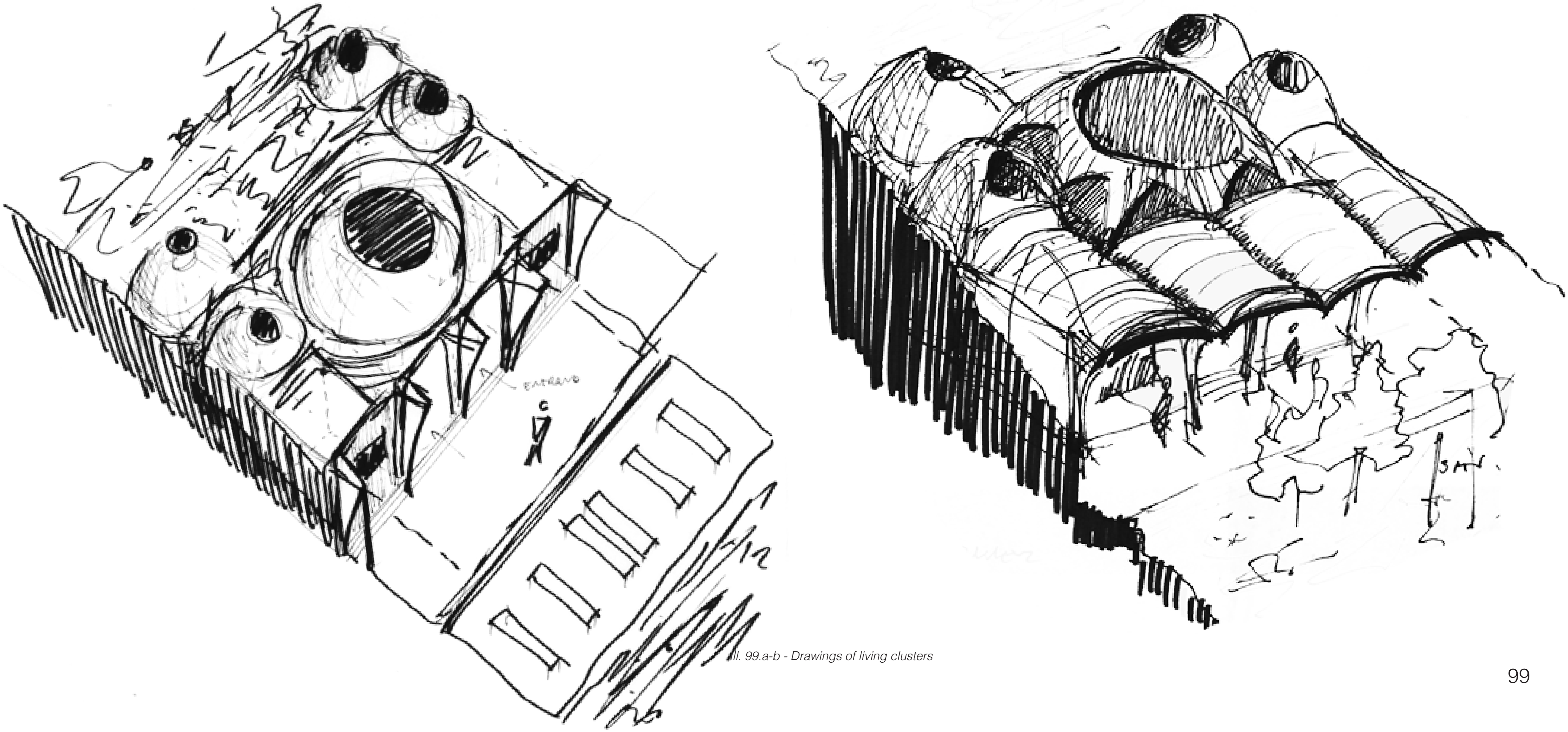




Ill. 98.a-d - initial merged composition of the shadepath, living unit and thermal bath

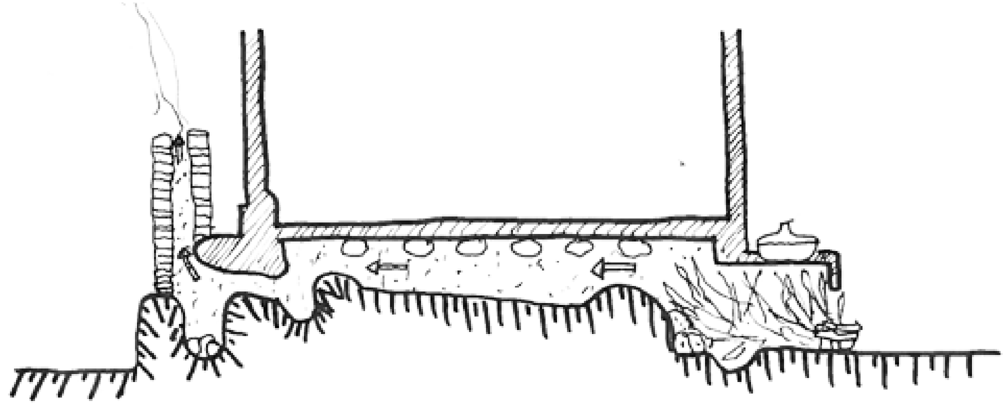
Initiating the last part of the design phase a culmination of a lot of different parameters came together, but designing through this last bit of spatial gestures and phenomenological qualities one also have to look upon how to create a comfortable climate.

This would indeed turn to be a challenge, since the initial idea was to change the way we live by stripping all water and technology, except electricity from the units. But by addressing the problem we thought of turning back to vernacular methods and learn from them. The next pages will elaborate how the roman empire and the koreans which both had invented a floor heating system, which could prove as a solution.



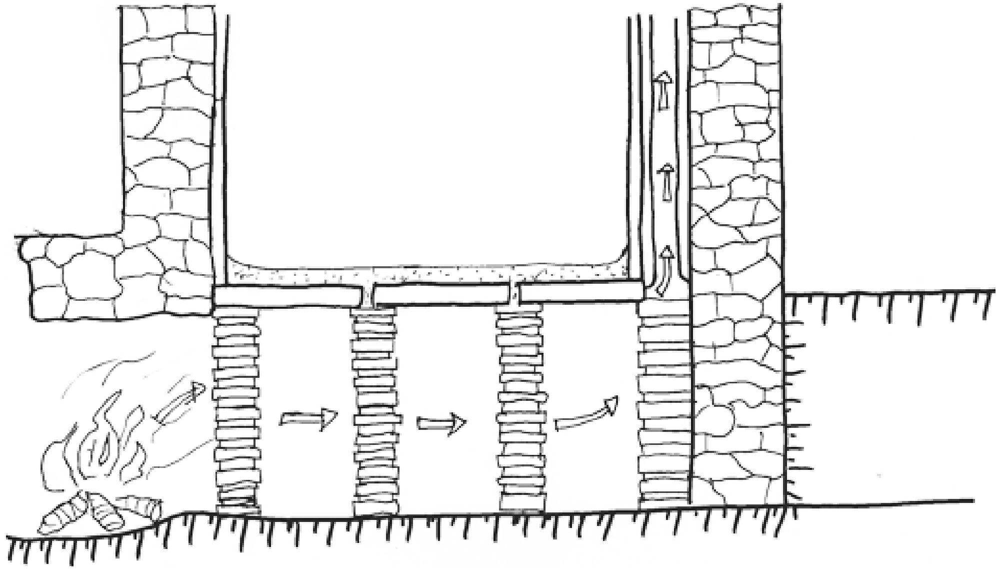
Ill. 99.a-b - Drawings of living clusters

RENEWAL OF HEAT SYSTEMS

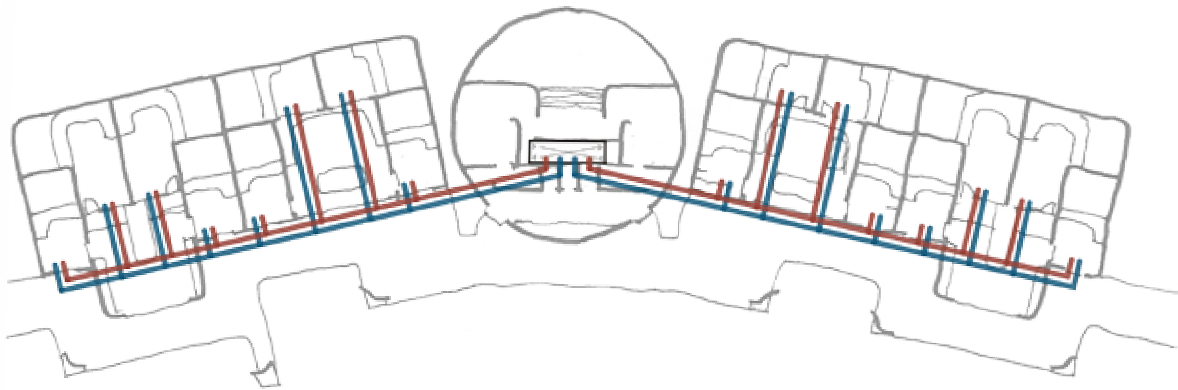


Ill. 100.a - Ondol system

The hypocaust system (ill.100.b) is one of the oldest and best-known floor heating systems. During the Roman Empire the romans invented this system that provided the large bath and the rich with the luxury of floor heating. A large fireplace in one side of the building is making the heat for the system, the floors are raised on pillars to make large cavity for the hot air to circulate under. To increase the circulation the walls are made of hollow bricks working as small chimneys, this would at the same time heat up the walls. All the building materials where made of stone and mortar, with a large thermal mass, hence the heat would last for long period once the stones are heated. [Goran, 2017]
The Koreans made a similar system, not as refined as the romans, but with the same efficiency or better. It is called Ondol (ill. 100.a), and is working in principle the same way, with a fire in one end of the building and a chimney in the other to increase the circulation of the hot air. It's is carved out in the ground in a specific way to ensure a optimal accumulation of heat. [Wol.jw.org, 2003]

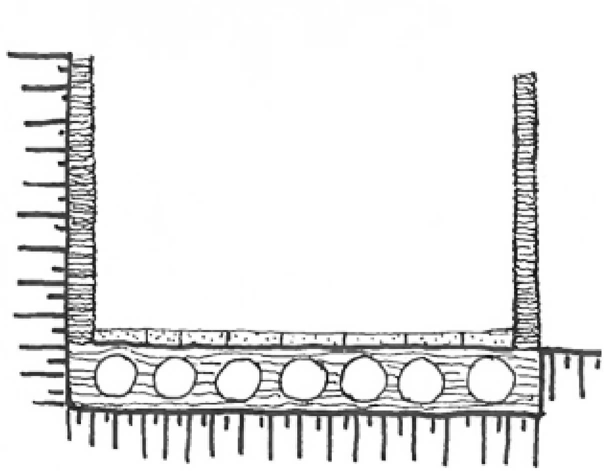


Ill. 100.b - Hypocaust system



Ill. 101.a - Principal sketch of the distribution of the hot air from a central placed aggregate

These two vernacular heating methods are adapted into the Martian design, using the newest technology of heat pumps and recovery systems. The idea is to minimize the use of pipes, so each living clusters is connected to a bath that provides water, heat and electricity, extracted from either the ground or through a centralized distribution center inside the settlement, that is supplied by renewable energy sources. The bath distribute heat through a aggregate placed central, in the technical room.
The floor underneath the living clusters is 3d printed with holes, which allow hot air to circulate back and forth from the baths aggregate and heat the living spaces. The new element in this system compared to the two others, is that this system is air tight due to the 3d print, and runs through a ventilation system with a cross heat exchanger reusing the residual heat. Instead of a large fire providing the heat - a heat pump combined with thermal mass is used. This way of learning and optimizing low-tech traditional heating methods and apply them in a high tech situation, is the essence of the method developed earlier in the booklet. The structural system of the floor heating, will not only pragmatically speaking heat the units, but as well create a phenomenological feeling when physically experiencing the floor and thereby, generate a spatial gesture - emphasizing what is inside and herby also what is outside, private and public.



Ill. 101.b - Principel sketch of martian design floor heating

FUNICULAR FORM FINDING

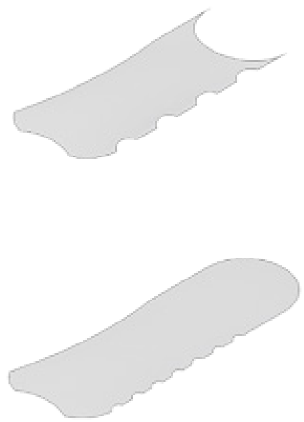
Jumping from traditional building methods and continuing with visionary methods, we encountered the method and optimization of building only in compression when design the thermal bath, single units and the shaded path. This method of forming was amplified by a program called Rhino Vault. Rhino Vault explained by the developer themself is: ".. an intuitive, fast funicular form-finding method" [Mele, 2018]. The tool assisted in creating different solutions for the shaded path, as well as other buildings, as compression constructions. The attractive idea of creating such structures lies in their elegant way of utilizing a materials strength through form and at the same time reducing the amount of material used for construction.

This is an interesting fact, in light of the limited amount of resources on Mars and referring back to "what is taken away, is used somewhere else" fortunately assist our cause. In "A Novel Material for In Situ Construction on Mars" by Lin Wan, Roman Wendner, Gianluca Cusatis. They state to have investigated in a type of martian concrete, made without the presence of water, just by heating sulphur to 120°C and combining it with the regolith from Mars. A material of high strength is formed, which can compete with standard concrete. [Wan, L., Wendner, R. and Cusatis, G., 2015].
Additionally two companies (Heijmans and CyBe Construction) have proven to 3D print concrete a layer of approximately 20mm, at 13m pr. Min. [Heijmans N.V., 2016].
Combing the two contemporary technologies started our attempt to find the optimal forms for different functions with the qualities and compression only for final designs. The different iterations can be seen on the page to the right, all forms is made within Rhino Vault, and it made it possible to exclusively look at the spatial experiences, light, shade and size the form give the atmosphere we were looking for.

Thermal bath

Ill. 103.a-e - Thermal bath itterations

People's house roof



Ill. 103.f&g - People's house iterations

Houses roof

Ill. 103.h-j - House roof iterations

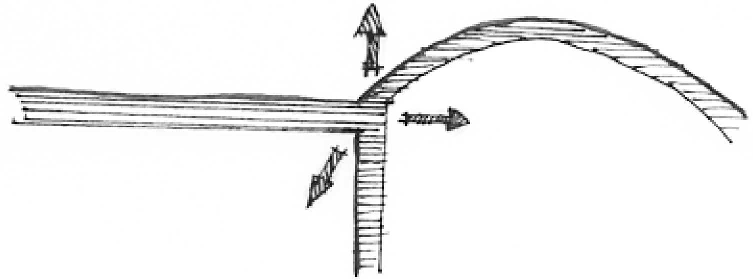
Kitchen roof

Ill. 103.k-o - Kitchen roof iterations

Shaded path & kitchen

Ill. 103.p-t - Shaded path & kitchen iterations

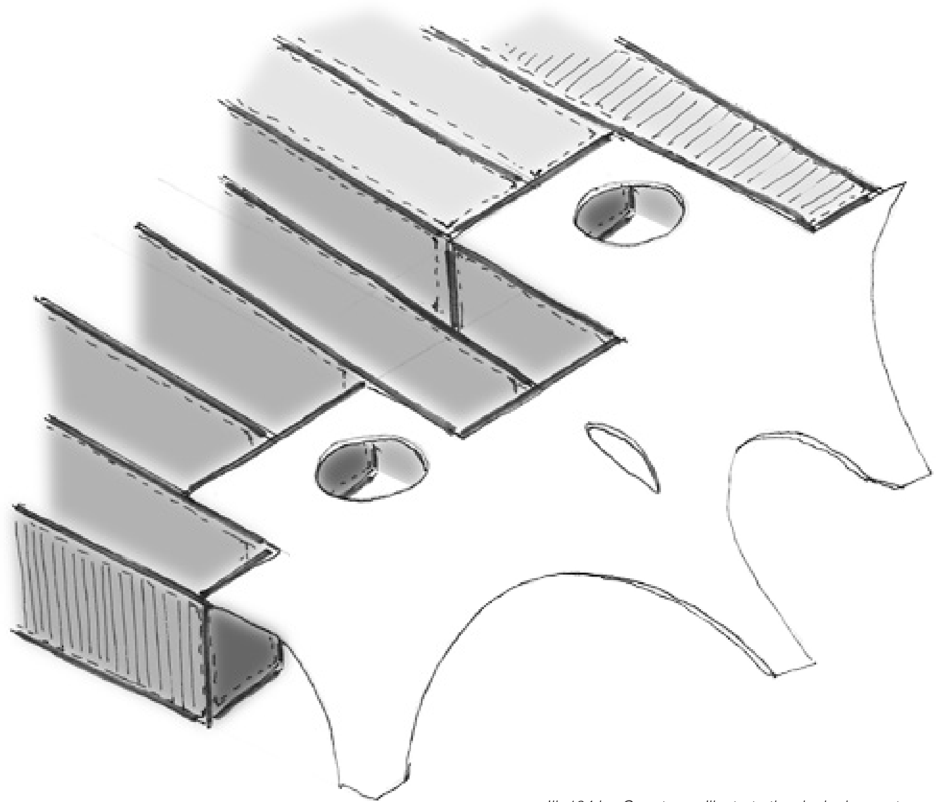
SHELL THICKNESS



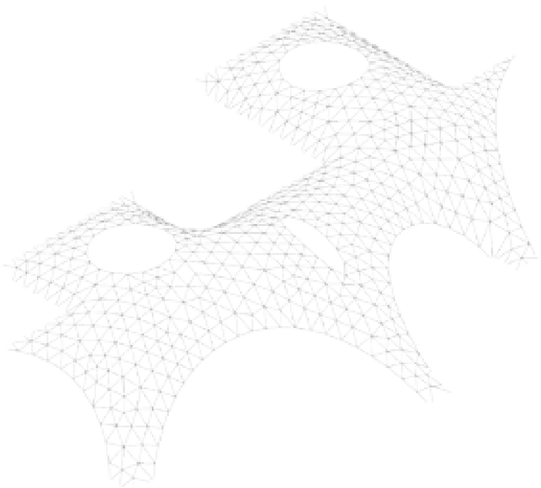
Ill. 104.a - Concept of drawing the reaction in thes structure

After testing several different form and expressions, the shaded path structure which covers the kitchen while at the same time connects the whole living cluster together. Different calculations of the structure were made in karamba to find the thickness, and 100mm, 50mm and even 10mm (ill. 105.a-c) were tested under the influence of Mars' 1/3 gravity and compared in respect to their deformation, weight and to double check what forces influenced the structure. The result from calculation determined that the 100mm would have the smallest deformation, and furthermore we want the structure to be able to interact with without breaking. Not walking upon, but rather support yourself and hanging element or decorations on it.

