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2072 MARS

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MARTIAN CONDITIONS

a quick comparison to Earth

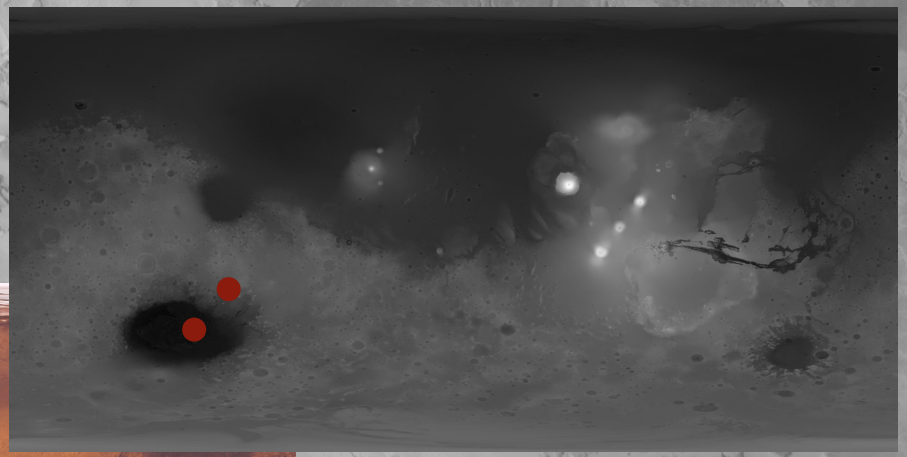
	EARTH	MARS
Tilt of Axis	23.5 degrees	25 degrees
Length of Year	365.25 days	687 days
Length of Day	23 hours 56 minumtes	24 hours 37 minumtes
Gravity	2.66 times that of Mars	0.375 that of Earth
Temperature	13.6 degrees celcius	-62.7 degrees celcius
Atmosphere	nitrogen, oxygen, argon and others	mostly carbon dioxide, some water vapor

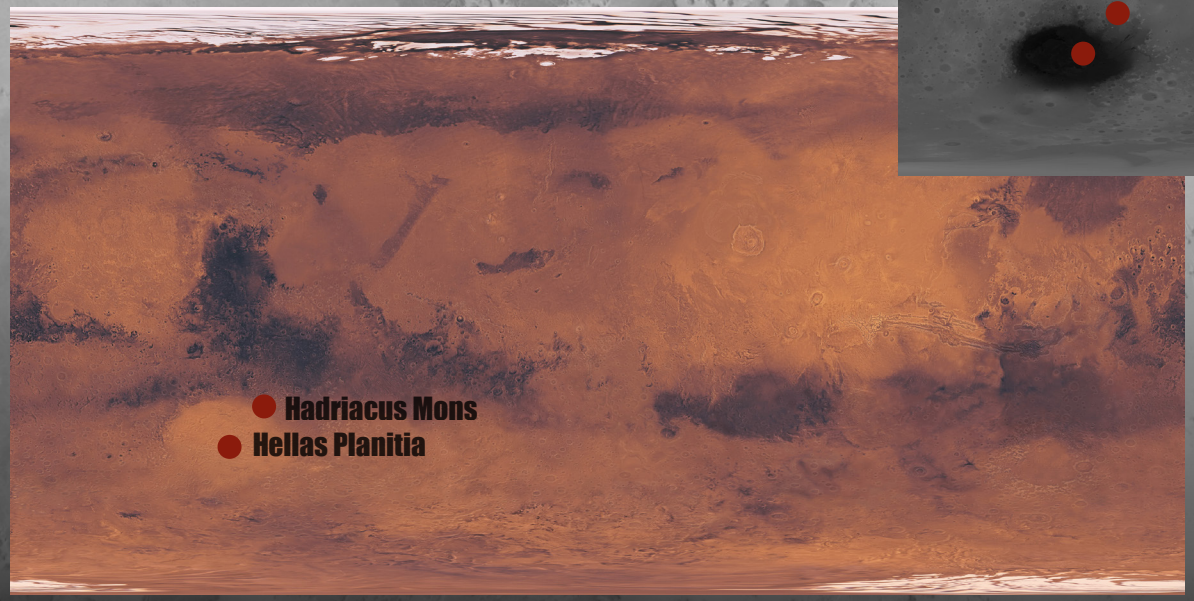
THE RADIATION CHALLENGE & SITE SELECTION

Mars has a thin atmosphere of 16g/cm^3 density and a weak magnetic field (>1500 nT, 16-40 times less than Earth's), which allows the SEP (solar event particles) and the GCR (Galactic Cosmic Rays) to reach the Martian Surface.

The radiation levels on Martian Surface were measured to be 0.87 mSV/day for GCR and 270 mSv/solar event for SEP respective to 0 km altitude. To compare, an average person in a developed country is exposed to 0.017 mSv of radiation daily, and the radiation limit for one year space missions is 500 mSv, which necessitates a radiation shielding for human habitation on Mars.

Since the primary challenge is the radiation, the site has been chosen accordingly as Hadriacus Mons, which is a once-active volcano located on the north east of Hellas Planitia. Even though it is more elevated than the Hellas Planitia, there are various Lava Tube chains detected around the area, which makes it a good candidate for the longterm human habitation.