The shade paths diagonal force (ill. 104.a) is stabilized by its how it joints with the vertical and horizontal wall of the living units, serving as a deck-slap system. (Ill 104.b) It is made as such to withstand the potential shear forces and moment the structure possible could apply the living units.



Ill. 104.b - Gray tones illustrate the deck-slap system



Ill. 105.a - 10mm thick shell

Ill. 105.b - 50mm thick shell

Ill. 105.c - 100mm thick shell

1. Iteration
Thickness: 10mm
Def: 58mm
Weight: 54kg
Max N: -0,14kN
Max M: 0kNm
Max F: 0kN

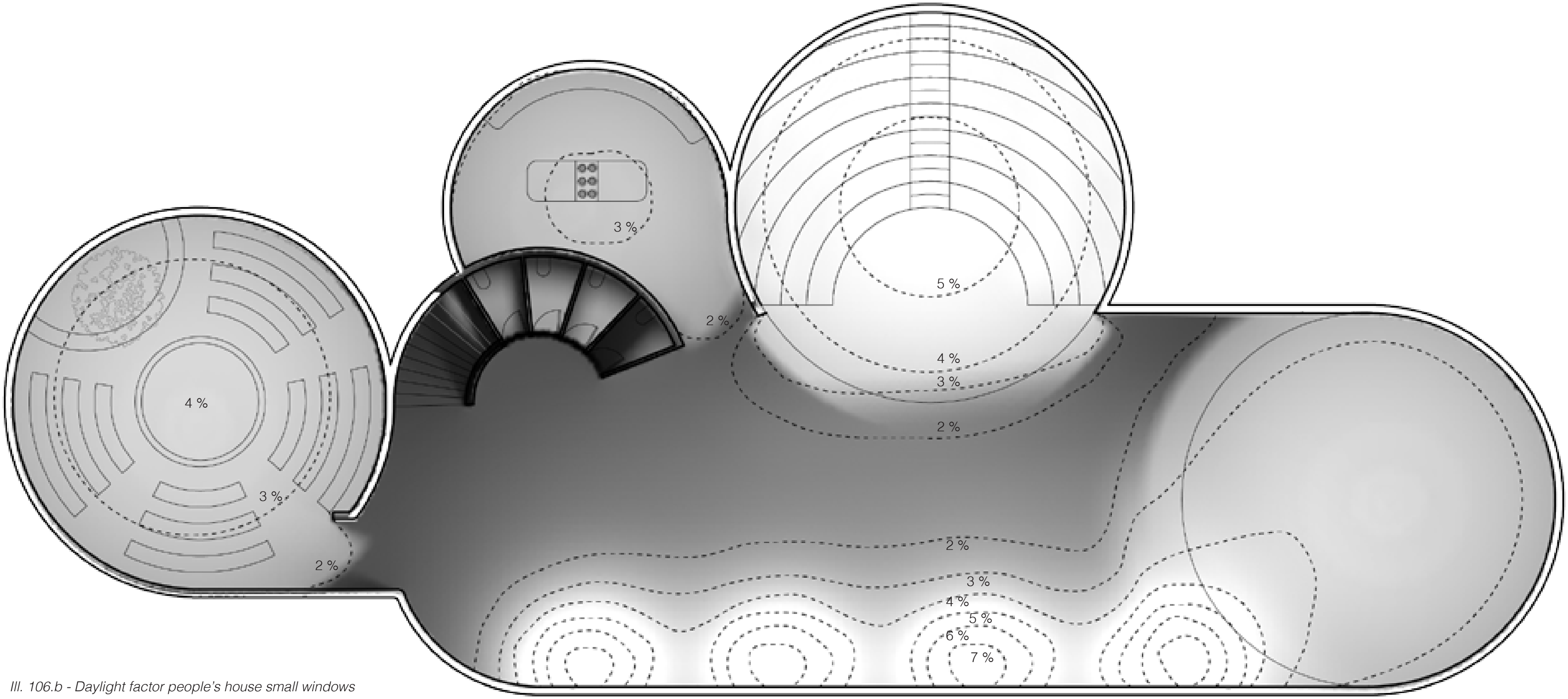
2. Iteration
Thickness: 50mm
Def: 6mm
Weight: 1,9t
Max N: -2kN
Max M: 0,002kNm
Max F: 0,003kN

3. Iteration
Thickness: 100mm
Def: 3mm
Weight: 7,9t
Max N: -10,8kN
Max M: 0,001kNm
Max F: 0,012kN

SOLAR ANALASIS

Through the design process it hasn't only been calculation upon the structural elements, but as well the daylight inside People's house.
The larger openings draw significant more daylight deep in the dining hall, providing it with an increased amount of daylight. The different lights in the different cylinders are ensured by angled cuts in the top shells, which is angled differently and therefore let the light enter in different periods.

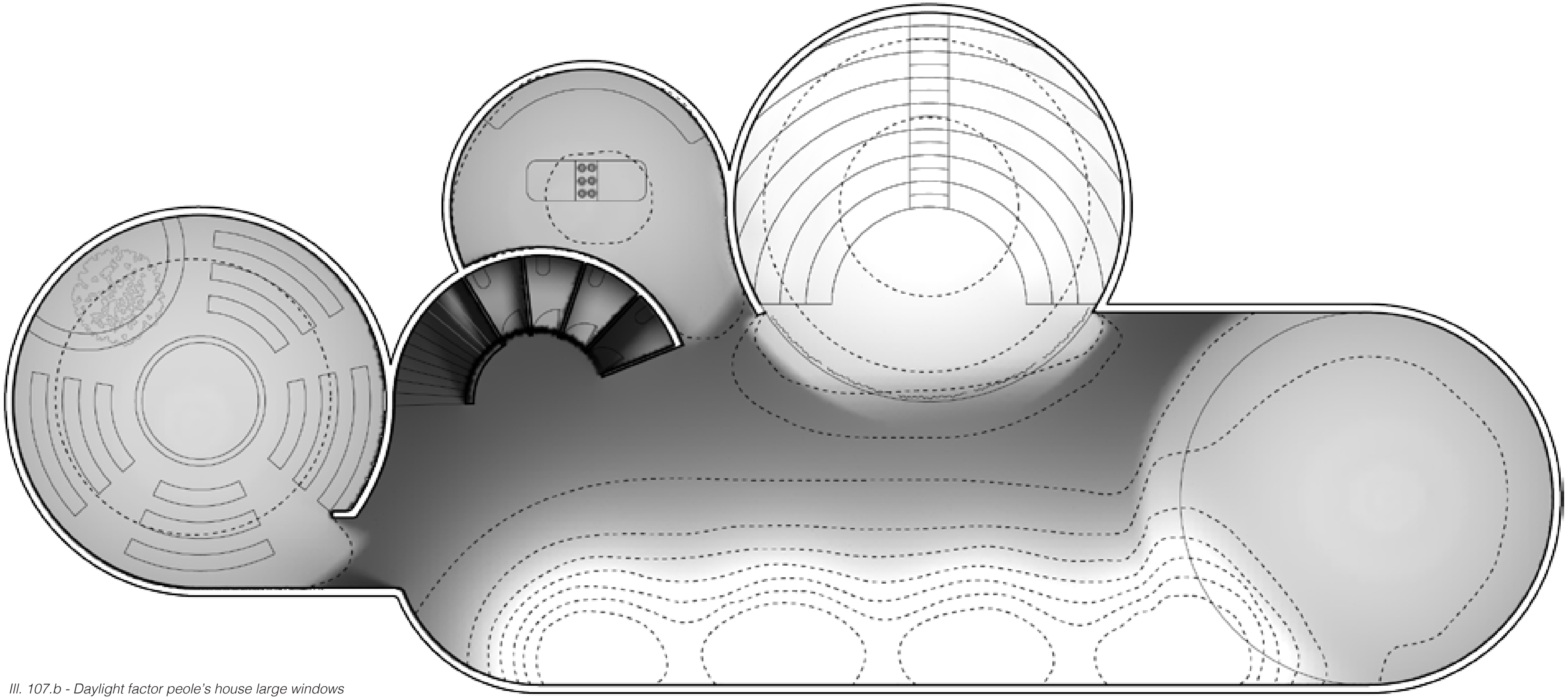
Ill. 106.a - Isometric people house small windows



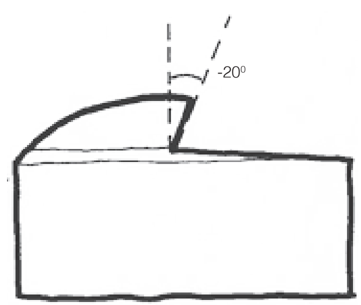
Ill. 106.b - Daylight factor people's house small windows

The directions are chosen according to the use of the rooms. The chapel hole are turned against east providing the room with reflections of the first light beams, the hole in the amphitheater are turned against west use the late sun to light the stage area.

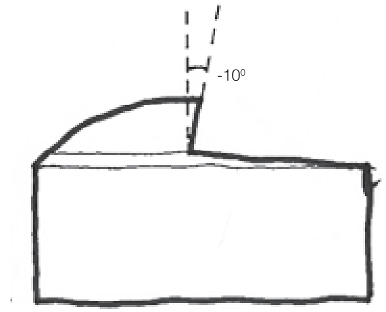
Ill. 107.a - Isometric people house large windows



Ill. 107.b - Daylight factor peole's house large windows

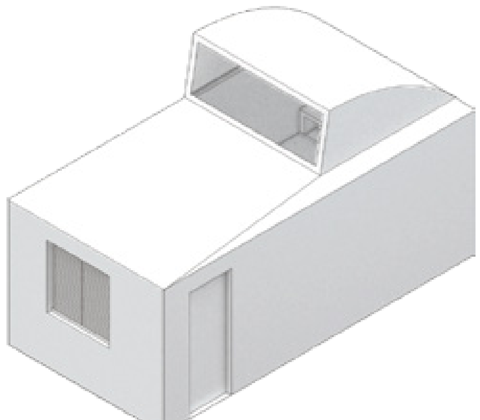


Ill. 108.a - Opening angle -20 degrees

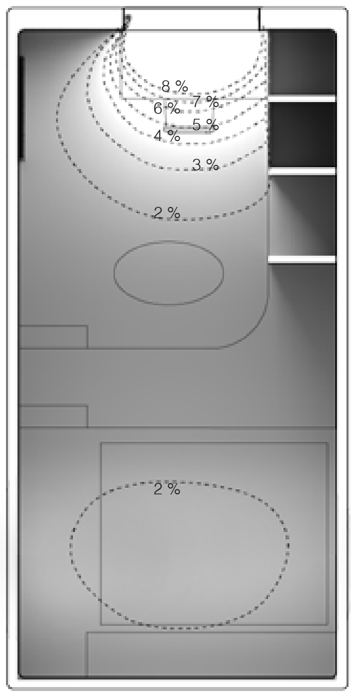


Ill. 108.b - Opening angle -20 degrees

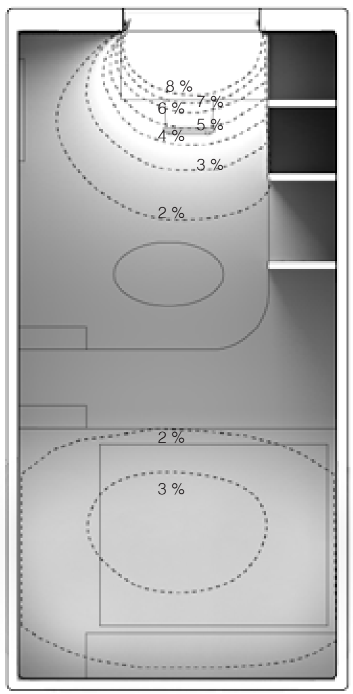
To obtain good light conditions in the living units, without letting too much direct sun in, windows are placed high or under shading. In this way it is diffused and reflected light that penetrates in the largest part of the rooms. Velux visualizer is used to create different solutions and determine the angle of the roof. Ill. 109.c is chosen as the angle, as it allows a minimal amount of direct daylight, but at the same time let a preferable amount oflight penetrate while bein visually asthetic.



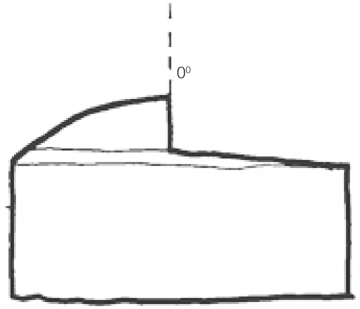
Ill. 108.c - Isometric singlehouse



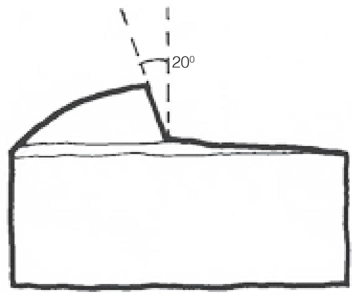
Ill. 108.d - Daylight factor opening angle -20 degrees



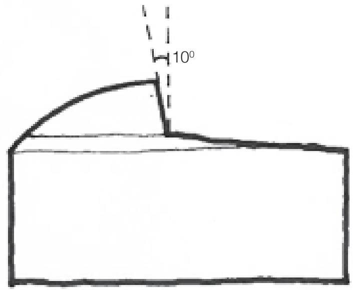
Ill. 108.e - Daylight factor opening angle -10 degrees



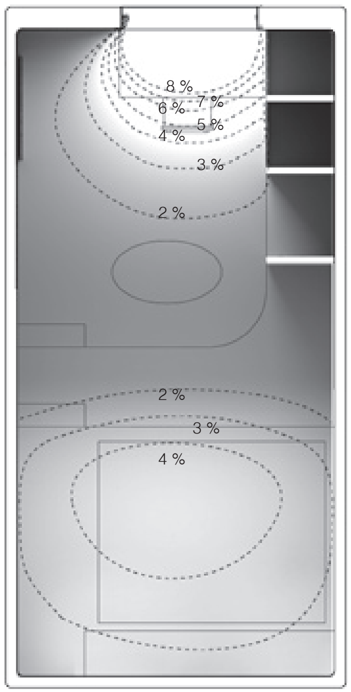
Ill. 109.a - Opening angle 0 degrees



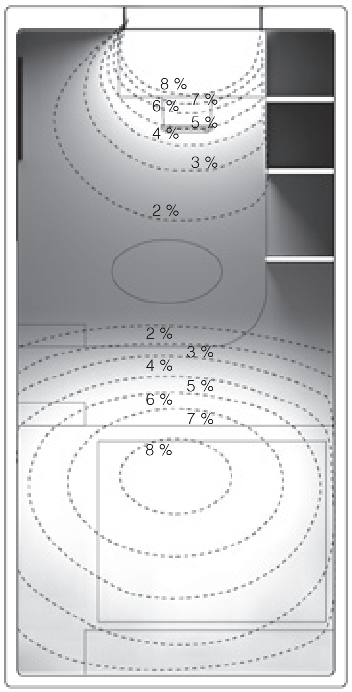
Ill. 109.b - Opening angle 20 degrees



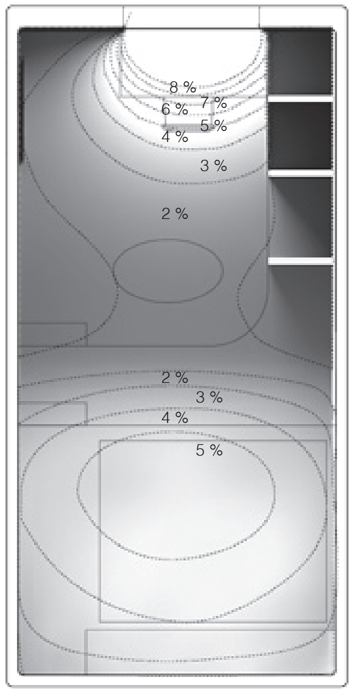
Ill. 109.c - Opening angle 10 degrees



Ill. 109.d - Daylight factor opening angle 0 degrees



Ill. 109.e - Daylight factor opening angle 20 degrees



Ill. 109.f - Daylight factor opening angle 10 degrees

PRESENTATION

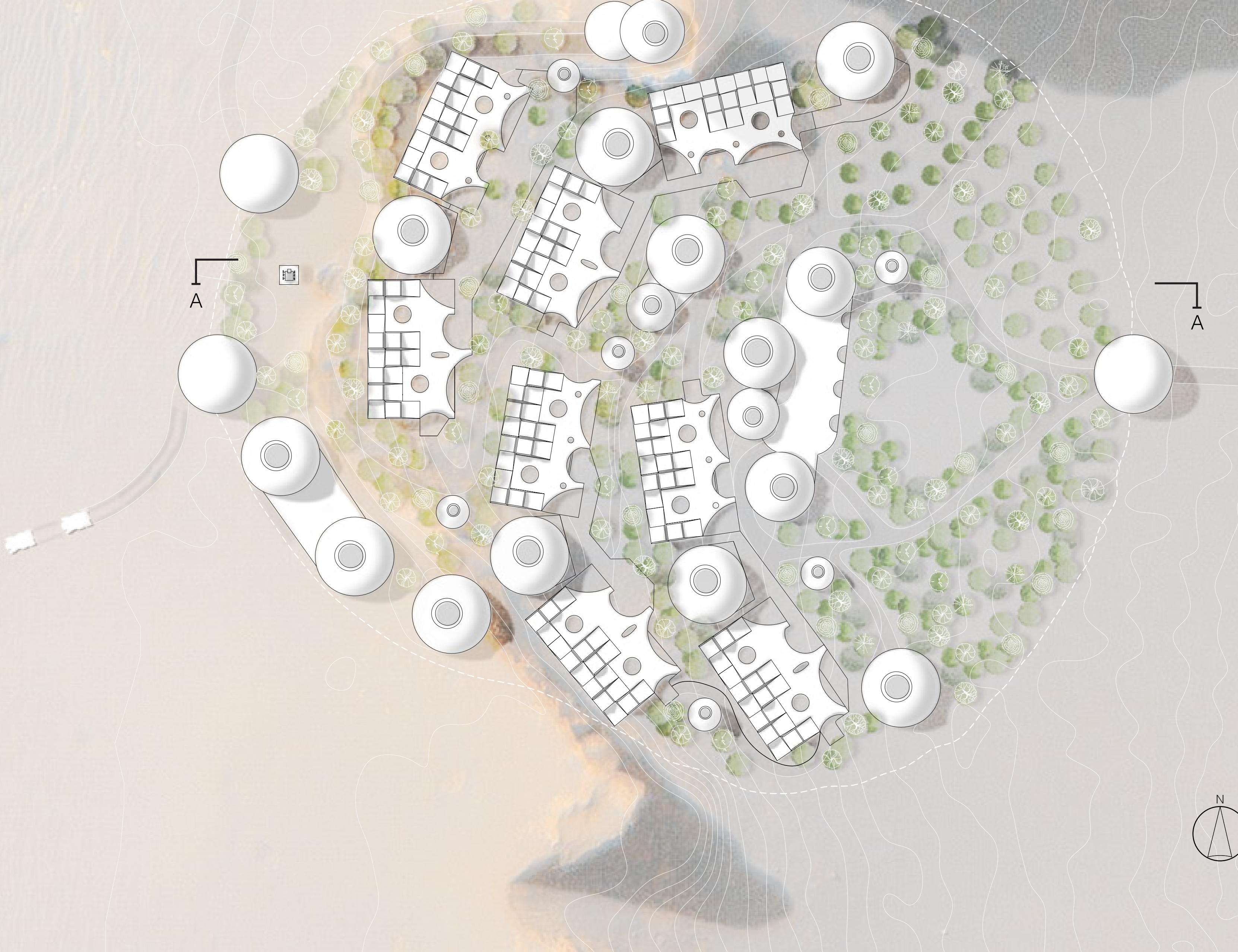
The presentation material is a culmination of all the knowledge gathered through the chapters of, “Tectonic history”, “Case Studies”, “Mars- and human conditions” which lead to a programme that initially kickstarted the design process, thus leading the path towards the final design. Furthermore, we see the final design as the symbiotic answer to the developed methodology of “Gesture, Principle and Genius Loci”, with a imbued sense of the words “Tradition” and “Vision” through the whole project.

MASTERPLAN & SECTION	CONSTRUCTION STRATEGY	PEOPLE’S HOUSE	BUILDING CLUSTER	KITCHEN COMMUNITIES	CONCLUSION
DEVELOPMENT STRATEGY	INFLATABLE SUPPORT	CHAPEL	THERMAL BATH	HOUSE MODULES	REFLECTION
STRATEGIES		PRESENTATION			EPILOUGE

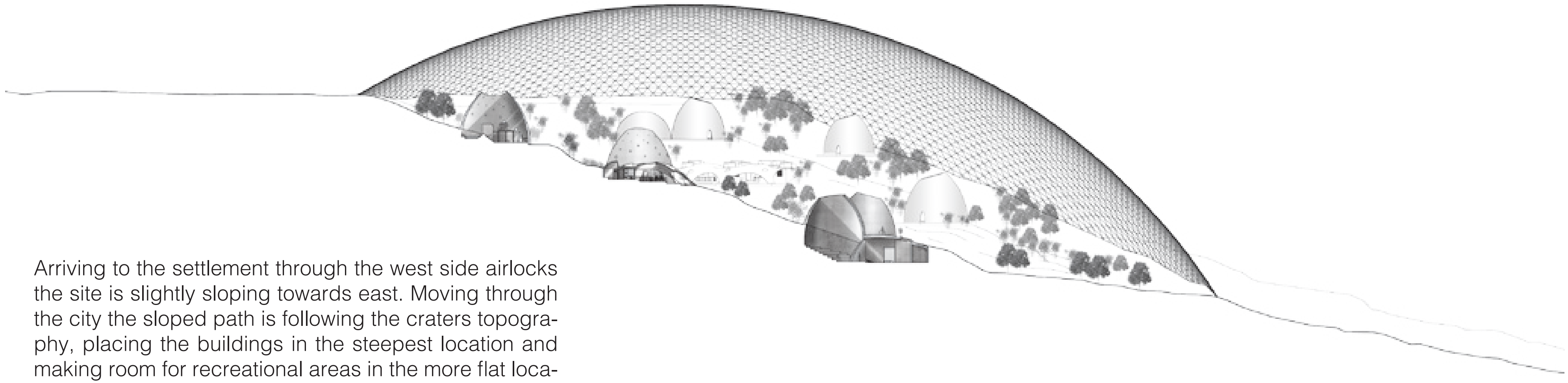
Ill. 110.f - Settlement perspective

PRESENTATION

MASTERPLAN & SECTION



Ill. 112.a - Masterplan 1:1000

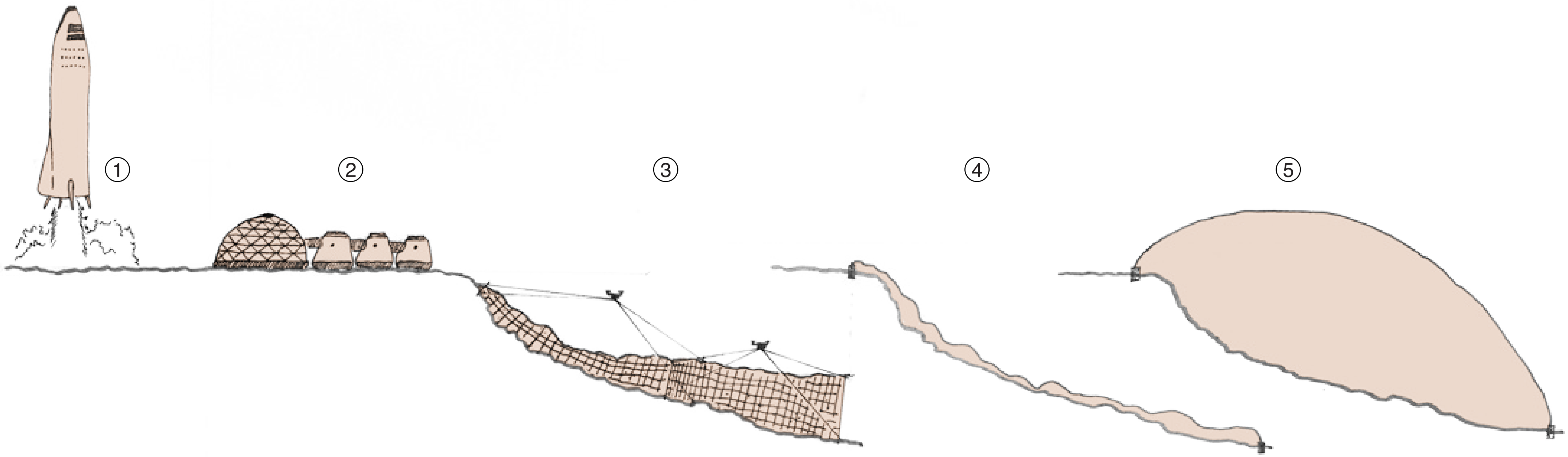


Arriving to the settlement through the west side airlocks the site is slightly sloping towards east. Moving through the city the sloped path is following the craters topography, placing the buildings in the steepest location and making room for recreational areas in the more flat location. The buildings are carved into the crater side, making them rise out of the crater. Safety zones are evenly distributed in the, plan making them easy accessible. The people's house is placed in the middle of the pocket working as a gathering point, accessible from all sides.

Ill. 113.a - Section A 1:1000

Ill. 113.b-k - Building description

DEVELOPMENT STRATEGY



1. Safely repulsive landing of the space vehicle, near Victoria crater.

2. Contemporary established settlement to sustain living, while preparing.

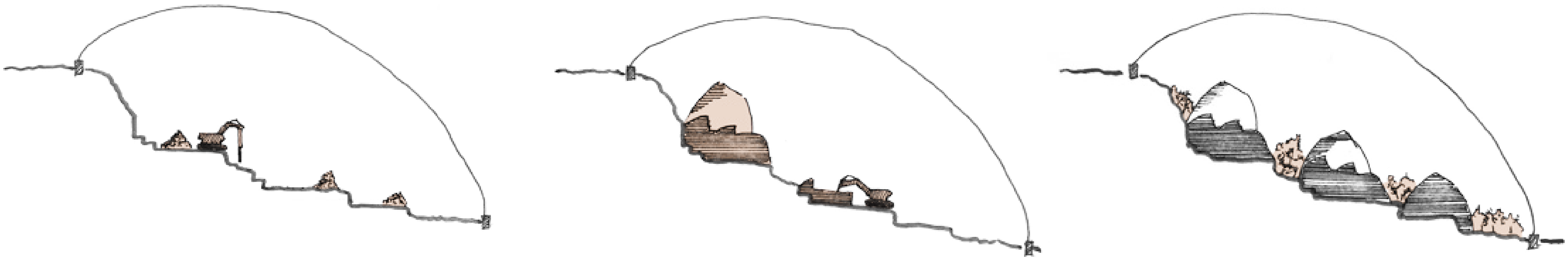
3. Drones are sent our to the chosen cavity to 3D scan the inclination and area.

4. Membrane is unrolled on to the cavity and fixed to the ground.

5.The membrane is pressurized by 1 atm to enable human life.

Ill. 114.a-c - Development strategy

⑥ ⑦ ⑧



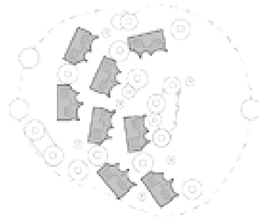
6. 3D milling into to the cliff side to create plateaues.

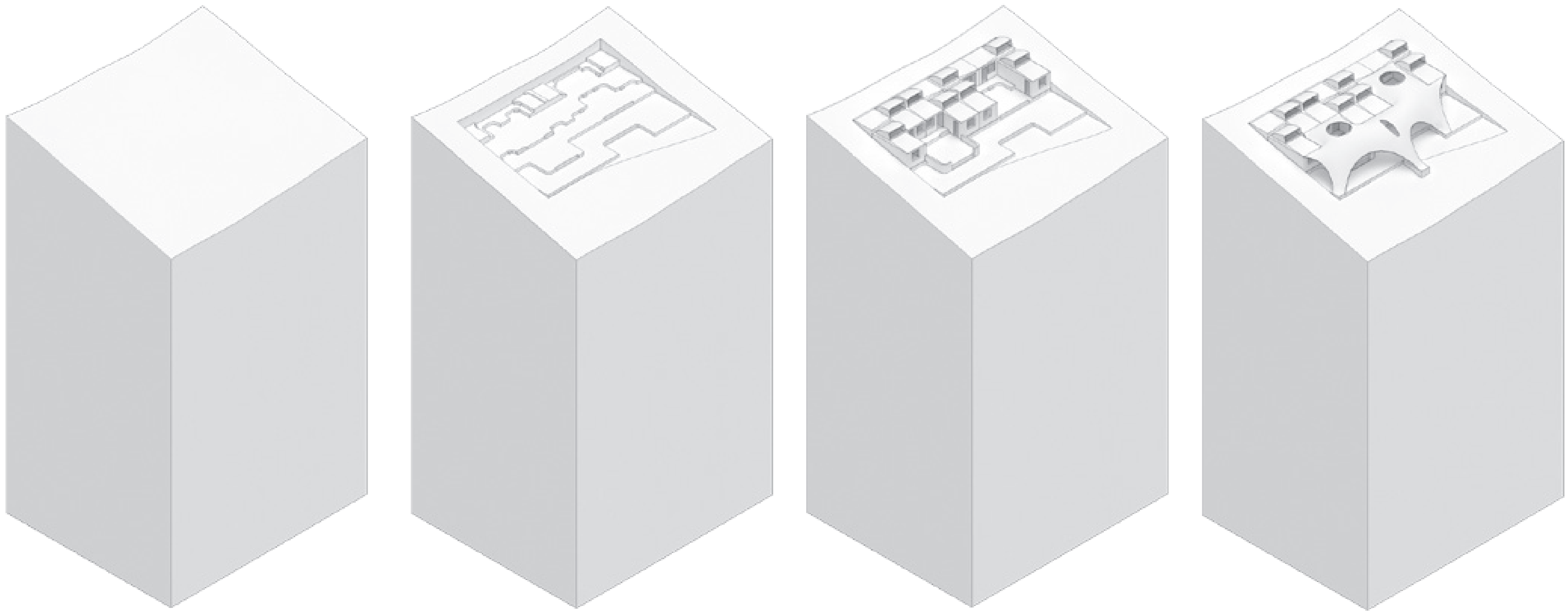
7. 3D printing volumes with excessed regolith from excavating and milling into the cliff.

8. First martians arrive and establish a community. Step four to seven is reapeated around the periphery of Victoria crater.

Ill. 115.a-c - Development strategy

CONSTRUCTION STRATEGY





1. The cavity is approached and scanned by drones.

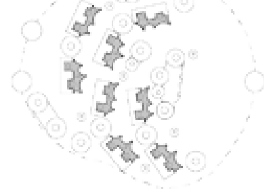
2. A 3D millling machine creates plateaues with climbing levels, as an attempt to follow the natural inclination.

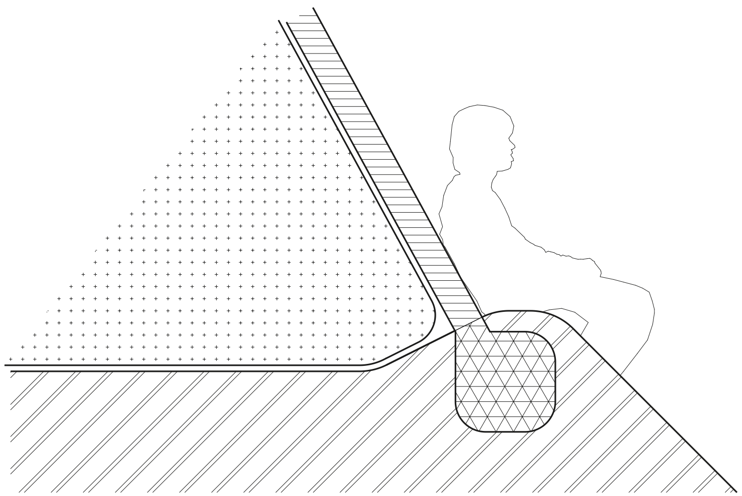
3. 3D printning housing modules on top of the plateaues, with the excessed regolith from excavating into the cliff.

4. Lasty the shade path is 3D printed into a complet compression structure, with an inflatable structure as support.

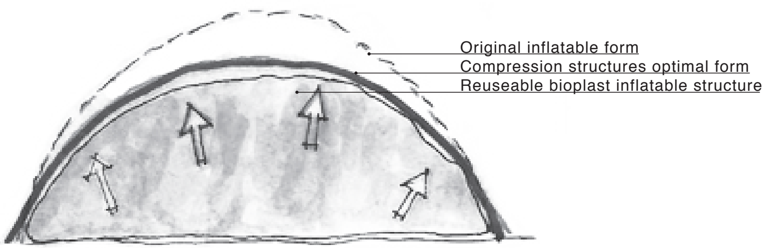
Ill. 116.a&b - Construction strategy

INFLATEABLE SUPPORT

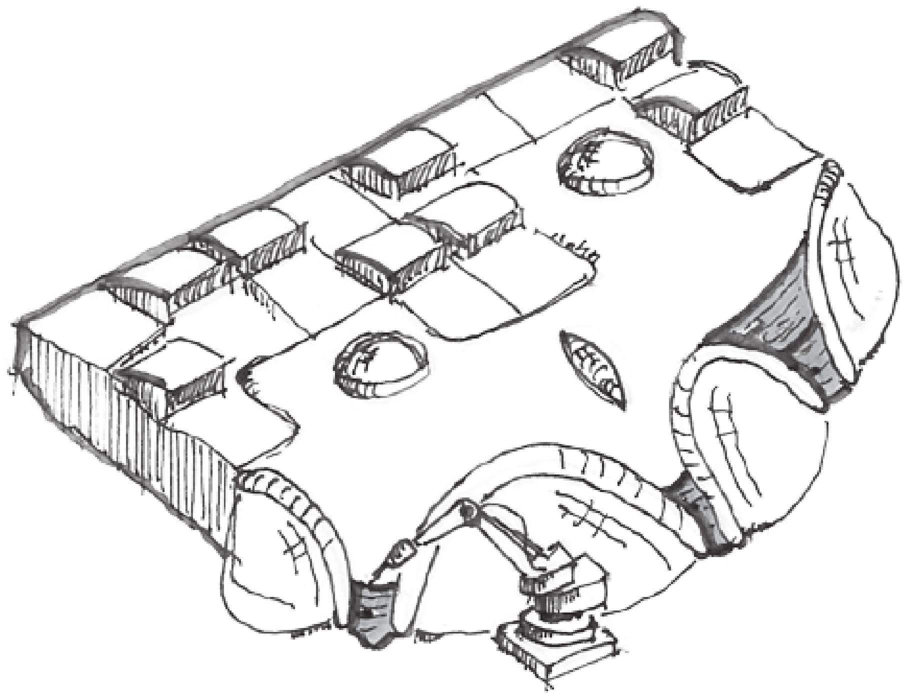




Ill. 117.b - Shadepath concept joint

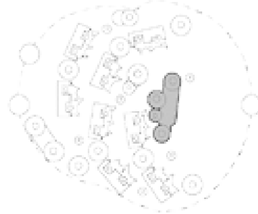


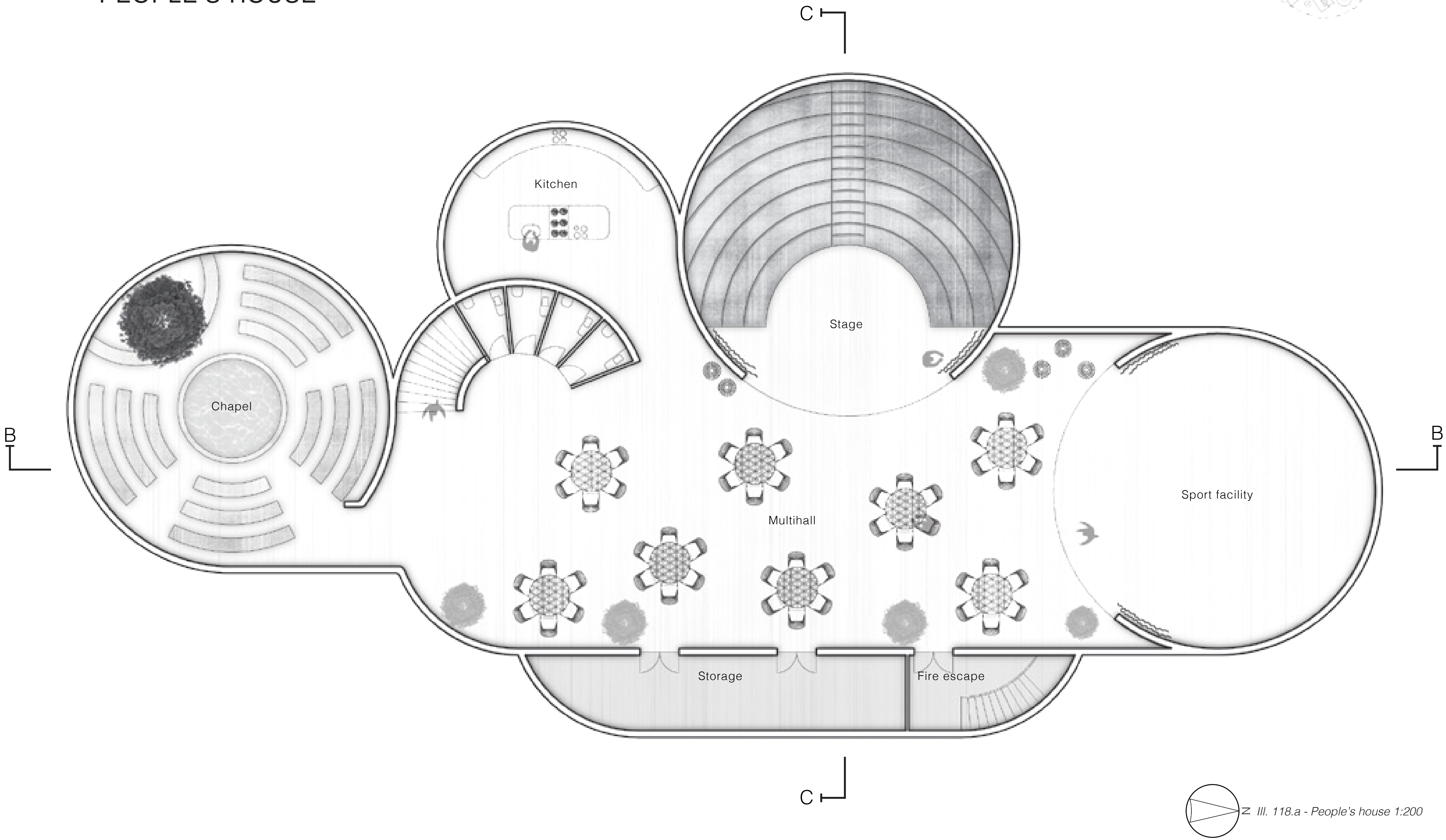
Ill. 117.a - Inflatable structure deformation concept