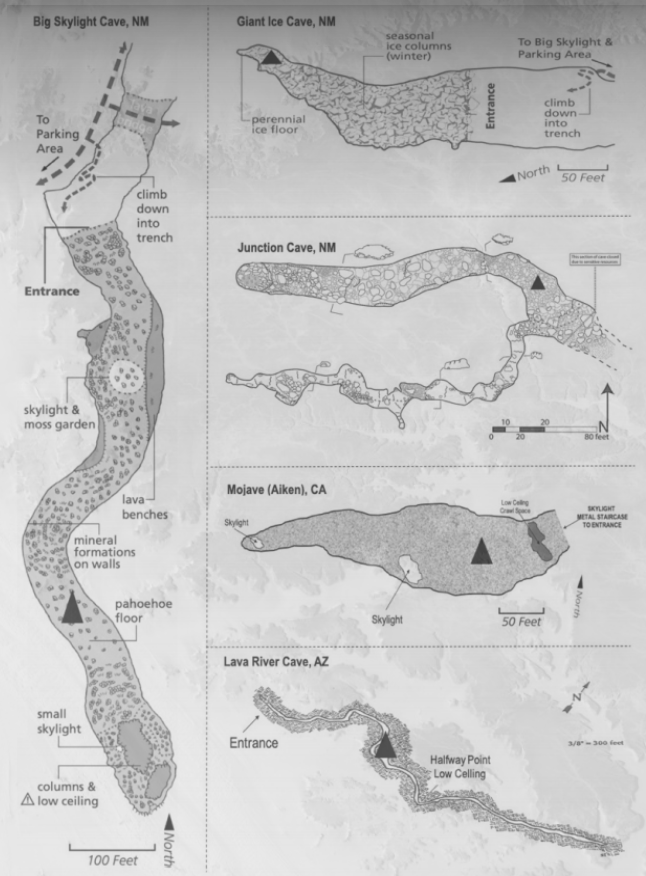
The radiation levels highy depend on the elevation of the site and the values alter between 273 up to 547 mSv/day. Higher elevations are more vulnerable to the radiation as the thickness of the atmosphere decreases at those levels.

LAVA TUBES

The orbital imagery of NASA's Mars Reconnaissance Orbiter (MRO), the High Resolution Imaging Science Experiment (HiRISE) and the Context Camera (CTX) has identified chains of lava tubes in the vicinity of Hadriacus Mons, the deepest pit with the lowest elevation on Martian surface.

According to the radiation studies conducted in the analogous lava tubes located at Mojave, CA, El Malpais, NM and Flagstaff, AZ , it has been determined that the radiation levels are reduced by %82 inside the lava tubes compared to the surface radiation levels.

It has been concluded that in Hadriacus Mons (with an average radiation level of 342.46 mSv/day) the lava tubes are presumed to reduce the radiation levels down to 61.64 mSv/day.



Analog Site	Avg Surface Reading uSv/hr	Average Interior Reading uSv/hr	Avg Surface Temperature - C	Average Interior Temperature - C
Mojave Aiken - California	0.468	0.088	12	9
El Malpais - Big Skylight - New Mexico	0.501	0.062	20	13
El Malpais - Giant Ice Cave - New Mexico	0.434	0.098	18	10
El Malpais - Junction Cave - New Mexico	0.458	0.078	17	11
Lava River Cave - Arizona	0.492	0.089	25	12
Average	**0.4706**	**0.083**	**18.4**	**11**

CONCEPT

I. CONCEPTUAL DEVELOPMENT

At the very beginning of the colonisation of Mars, it will not be possible to excavate the soil, which results in above ground housing solutions. However, once Mars is colonised, it will be easier to manipulate the environment which makes it an option to utilize the lava tubes as radiation shelters.

Then the project concept was shaped within the idea of having a mixed use complex that uses both the exposed exterior environment and the interior of the lava tubes.

In an attempt to protect the nature of Mars and minimalize the human interference, all the functions that do not require direct interaction with the surface were located inside the lava tube, and as the interior of the lava tubes are less hostile environments, it was designed as an isolated terraformed space for the 'Martians'.

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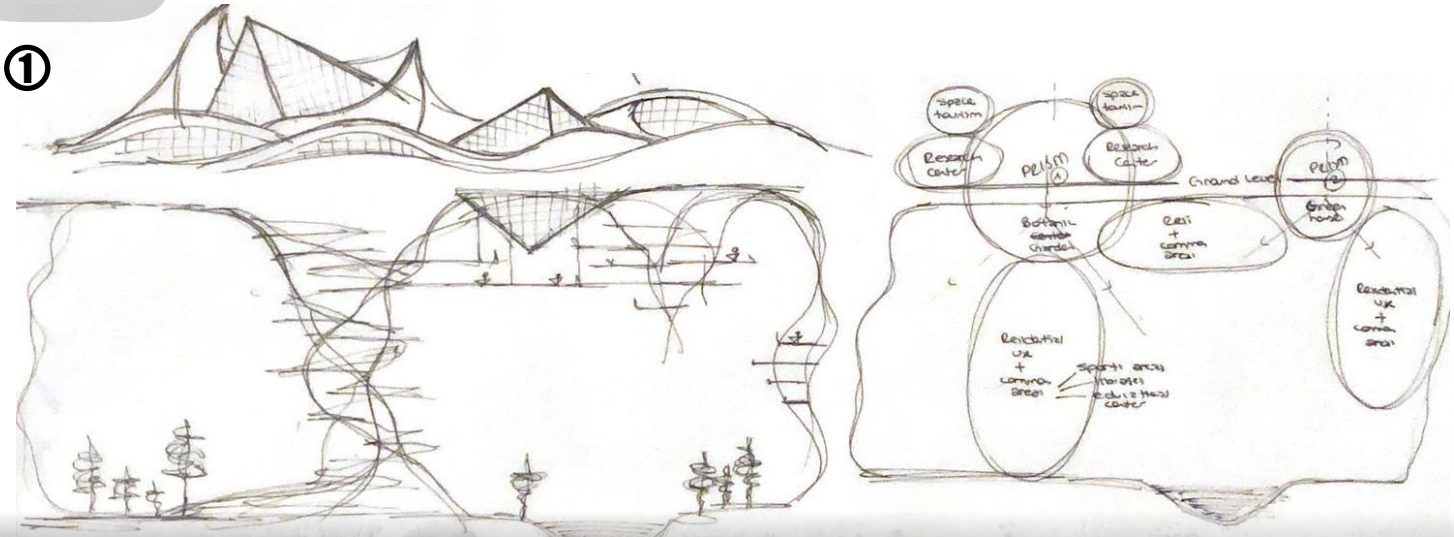