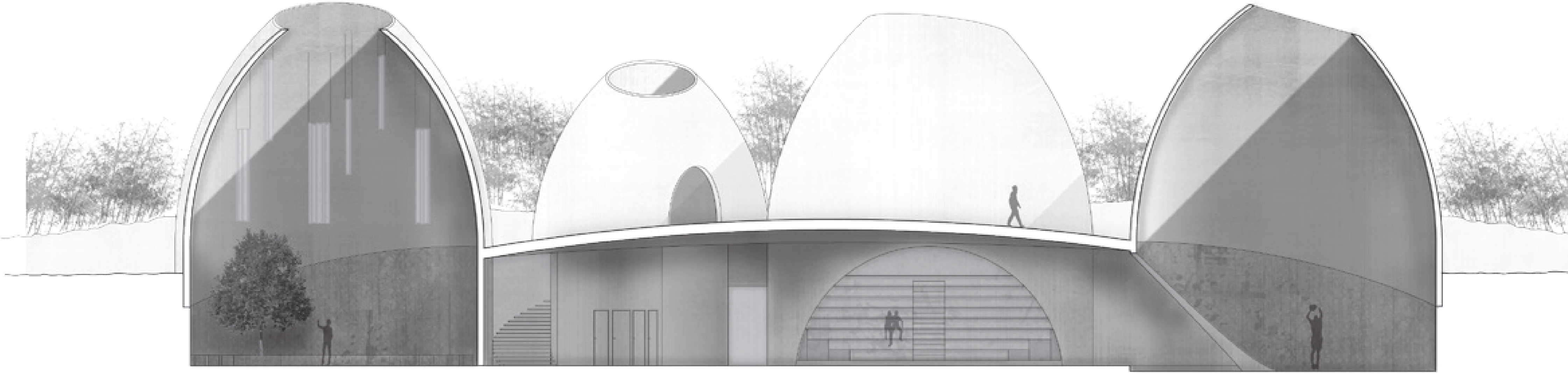
Ill. 117.c - Inflateable support concept drawing

PEOPLE'S HOUSE

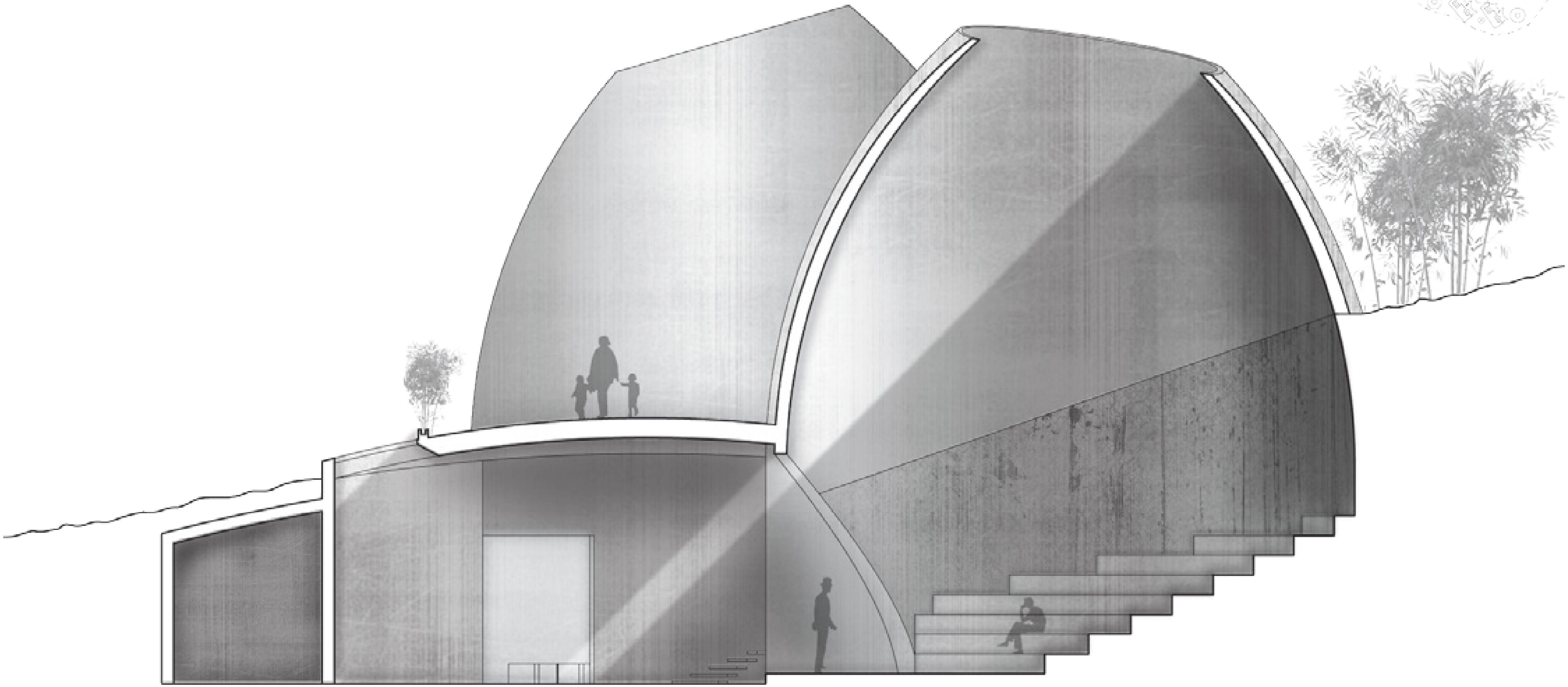




Ill. 118.a - People's house 1:200



Ill. 119.a - People's house section B 1:200

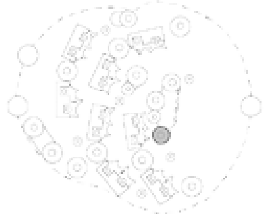


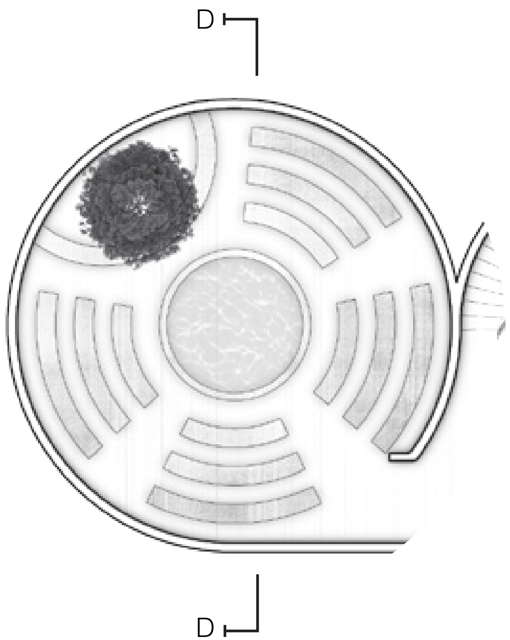
Ill. 120.a - People's house section C 1:100

Ill. 121.a - Visualization of inside People's house

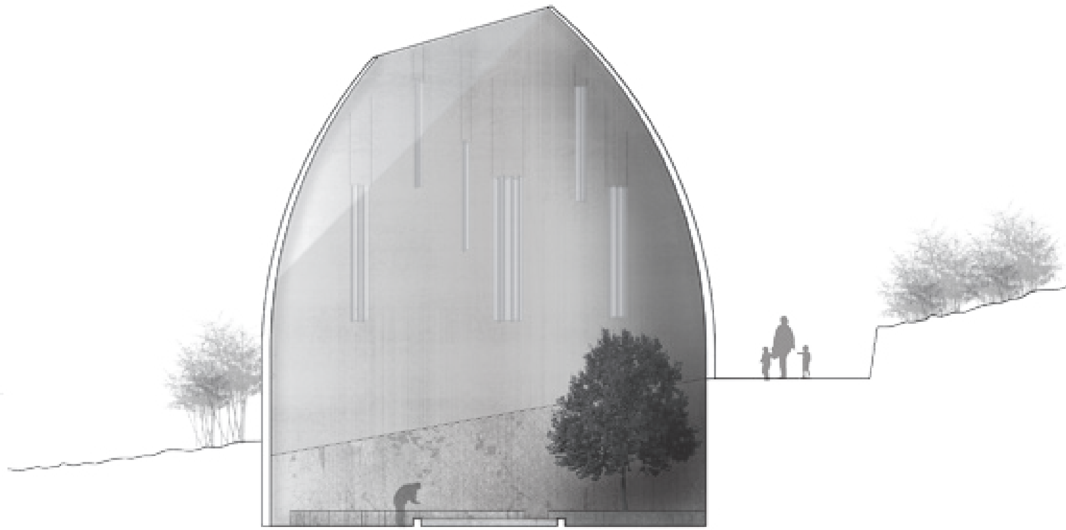
Walking down the stairs and entering the People's House - a gathering point under the Martian surface – you find yourself in a space full of contrast. Half of the building is cut out of the Martian surface, creating plateaus in the flooring. Plataus raising up from the ground, taking the shape of an amphitheater - extruded only from the Martian soil - suitable for entertainment and public meetings. A tribute to the traditional building methods. The excavated cliff side is rising and reaching for the sky while the material change from Martian soil to Martian concrete, up lighted by the sunlight. A light penetrating the building through the roof openings. This is making the People's House seem bright and almost outside in some areas and underground and intimate in others. The two circular room can be closed by bamboo textile curtains, making the house suitable for a wide range of activities, from sports facilities to theater and big gatherings.

CHAPEL





Ill. 122.a - Chapel plan 1:200

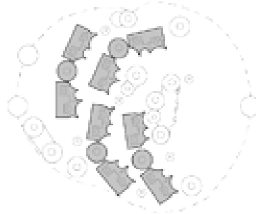


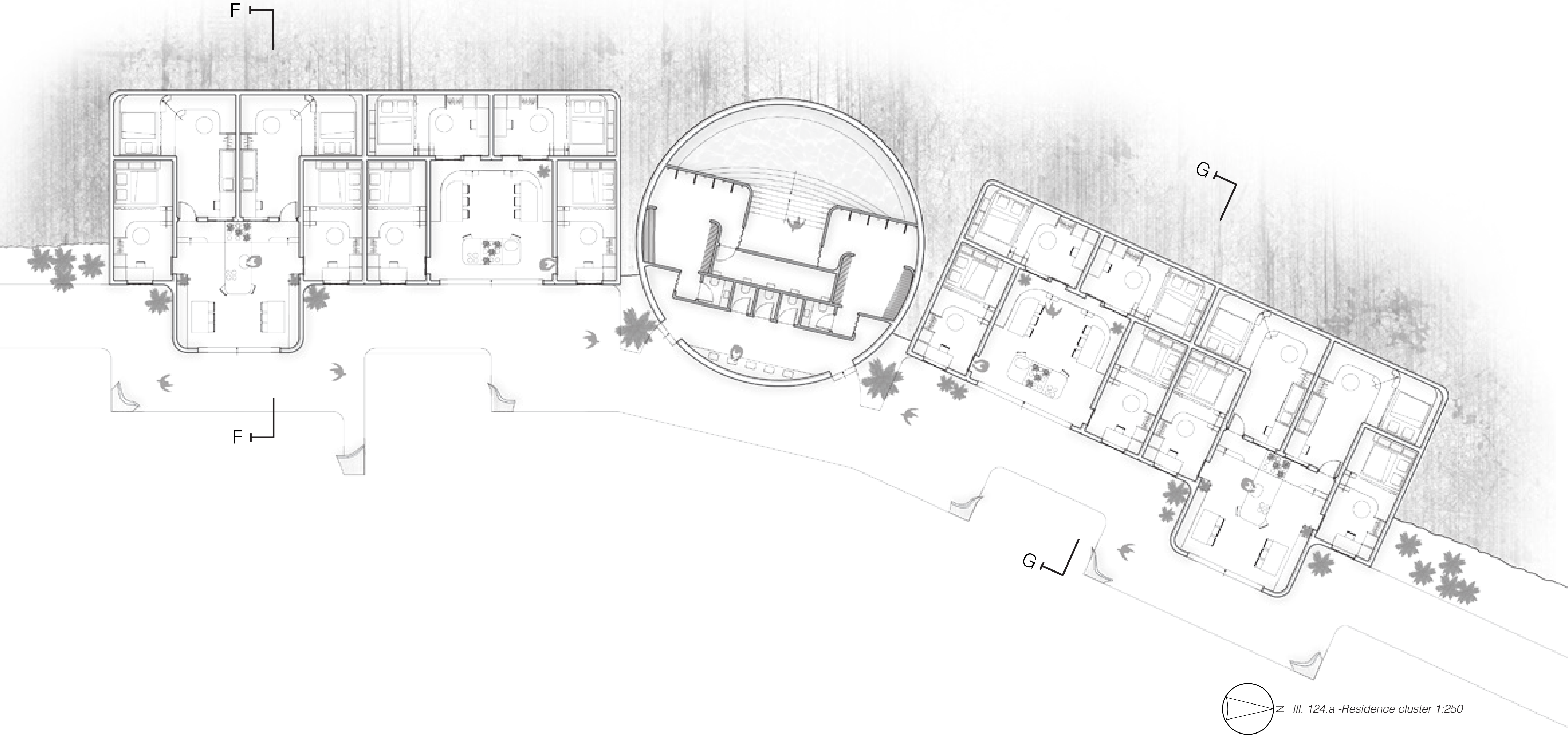
Ill. 122.b - Chapel section D 1:200

Ill. 123.a - Visualization of inside Chapel

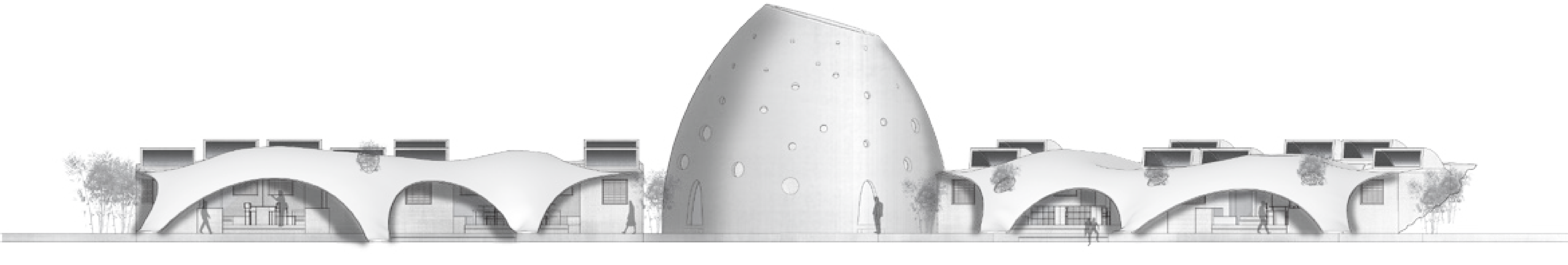
Inside of the People's House, is located a chapel. A place for dreaming, wishes, hoping and experiencing. The chapel is built around the natural elements of earth, wind, water and fire. All poetic elements coming to life through the architecture. The earth is the structural element - surrounding you - both in the excavation and in the 3D printed upper layer. The joint between these two materials separates the structure by a diagonal curve, generating a gesture of dynamic and movement to the space. The shape of the 3D printed structure continues up towards the sky, with an opening, connecting you with the external phenomena like the moons, the stars and the light during the day. A light symbolizing the fire; lighting the space, casting shadows and showing movement throughout the day. The hole in the top of the chapel also provides natural ventilation, where the buoyancy of the air will show its form, by moving bamboo weaved curtains suspended from the ceiling, symbolizing the Earth sensation of wind. Finally, in the middle of the chapel is the fourth element – the water – giving calmness and humidity to the space. But also, a reflection, a reflection of new life seen in the growing tree and a reflection of you and other people walking around in the meditating space. A space to release your worries and be in one with nature through the architecture.