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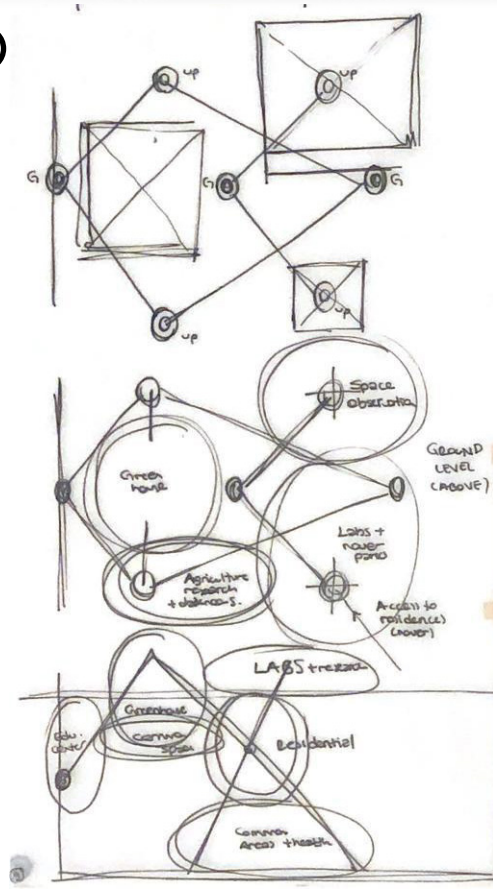

Then the concept of a diagonal structural system that would integrate the two parts of the design was introduced. It would both support the ceiling of the lava tube and act as the primary circulation core.

CONCEP

I. CONCEPTUAL DEVELOPMENT

Having the circulation axis figured out, the design was further developed; the interior landscape of the lava tube was manipulated and the distribution of the functions regarding the topography and the circulation axis were finalized.

Then the population of the colony was determined as 200 people, which restricted the minimum floor area for various functions including the greenhouses and the housing units.

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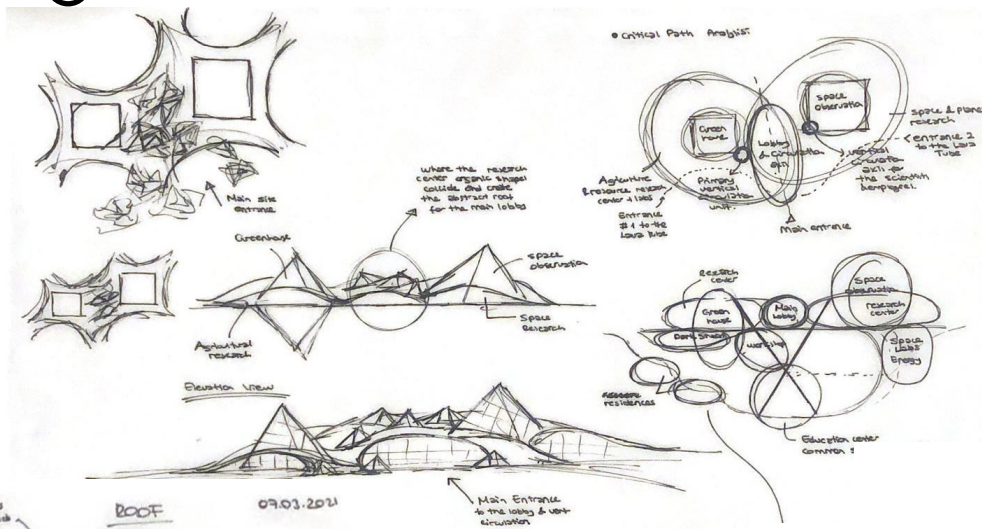