BUILDING CLUSTER



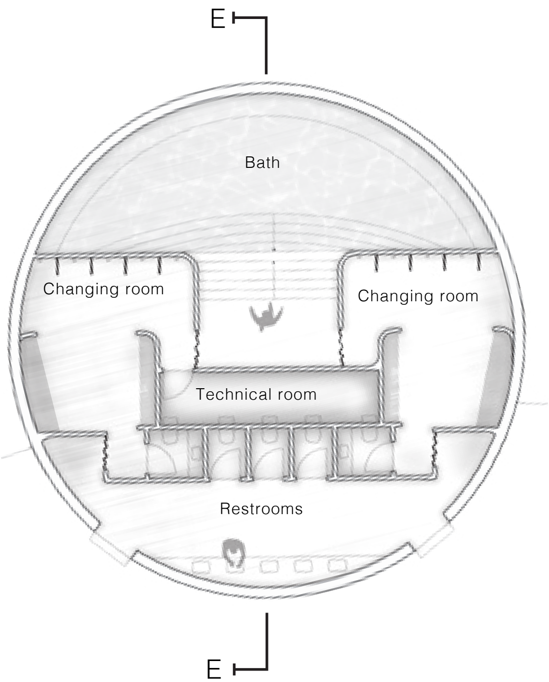


Ill. 124.a -Residence cluster 1:250

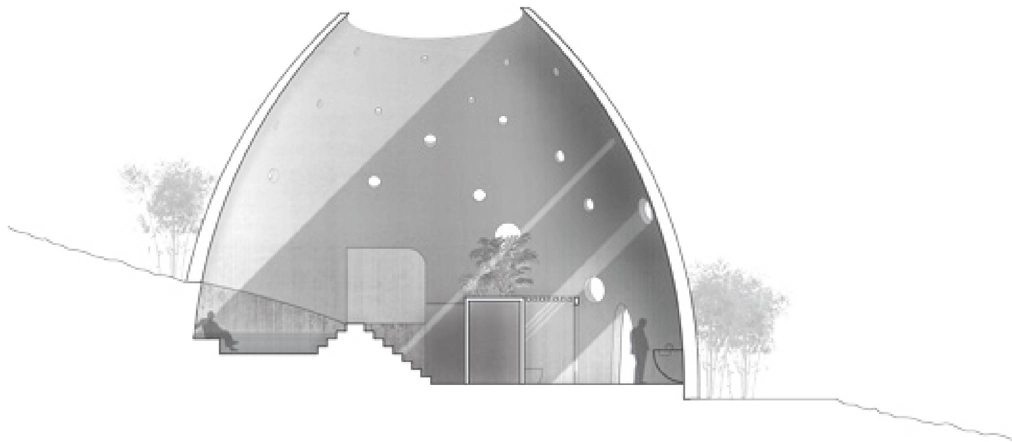


Ill. 125.a - Residence cluster elevation 1:250

THERMAL BATH



Ill. 126.a - Thermal bath plan 1:200

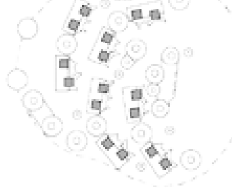


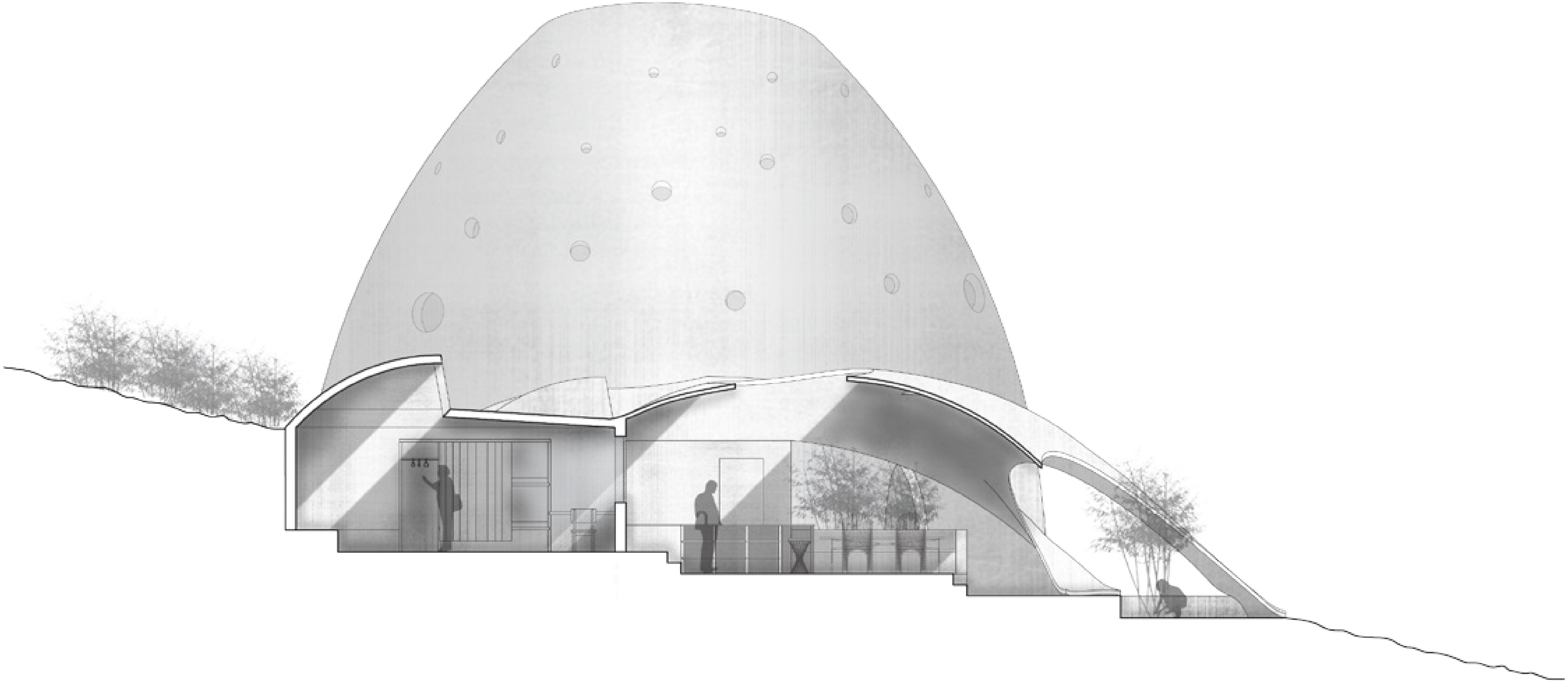
Ill. 126.b - Thermal bath section E 1:200

Ill. 127.a - Visualization of inside the thermal bath

The bath is a space for tactile sensations and light. Entering the bath and following the narrow corridor to each changing room gives the feeling of walking into the mountain side. The humidity starts to raise due to the thermal heat stored in the walls of the building. The light bamboo seating's is soft compared to the rough walls, giving atmosphere, tactility and contrast to the internal space. Moving further into the thermal bath, where the steam from the water is compressed and the rays from the light glows through the vapor. Entering the hot water, while looking back over the penetrated shell structure – working as a moving clock, where light gives a reference to the spinning globe and the time of the day. This is a place for recharging the batteries and socializing while interacting with natural phenomena and the gesture of the space.

KITCHEN COMMUNITY



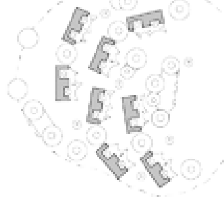


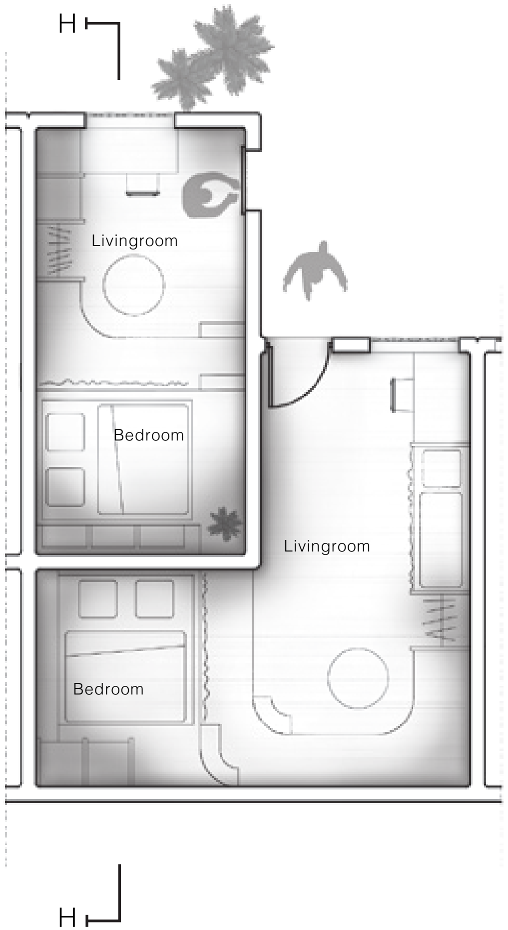
Ill. 128.a - Kitchen community section F 1:100

Ill. 129.a - Visualization of the kitchen community

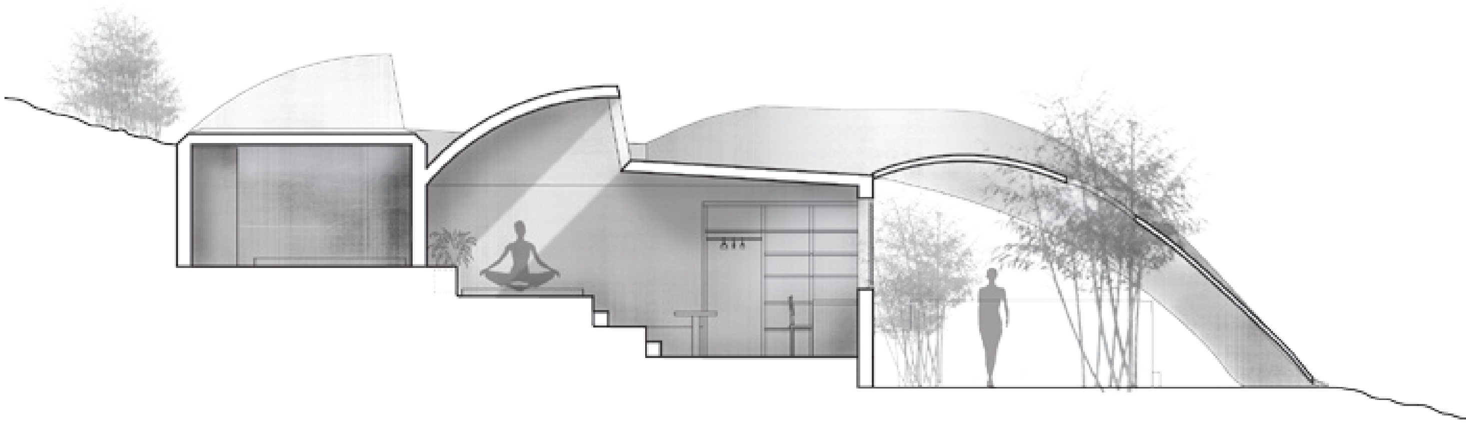
The kitchen is functioning as a social meeting point. Pushed into the cliffside to create a protection from the radiation, be in unity with the nature, and give an overview out from the homes and into the crater. The kitchen is cut out of the natural cliff side - creating a hierarchy through the earthwork – where the plateaus are emphasizing the borderline between the public, the semi-public and the private zones in the clusters. Light is penetrating the shading in selected locations, creating a natural light in the kitchen, without worrying of solar radiation. All the furniture is designed with the use of bamboo – where the light structure generates a great contrast to the heavy use of the local stone.

HOUSE MODULES

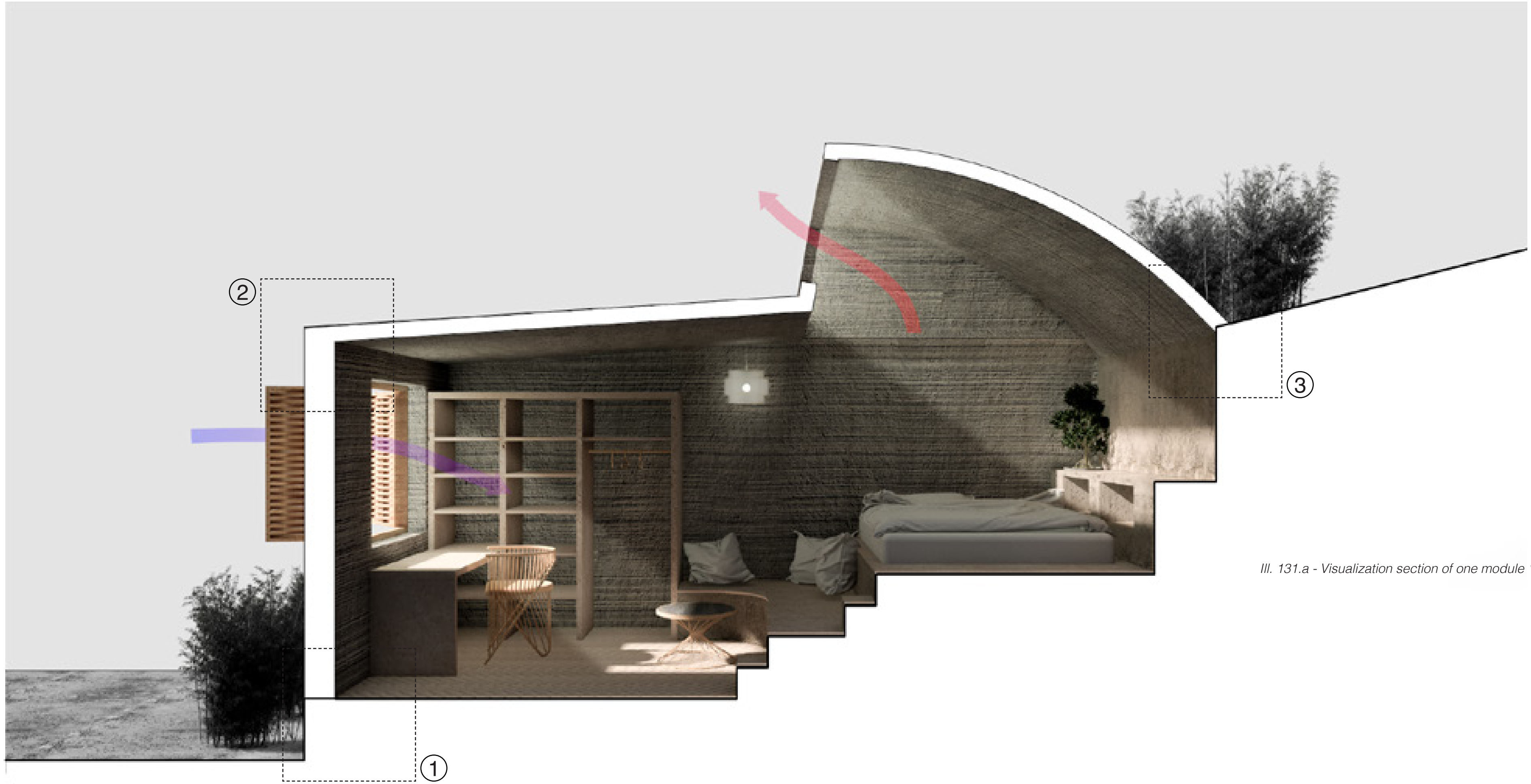




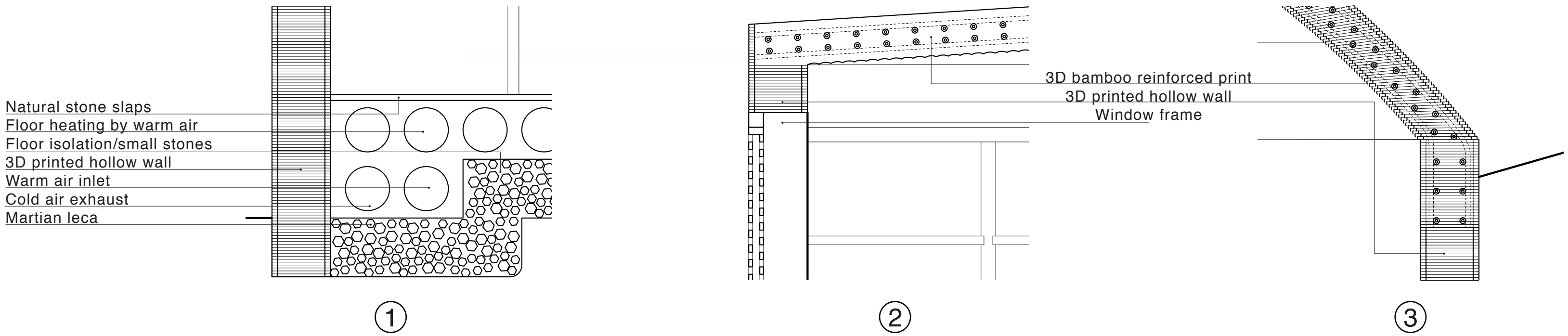
Ill. 130.a - House modules plan 1:100



Ill. 130.b - House modules section G 1:100



Ill. 131.a - Visualization section of one module 1:50



Ill. 131.b-d - Technical details 1:10

CONCLUSION

Throughout the master thesis a theory is developed to design a proposal for a small community on Mars. From a tectonic understanding and investigation, three keywords have emerged; Gesture, Principle and Genius Loci. Elements which let us in the direction of vernacular and utopian architecture, to further develop a theory and a generator for the design process with pivotal points in the words 'Tradition and Vision'. A theory with the vision of incorporating traditional building methods into a contemporary and visionary context, with the use of means available in the time and place. The main objective of this theory, is to bring architectural and engineering skills into a unification of poetry when engaging with the past and the future, the site, the structural principle and the gesture experienced in the spaces created.

Using this 'Tradition and Vision' throughout the integrated design process, a direction of creating high-tech facilities with low-tech strategies has been the preferred outcome when discussing the new Martian typology - following the vision of minimizing consumption and abundance and emphasizing the physical and sociological needs of the inhabitants.

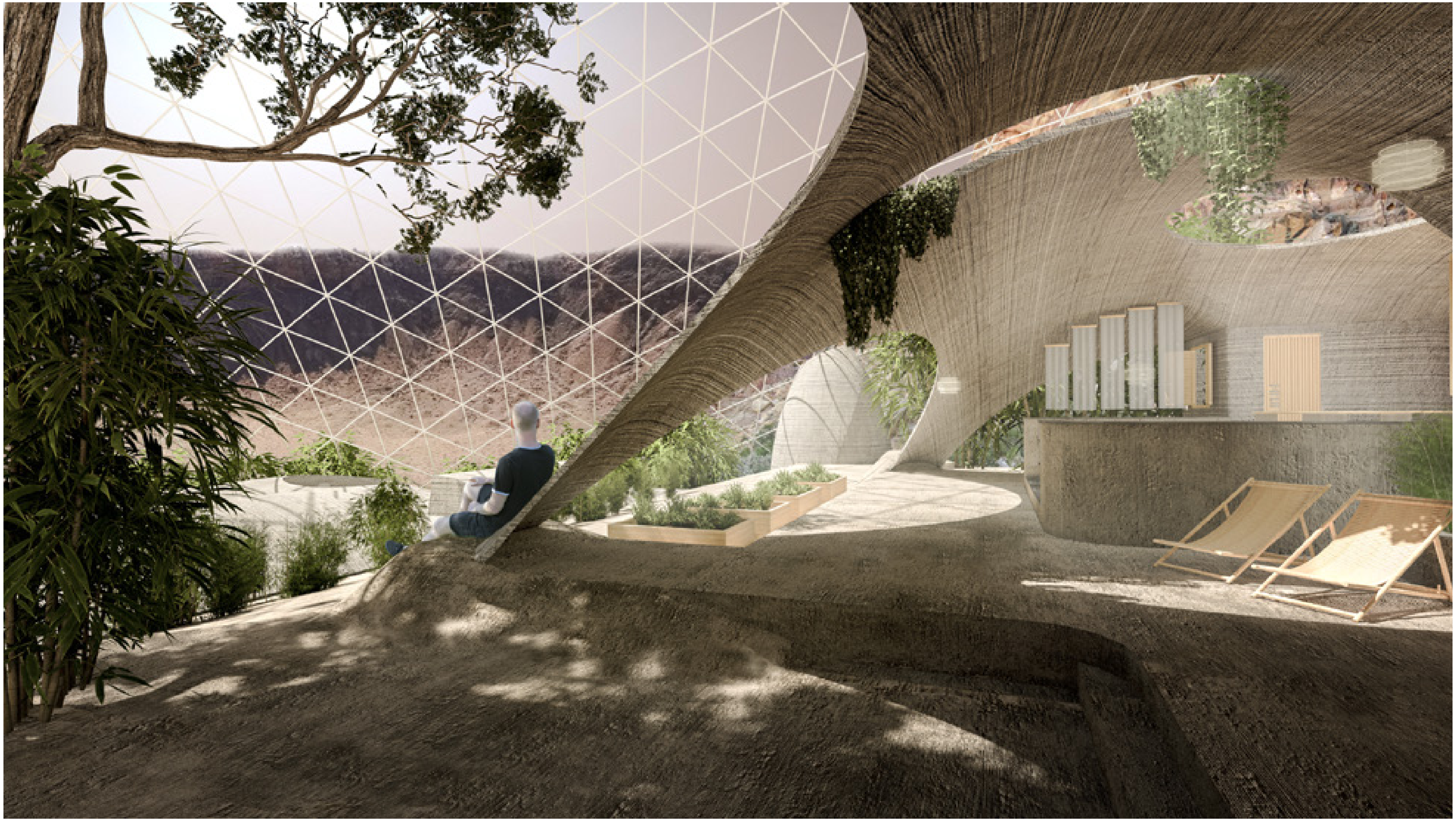
To make this possible a crater is chosen as building sites for pragmatic reasons, and afterwards partly covered by a structural tension membrane - designed to facilitate an artificial biosphereon the inside. A membrane developed through the live physics engine kangaroo, and further detailed and verified in the structural analysis tool Karamba. The membrane is designed to be structurally stable while minimizing the amount of material used, and at the same time generate a gesture to the internal space. A gesture of feeling the external tangible phenomena in the shape of light and shadow, the visuality of the crater, the extreme view of a night sky without light pollution and an intangible gesture of feeling safe and unrestricted in this new world.