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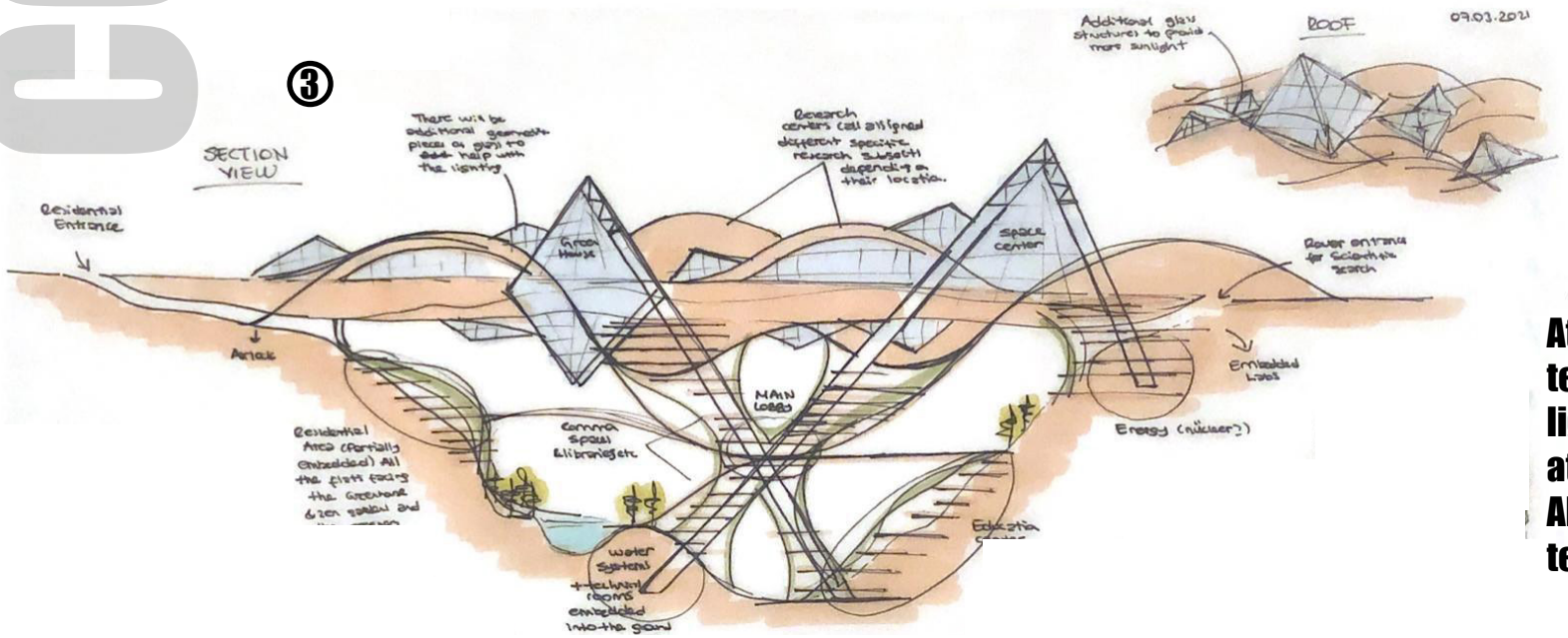
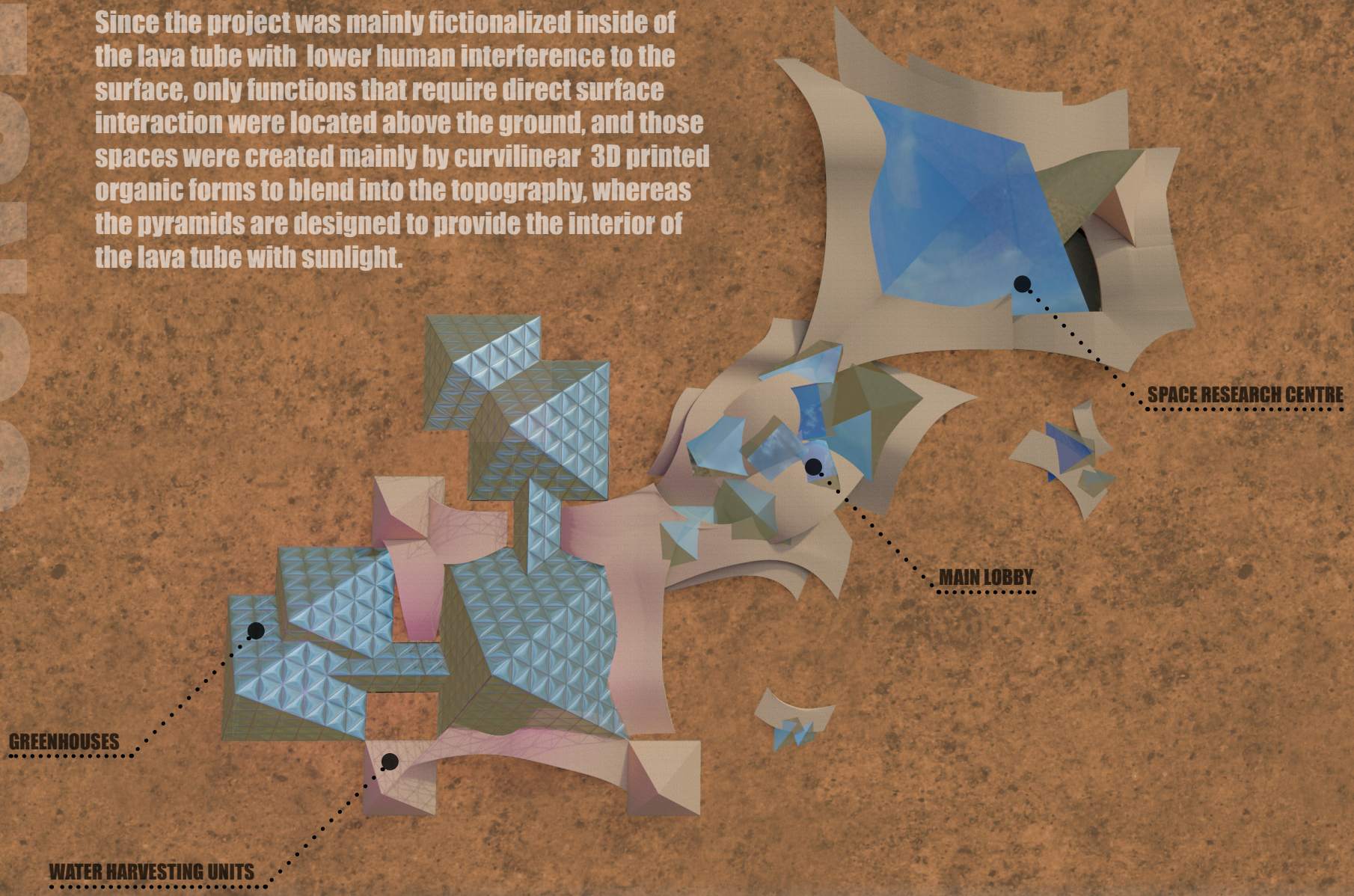


At that stage the environmental systems such as water harvesting and lighting were reconsidered and literature reviews were made thoroughly. Also the construction materials and techniques were studied.

CONCEPT

II. SITE PLAN

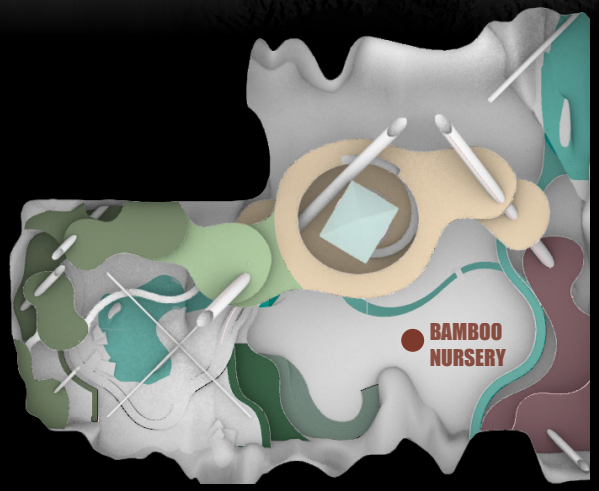
Since the project was mainly fictionalized inside of the lava tube with lower human interference to the surface, only functions that require direct surface interaction were located above the ground, and those spaces were created mainly by curvilinear 3D printed organic forms to blend into the topography, whereas the pyramids are designed to provide the interior of the lava tube with sunlight.

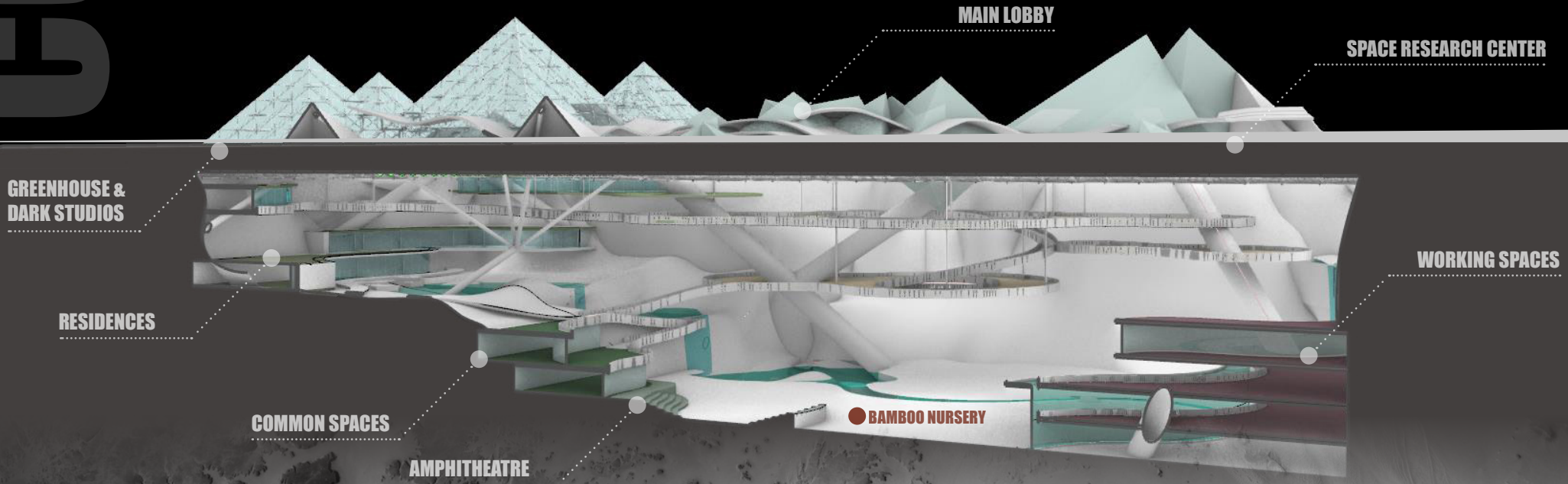


CONCEPT

II. FUNCTIONS

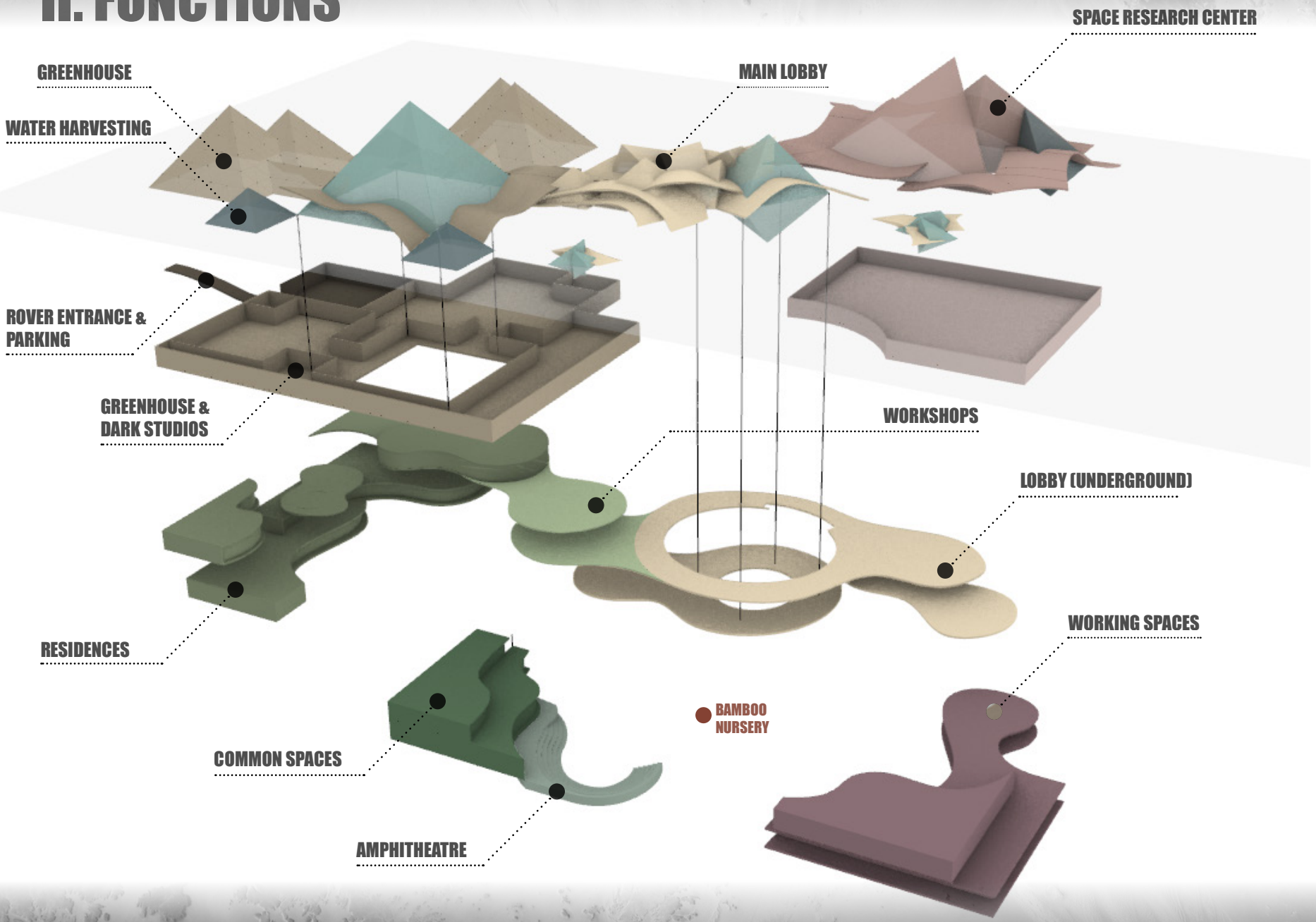
There are two main function divisions inside the lava tube, the green-coded spaces are related to personal and common spaces including the residences, education areas and greenhouses, whereas the pink coded spaces are dedicated to work and research activities. And every other space lying between those spaces are transition spaces which include zen gardens, bamboo nursery zones and a couple of lobbies.