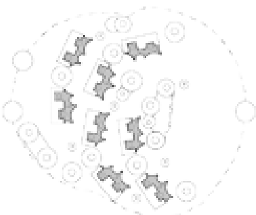
On the inside of the membrane a small community for approximate 200 people is designed, where two parts of the community has been selected for further detailing - a housing cluster with a bath and outside kitchens, and a cultural center with an amphitheater, sports facilities and a chapel. Both designed around tradition and vision – the buildings are built by milling out plateaus to utilize the ground as much as possible. Afterwards the excessive soil is used for material - 3D printed as Martian concrete, on top of these plateaus. This creates a visual poetic joint between the vernacular inspired earthwork and the visionary use of 3D printing. A joint unifying and emphasizing the local materials and their different tactility. This way of using the local available structural principle, in this new Martian typology, generates a spatial gesture to all of the buildings in the community.

Finally, a solar shading is designed to give the inhabitants a feeling of being outside in the nature without being in the direct sunlight and hereby minimizing solar radiation. This structure is designed through Rhino Vault, a funicular form finding tool, and later verified in Karamba. This creates a shell structure in compression only and hereby generate a three-dimensional structure, giving a gesture and variation when moving between the buildings and a visual form complimenting the organic surroundings. A visionary way of designing traditional common areas and meeting points in the community.

In conclusion we have created a theory out from our initiating motivation and used it throughout the master thesis, as a generator, a design criteria and a guideline - to keep the project on track and keep the tectonic values and the architectural poetry shine through in every decision.

Ill. 132.a - Dune Ripples in Her Desher Vallis





Ill. 133.a -Visualization of the shadepath by day

REFLECTION

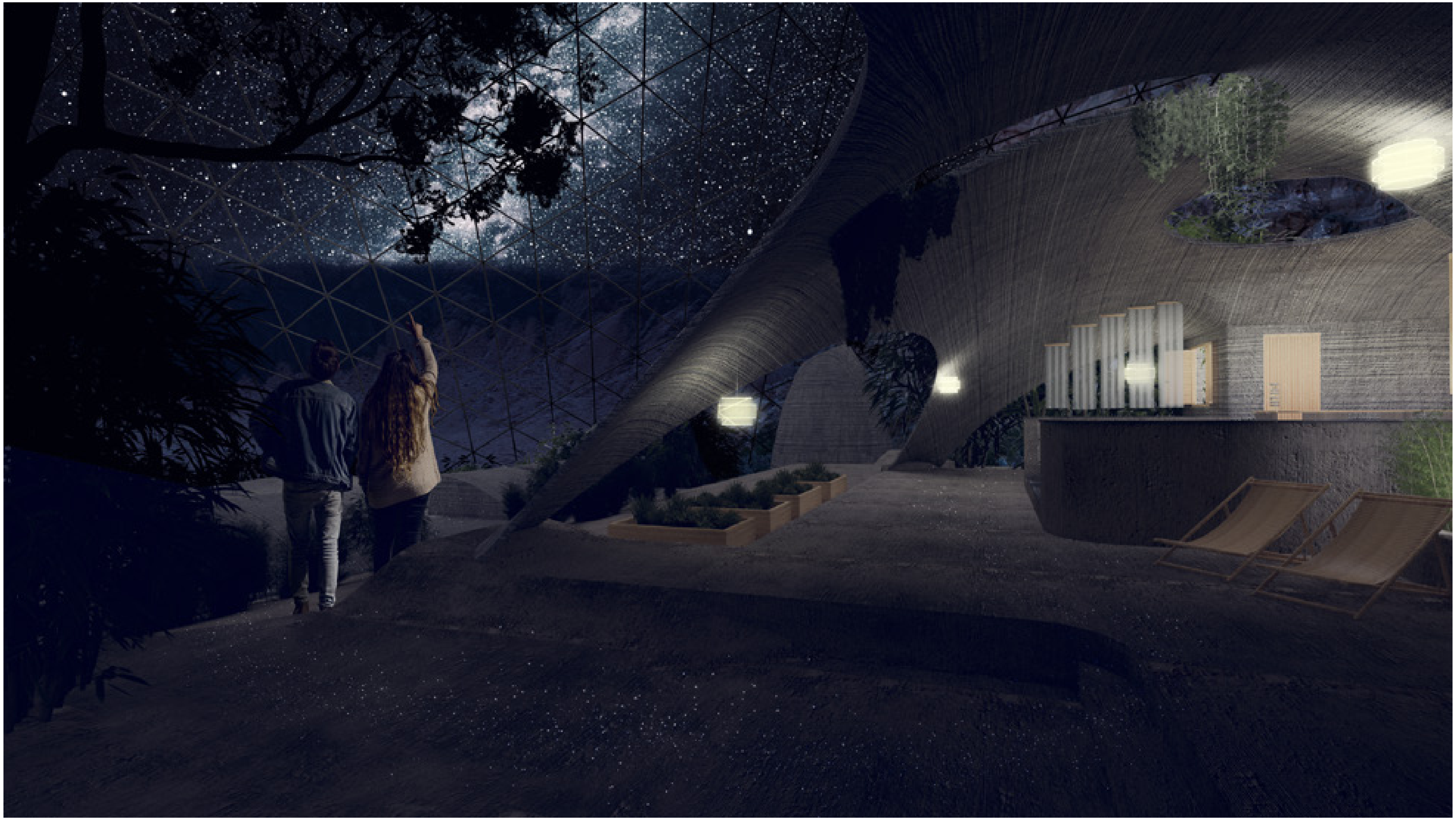
Creating a project for a place you haven't visited is one thing - creating a project where no human being has ever been, is a completely other situation. One has to rely on scientific estimations and countable unsure possibilities and merge them into a conceivable visualization of another world. A place where you do not know the smell, the correct lighting or the phenomenological perception. A place where there is no history or direction. A clean slate. This, has been a major challenge throughout the project. Designing without a specific context or a building regulation, without a codex or a correct way of going, has made it seem like every decision should be revolutionary to fit into the expectations. Why do the same, when you finally have the change to do different?
When trying to revolutionize the way we live and built, one has to look into new technologies, new ways of building – what is the next move? Is 3D printing outdated in 10 years or is it made even more efficient and useful - one can only wonder. Our approach to technology through the process has been to follow the new movements seen in contemporary society and tried to cross reference them with other methods, in order to push the limits and realize these new ways of using the known technology.

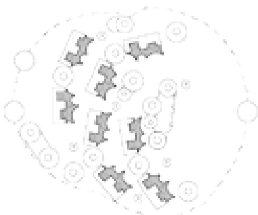
This can quickly be very tangible and pragmatic, when only designing in the limit of what's possible in the design moment - which isn't necessarily meant in a condescending way - but when designing utopian architecture, the limits of this project could have been pushed way further if a technological vision had been stated early in the process.

Even though the project works in the tension field of what's realistic and utopian, due to working on another planet. We feel that there is a great knowledge we can pull out of this master thesis and use in a wide range of projects here on earth. The creation of a self-sustainable community, where a connection between all elements is thought into a bigger picture is a relevant issue in a time where overconsumption is becoming a more discussed theme in the everyday life. Also, abundance and overwork, are parameters worked with through the thesis, and elements that can be rethought through architecture without people feeling that they are missing out. As long as the three tectonic elements described throughout the booklet, is shining through in the design decision, we feel that great architecture can be achieved in all sizes, with different materials choices and in different contexts.

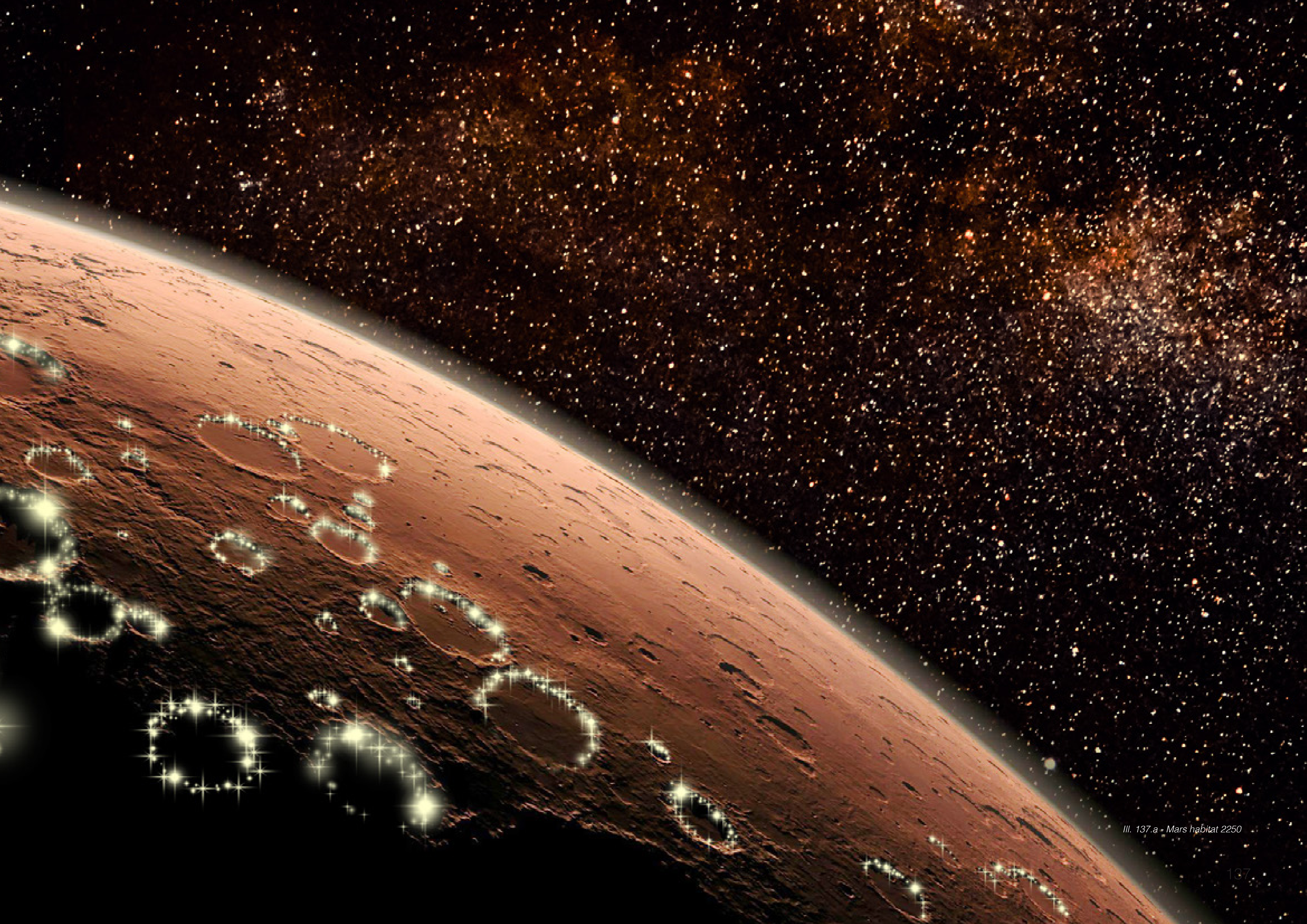
And finally, as written in our motivation, we wish to inspire – inspire other minds to think in new directions, inspire our fellow students to try new directions, and hopefully inspire future architects - troubling their mind one day - when designing livable areas on other planets. Because who knows when people will be wandering around on other planets looking back upon Earth? Who knows what the world will look like 20 years from now?

Ill. 134.a - Dune Ripples in Her Desher Vallis





Ill. 135.a - Visualization of shadepath by night

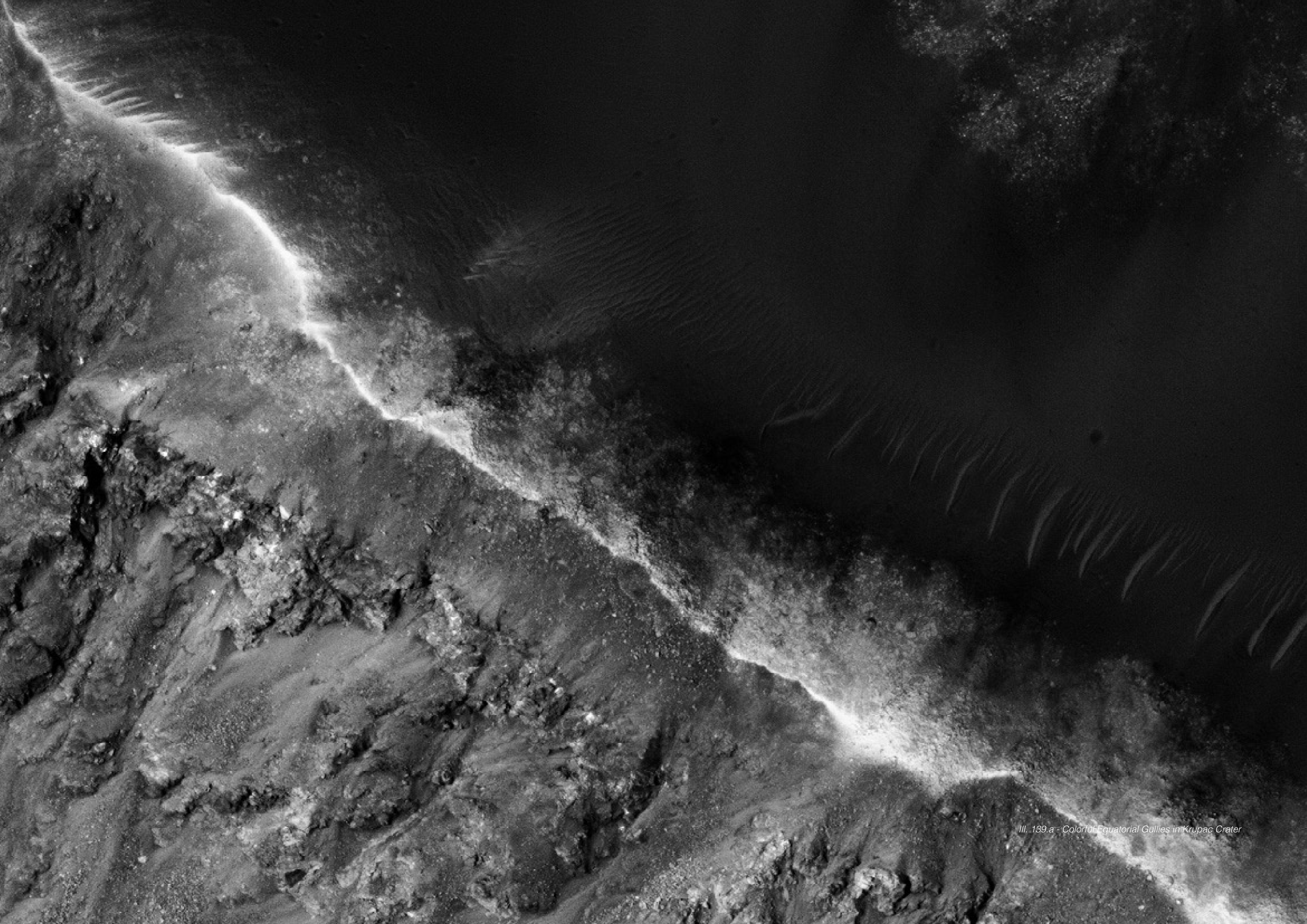


Ill. 137.a - Mars habitat 2250

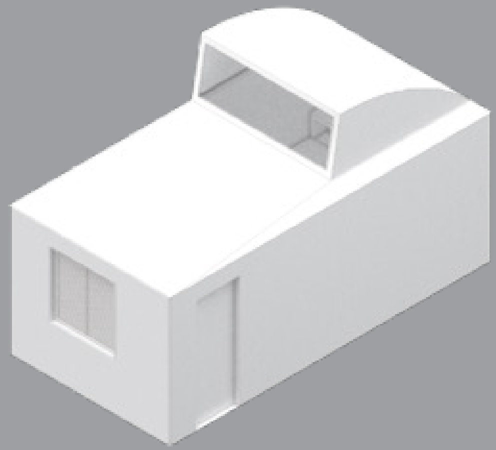
BUILDING CATALOGUE

The building catalogue is a collection of all the designed constructions, illustrated in plan, section and a isometric visualization. The illustration give a singlehanded overview of the individual houses, bath, shading, kitchen and People's house.