CONCEP

II. FUNCTIONS

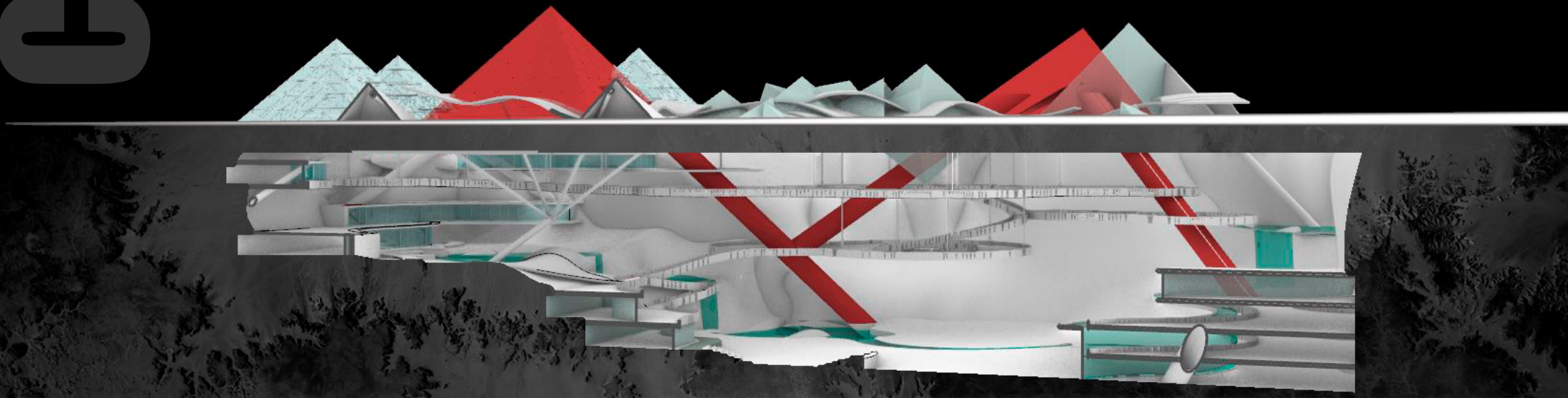


CONCEPT

III. STRUCTURAL CONCEPTS

In an attempt to support the ceiling of the lava tube and create a structural integrity with the upper spaces, a set of diagonal structural elements were designed, which also act as the vertical circulation cores. They propose two alternative pedestrian entrances to the complex.

A sample diagonal elevator section from the Eiffel Tower



CONCEP

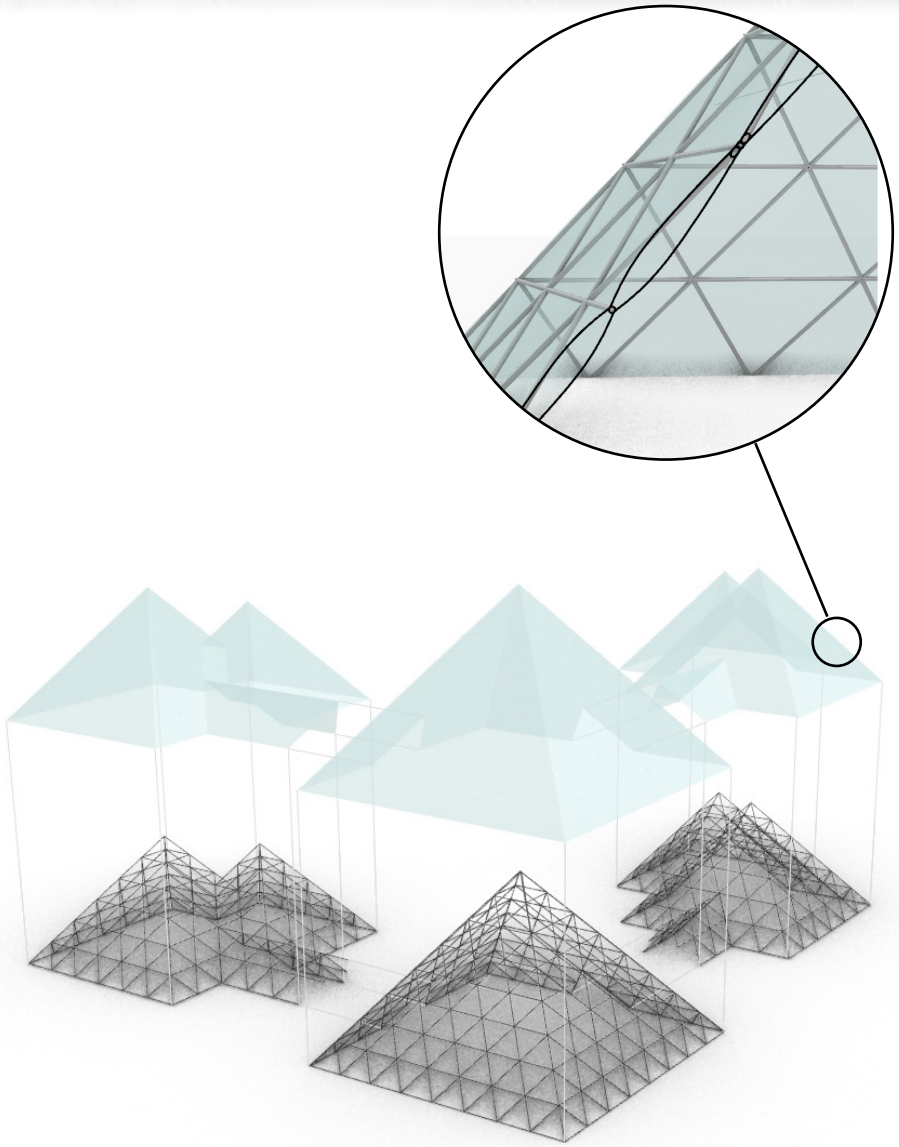
III. STRUCTURAL CONCEPT - ICE WALLS

Due to hydrogen having low atomic number, ice has a really high radiation shielding property, and also it being translucent makes it a perfect candidate for spaces that require sunlight. Therefore ice has been used in the greenhouse structures as well as in the light wells and in the observation spaces.

Since the atmospheric pressure of Mars does not allow for water to freeze, the water is filled into pressurized inflatable membranes, and once pressurized it freezes to the shape of the panels with the low temperatures.

To prevent the heat transmittance, a second layer of inflatable membranes filled with carbon dioxide was used, as it is the most common component of the Martian atmosphere while being an insulating gas.

Case Study: Ice House



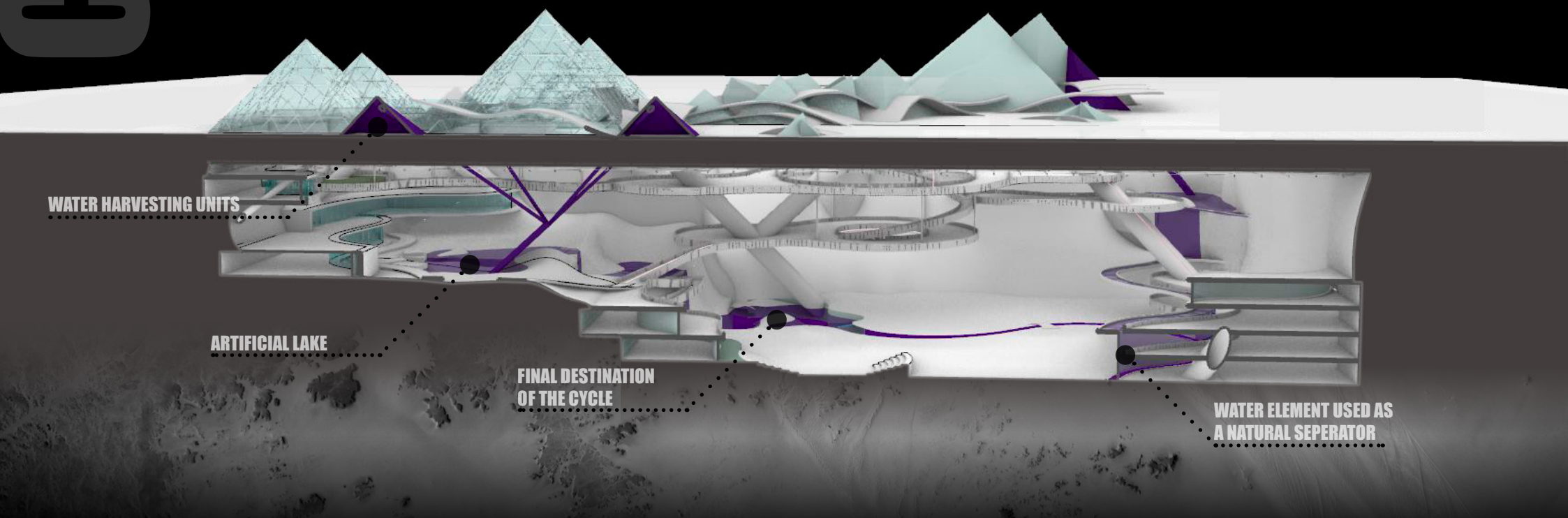
CONCEPT

WATER HARVESTING

Recent studies show that the Martian soil does include water ice, but when brought to the surface it sublimates. Therefore the pieces of ice mixed within the soil could be collected and exposed to low pressure environment e.g. the surface, and the water vapor could be collected from the top to be repressurized and converted into pure water.

Then the pipes located in the water harvesting pyramids collect the water and bring it to the artificial lakes on the lava tube interiors. The water proceeds in the artificial water path on the surface and provides water to the various plants and trees whilst getting purified. Later it is collected, purified and distributed to the complex.