Inflatated torus form Ill. 138.e&f

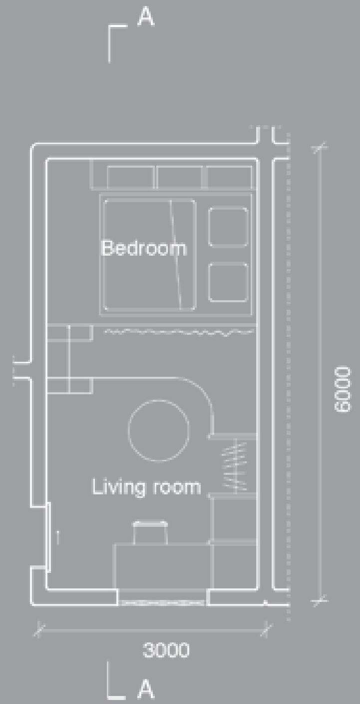


Ill. 139.a - Colorful Equatorial Gullies in Krupac Crater



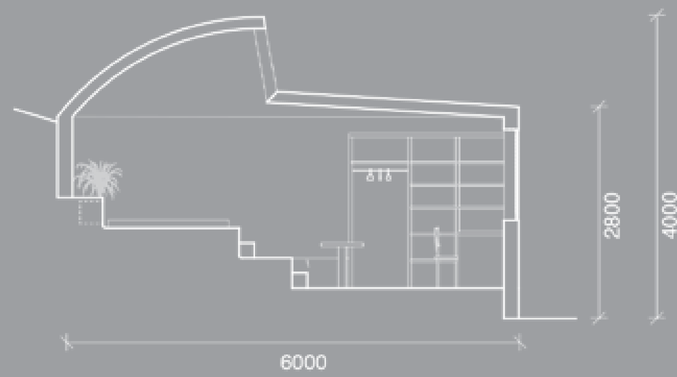
Isometric

Ill. 140.a



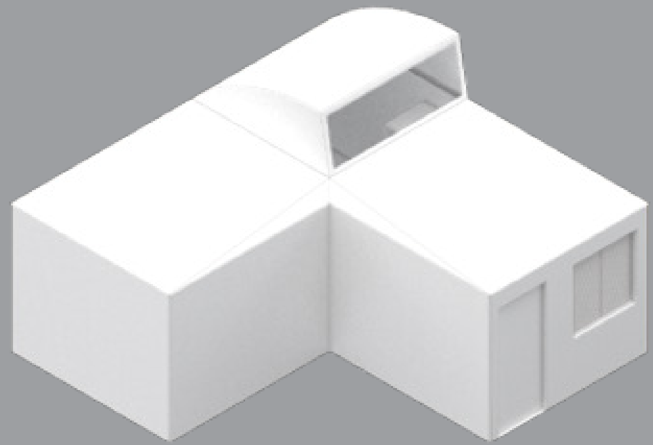
Plan 1:100

Ill. 140.b



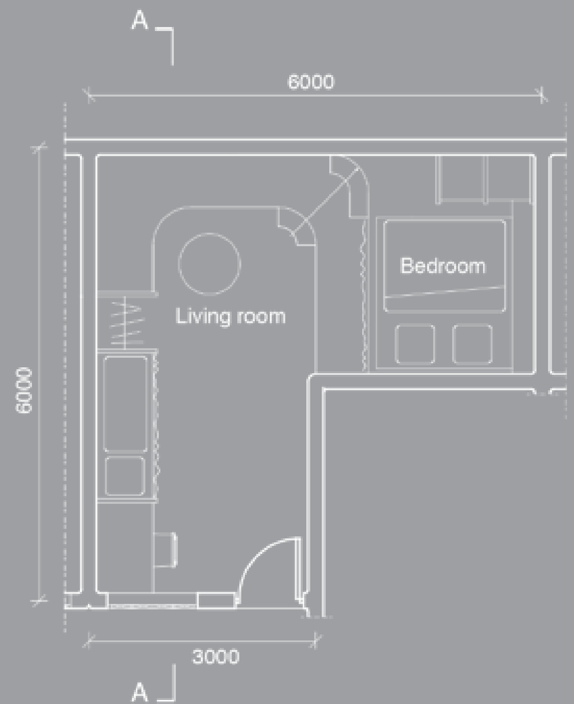
Section A/A 1:100

Ill. 140.c



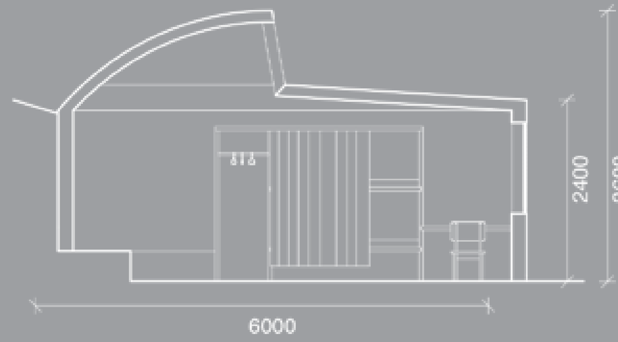
Isometric

Ill. 141.a



Plan 1:100

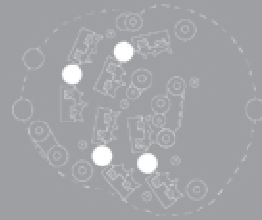
Ill. 141.b

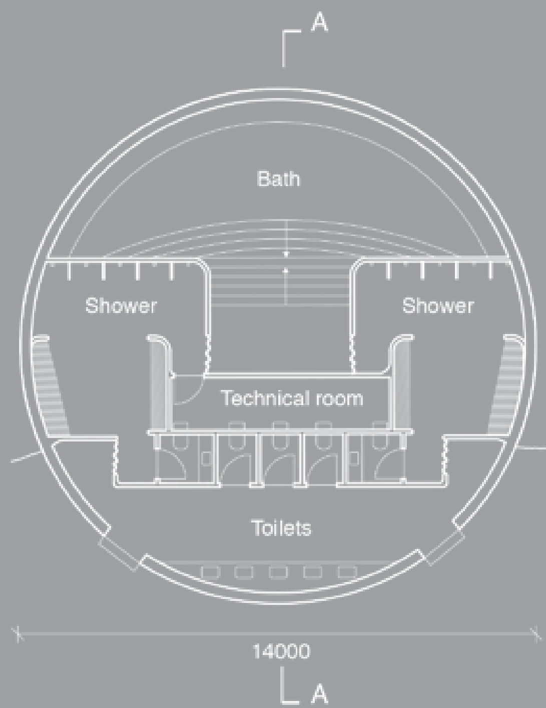


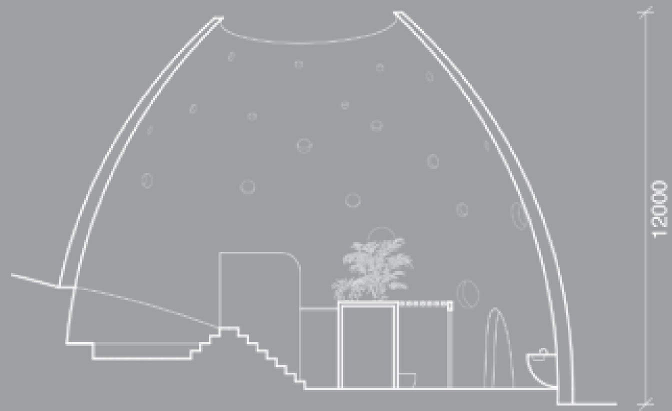
Section A/A 1:100

Ill. 141.c

BATH







Isometric

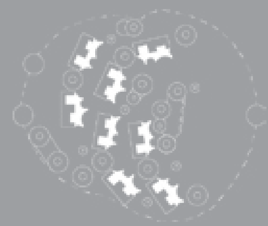
Ill. 142.a

Plan 1:200

Ill. 142.b

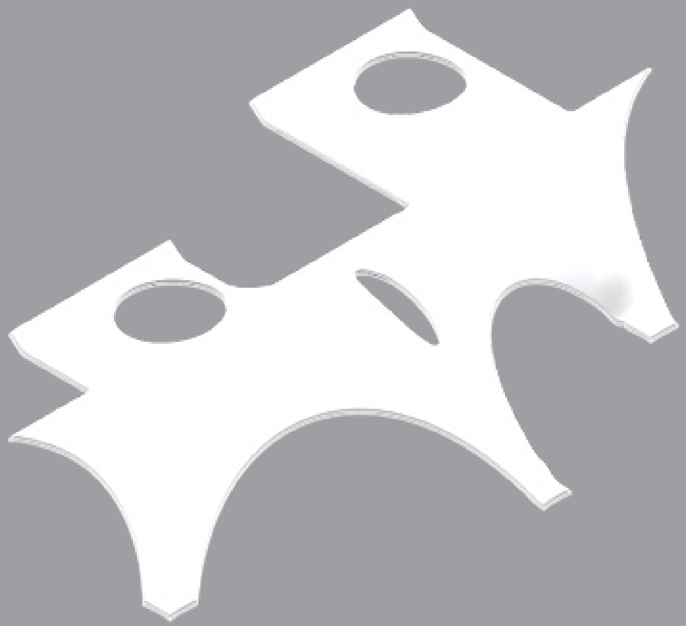
Section A/A 1:200

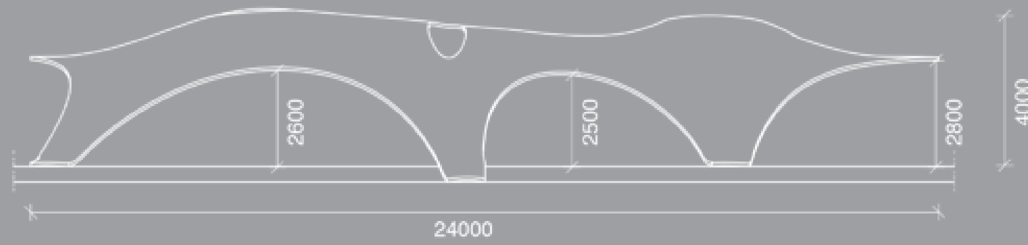
Ill. 142.c



BUILDING CATALOG

SHADING



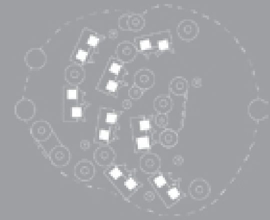


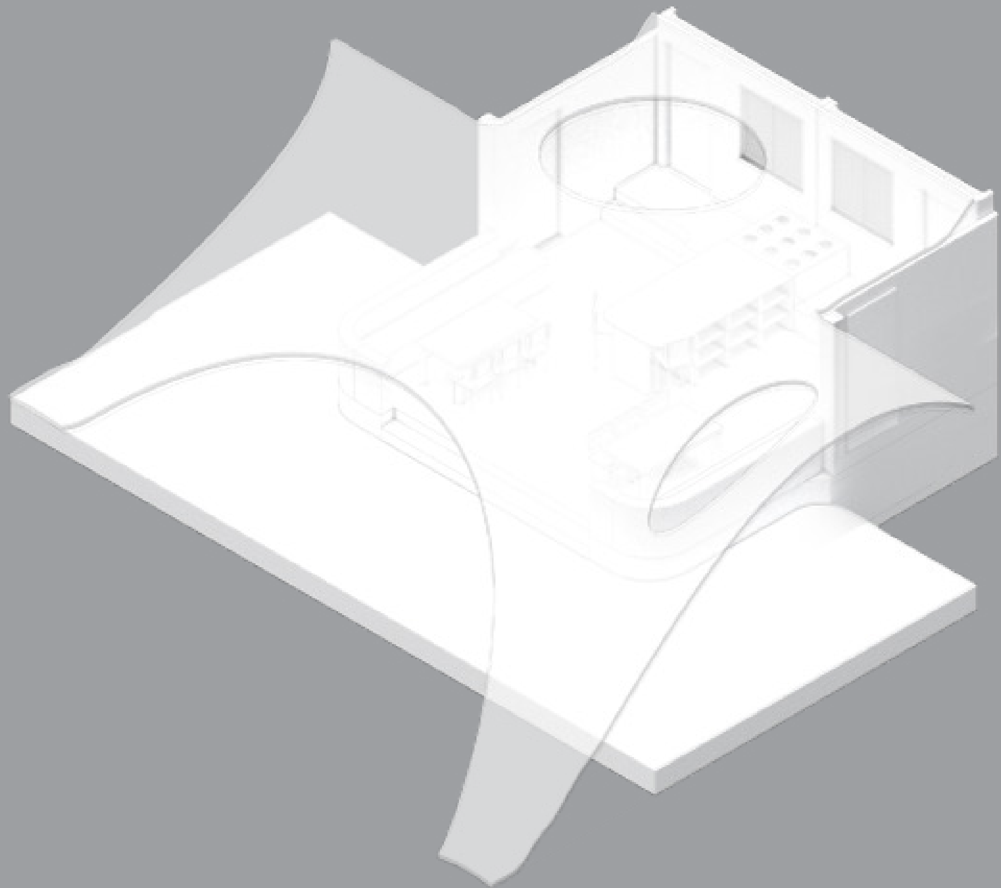
Isometric

Ill. 143.a

Elevation 1:200

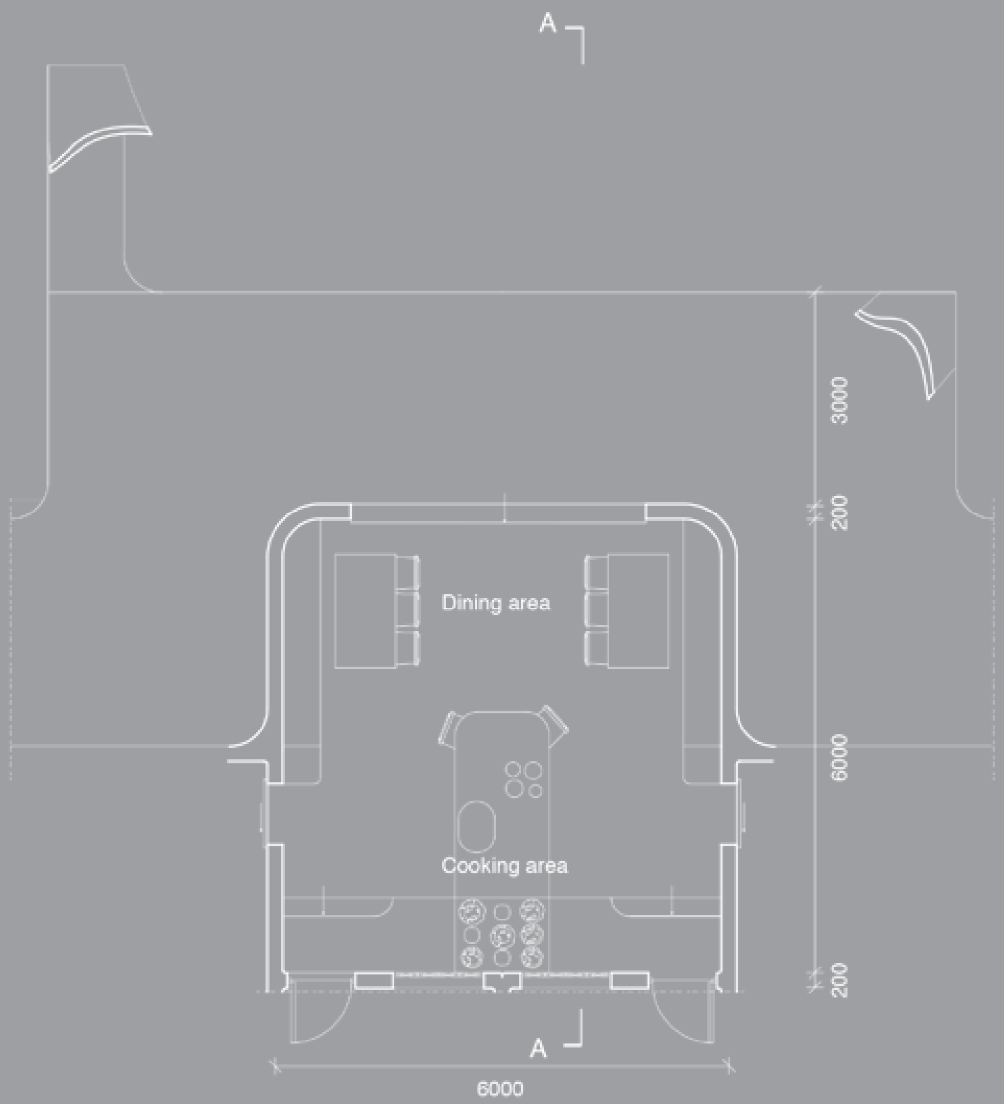
Ill. 143.b





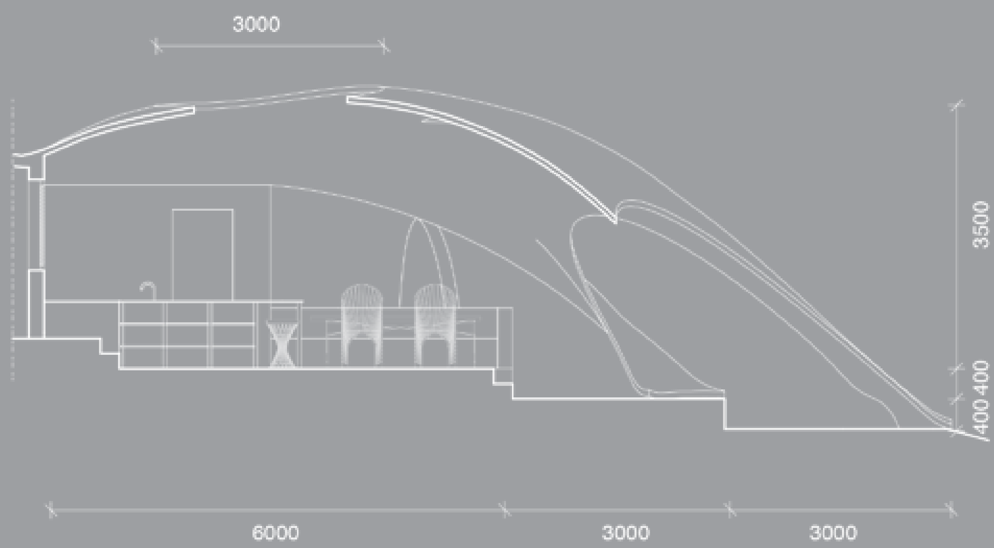
Isometric

Ill. 144.a



Plan 1:100

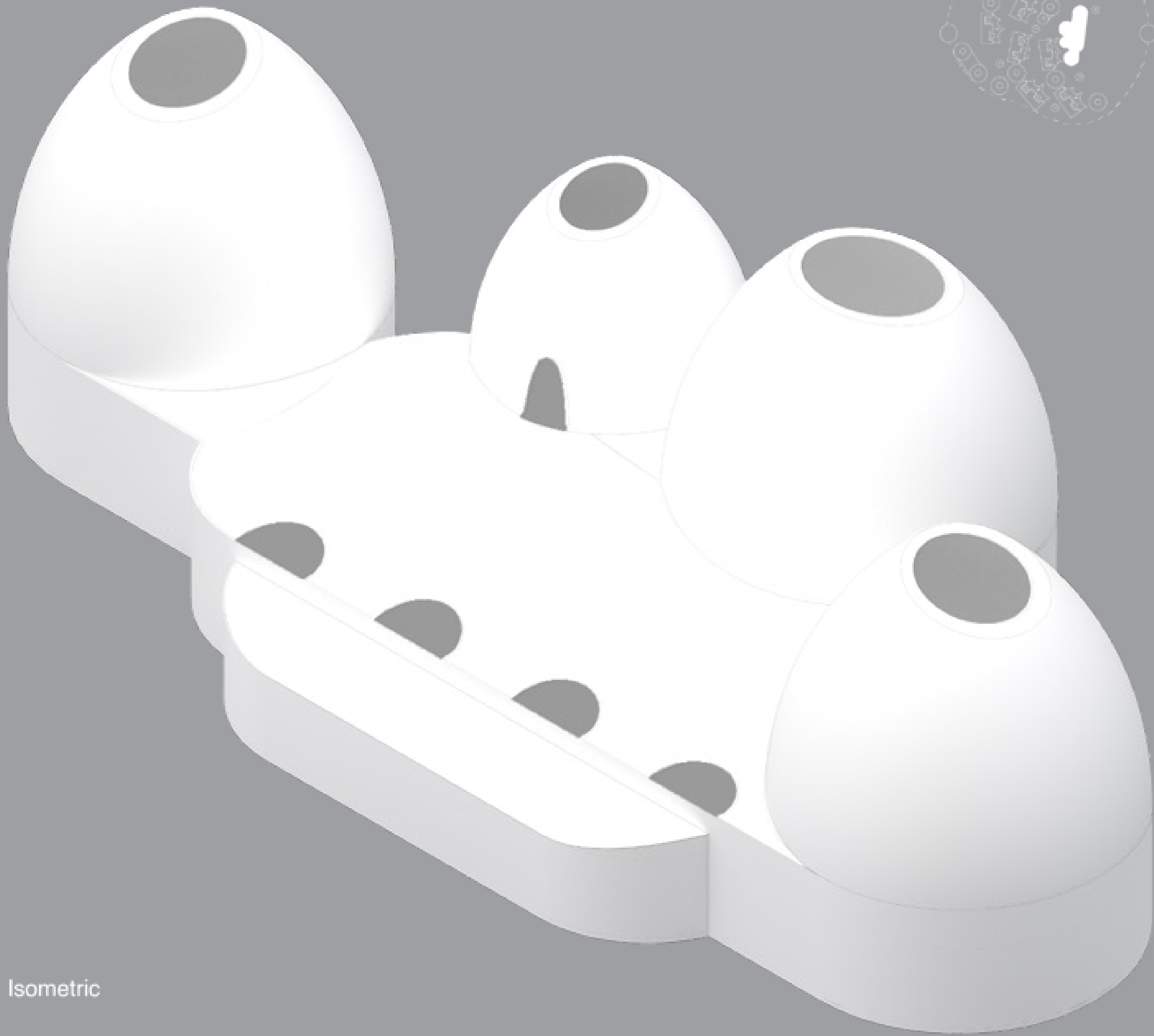
Ill. 145.a



Section A/A 1:100

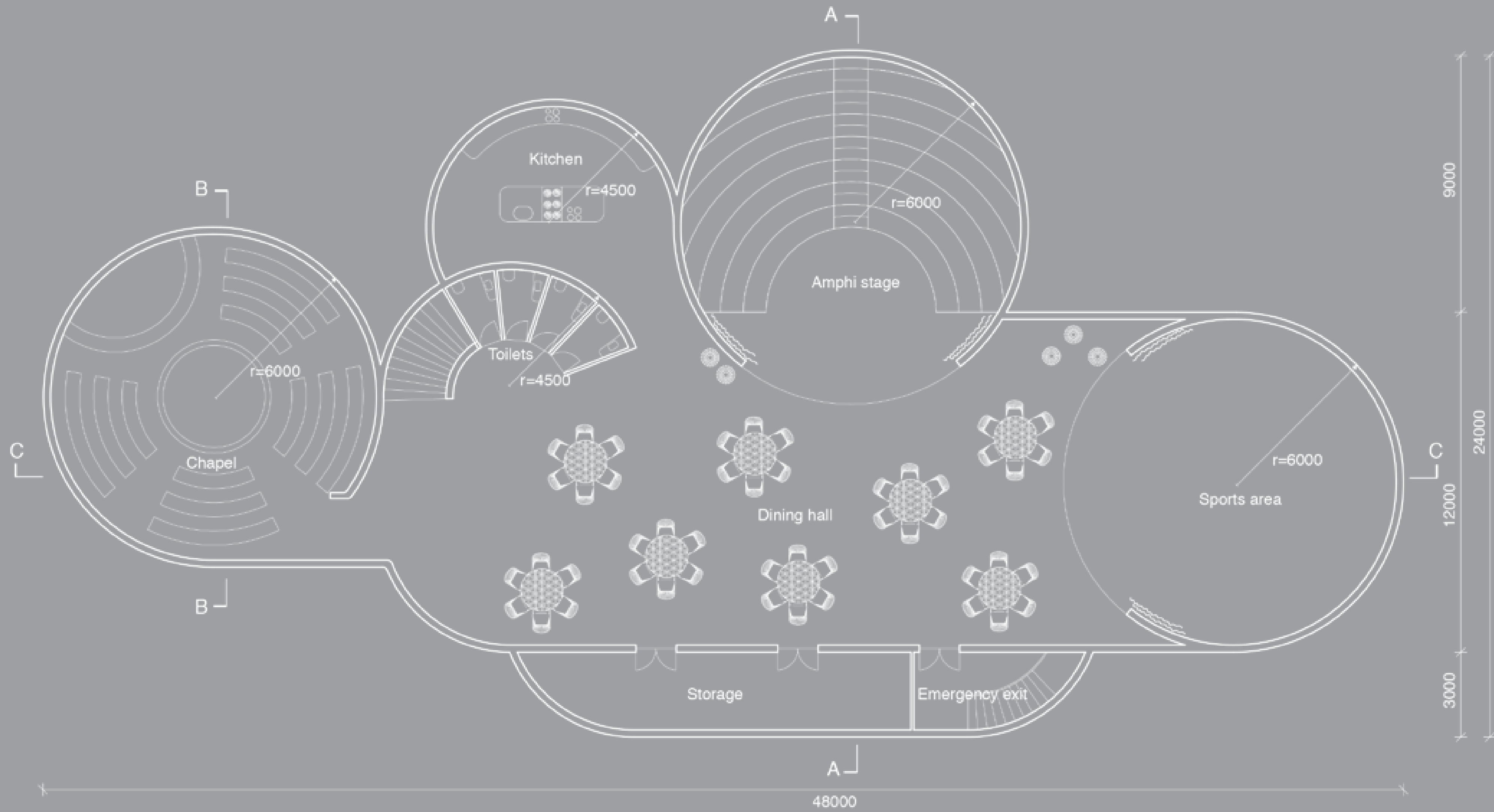
Ill. 145.b

PEOPLES HOUSE



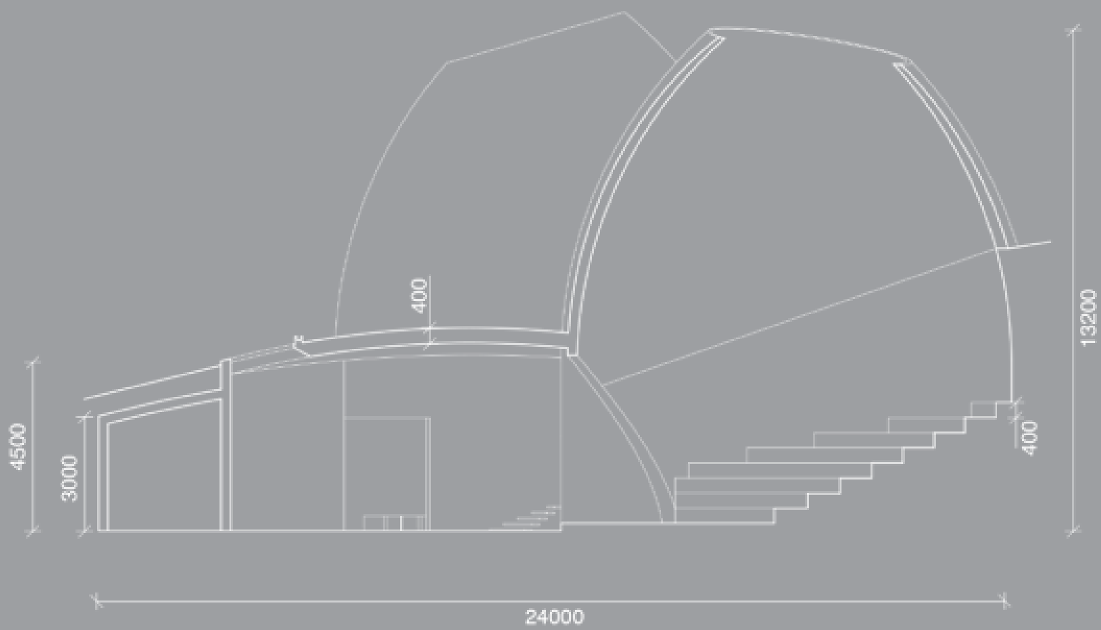
Isometric

Ill. 146.a



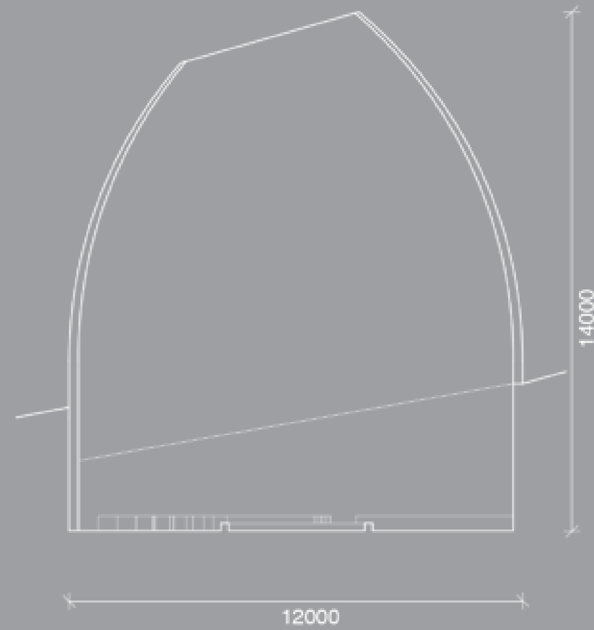
Plan 1:200

Ill. 147.a



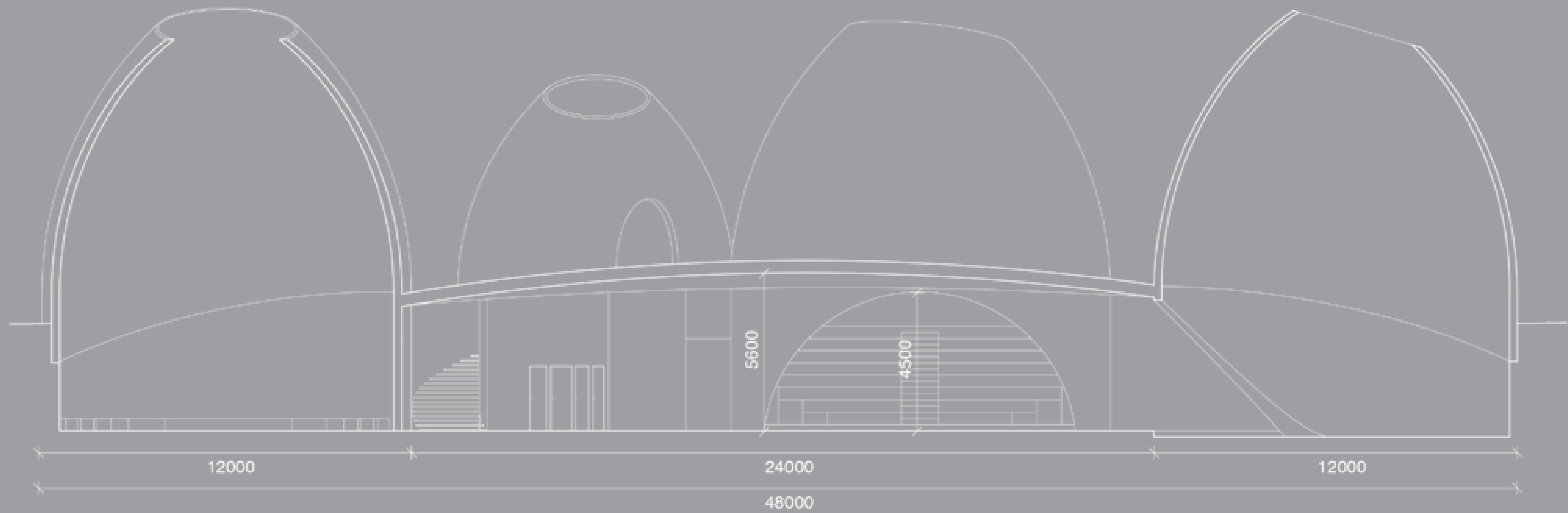
Section A/A 1:200

Ill. 148.a



Section B/B 1:200

Ill. 148.b



Section C/C 1:200

Ill. 149.a

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ILLUSTRATIONS

Ill. 7.a - A Rocky Deposit on the Floor of Dawes Crater	https://www.uahirise.org/catalog/
Ill. 10.a - Semper	Own creation
Ill. 10.b - Sekler	Own creation
Ill. 11.a - Nordberg-Schulz	Own creation
Ill. 11.b - Frampton	Own creation
Ill. 11.c - Hvejsel	Own creation
Ill. 12.a - Integrated design process	Own creation
Ill. 13.a - Tectonic elements as generators	Own creation
Ill. 14.a - Tungkwan settlement under ground	(Rudofsky, 1964)
Ill. 16.a - Mugsum Mud Huts, Conceptual Section	Own creation
Ill. 17.a - Mugsum Mud Huts, Cameroon	By Colibryus (Bruno Trédez) [CC BY-SA 4.0 (https://creativecommons.org/licenses/by-sa/4.0)], from Wikimedia Commons
Ill. 18.a - The Radiant city by Le Corbusier, 1924	http://www.businessinsider.com/le-corbusiers-plan-voisin-for-paris-2013-7?r=US&IR=T&IR=T
Ill. 19.a - Stuytown planned by Robert Moses, 1942	https://www.stuytown.com/solar
Ill. 19.b - Marine city by Kiyonori Kikutake, 1963	https://www.designboom.com/architecture/kiyonori-kikutake-1928-2011/
Ill. 20.a - New technology breed Utopia, but can Uto pia breed new technology?	Own creation
Ill. 21.a - Concept of Auroville by Roger Anger from 1966	https://magazine.machimach.com/13-planned-cities-e9ec3f651ba4
Ill. 22.a - Concept diagram of the theory 'Tradition and Vision'.	Own creation
Ill. 25.a - Mounds West of Schiaparelli Crater	https://www.uahirise.org/catalog/
Ill. 26.a - Can Lis plan drawing	Own creation
Ill. 27.a - Can Lis	Photografer Torben Eskerod
Ill. 28.a - Can Lis living room	Photografer Torben Eskerod
Ill. 29.a - Interior detail	Photografer Torben Eskerod
Ill. 30.a - Sketch of a section of the Tietgen Dormitory	Own creation
Ill. 30.b - Sketch of a section of the Chinese Tulou typology	Own creation
Ill. 31.a - Courtyard Tietgen Dormitory	Ole Olin Egebaek
Ill. 32.a - Interior Tietgen Dormitory	Lundgaard & Tranberg Arkitekter
Ill. 33.a - Extrution of the common area	Jens M. Lindhe
Ill. 37.a - Slope Monitoring in Hale Crater's Central Peaks	https://www.uahirise.org/catalog/
Ill. 38.a - Timeline	Own creation
Ill. 40.a Solar system	Own creation
Ill. 41.c Mars' surface	https://www.uahirise.org/catalog/
Ill. 42.a - Mars' geographical map	Own creation
Ill. 44.a - Flat surface	Own creation
Ill. 44.b - Mountain side	Own creation
Ill. 45.a - Canyon	Own creation
Ill. 45.b - Lavatubes	Own creation
Ill. 45.c - Crater	Own creation
Ill. 46a Temperature avg. during a martian year	Own creation
Ill. 47.a - Victoria crater at Meridiani Planum with an overlay of the sun's path upon the crater	Own creation
51.a - Rock Outcrops and Dark-Toned Bedforms	https://www.uahirise.org/catalog/
Ill. 53.a - Human body	Own creation
Ill. 55.a - Agricultural methods versus area and water needed to produce food for one person.	Own creation
Ill. 57.a - The structural need for the city	Own creation
Ill. 57.b - The psychological needs for the individual	Own creation
Ill. 61.a - Central Peak Remnant in Roddy Crater	https://www.uahirise.org/catalog/
Ill. 62.a-i - Design criteria	Own creation
Ill. 63.a - Urban programme	Own creation
Ill. 64.a - Interconnected system of the community which enables self sustainability and living conditions	Own creation
for both plants and humans.	Own creation
Ill. 67.a - Room programme	https://www.uahirise.org/catalog/
Ill. 71a - A Crater in Terra Tyrrhena	Own creation
Ill. 72.a - Periphery concept	Own creation
Ill. 72.b - Pocket concept	Own creation
Ill. 72.c - Epicentre concept	Own creation
Ill. 73.a - Completely covered concept	Own creation
Ill. 73.b - Cliff concept	Own creation
Ill. 73.c - Combination of cliff and pocket concept	Own creation
Ill. 74.a - Crater concept	Own creation
Ill. 75.a - Initial concept visualization	Own creation
Ill. 76.a - Focus area in the crater	https://mars.jpl.nasa.gov/mer/home/index.html
Ill. 76.b - Photo from the Oppertunity rover of Cape Verde and Duck Bay	Own creation
Ill. 77.a - 1:2000 plan with sun path diagram	Own creation
Ill. 78.a - 1:2000 situationplan	Own creation
Ill. 79.a-c - 1:2000 Landscape sections	Own creation
Ill. 80.a - b - Initial masterplan drawings	Own creation
Ill. 81.a - d - Initial concept drawings	Own creation
Ill. 82.a - b - Initial midterm drawings	Own creation
Ill. 83.a - b - Midterm seminar drawings	Own creation
Ill. 84.a - e - New idea concept drawings	Own creation
Ill. 85.a - g - New idea concept drawings	Own creation
Ill. 86.a - d - Drawings under one envelope	Own creation
Ill. 87.a-e - Drawings under one envelope	Own creation
Ill. 88.a-d - Inflatable structure	Own creation
Ill. 88.e-f - Inflatated torus form	Own creation
Ill. 89.a-c - Inflatated elipse form	Own creation
Ill. 89.d-f - Inflatated cluster of smaller domes	Own creation
Ill. 89.g-i - Inflatated circular form	Own creation
Ill. 90.a&b - Square grid pattern	Own creation
Ill. 91.a&b - Rotated square grid pattern	Own creation
Ill. 91.c&d - Diamond grid pattern	Own creation
Ill. 91.c&d - Triangular grid pattern	Own creation
Ill. 92.a - Membrane drawings	Own creation
Ill. 92.b - Concept drawing of inflatable membrane	Own creation
Ill. 93.a - Concept joint of membrane meeting the	Own creation