Case Study: Ice House



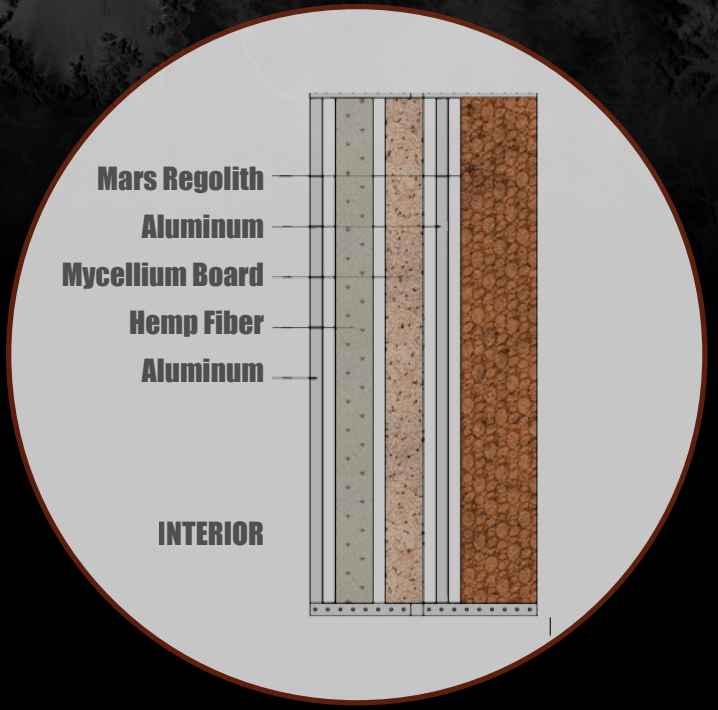
CONCEPT

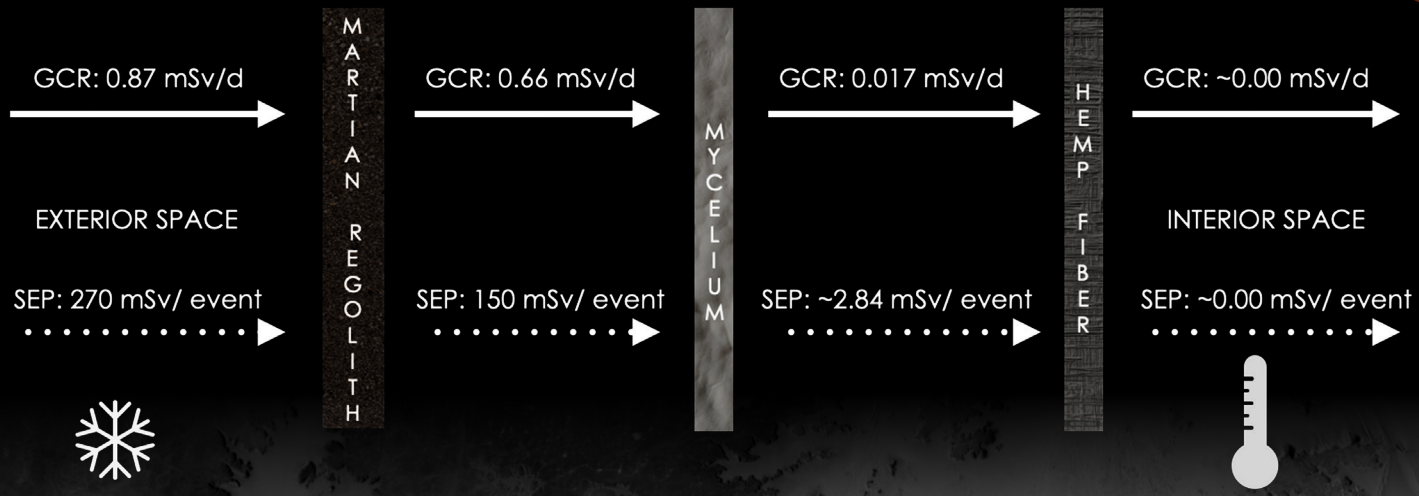
III. STRUCTURAL CONCEPT - HEMP COMPOSITES

PATENT NO: 2021/005449

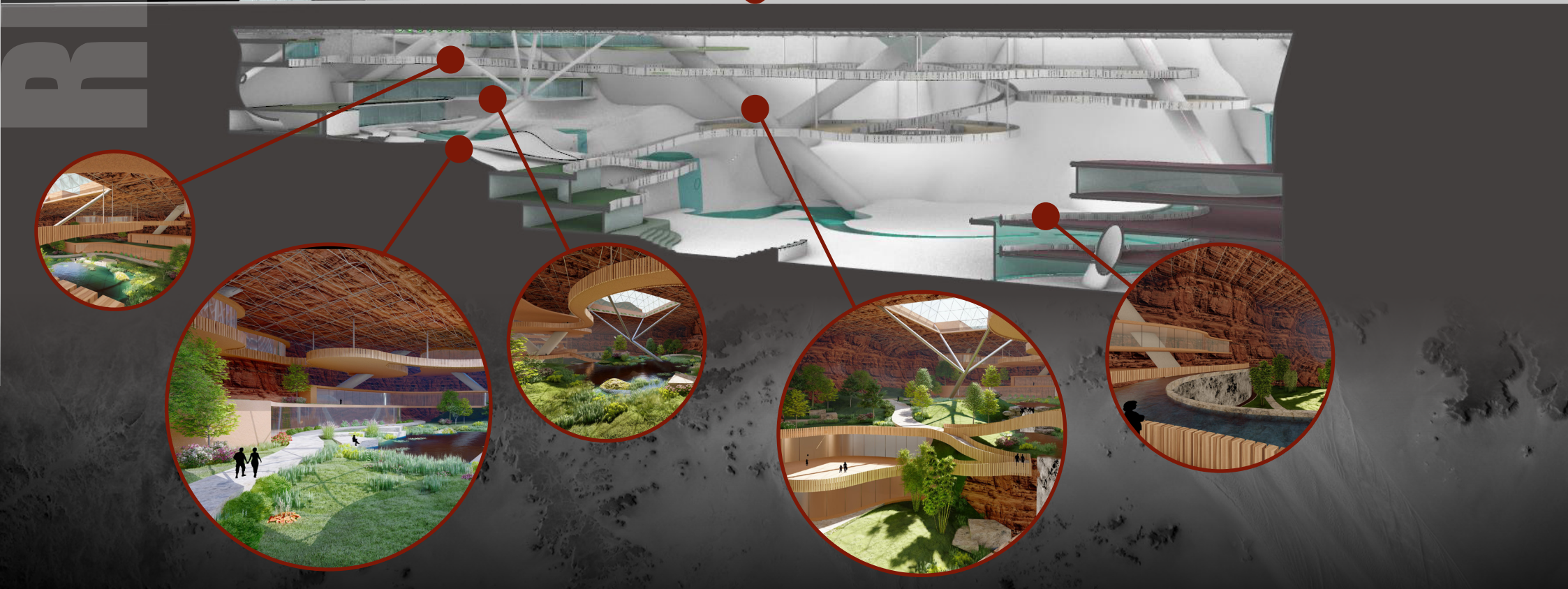
Use of ISRU materials have always been the main focus of the space exploration as it would reduce the transportation costs and be sustainable. The composite material used in this project also uses ISRU materials; martian regolith, hemp and mycellium. Those ingredients could be easily produced/collected on Mars which makes them sustainable, and they were theorically proven to reduce the deadly radiation levels to safe levels.

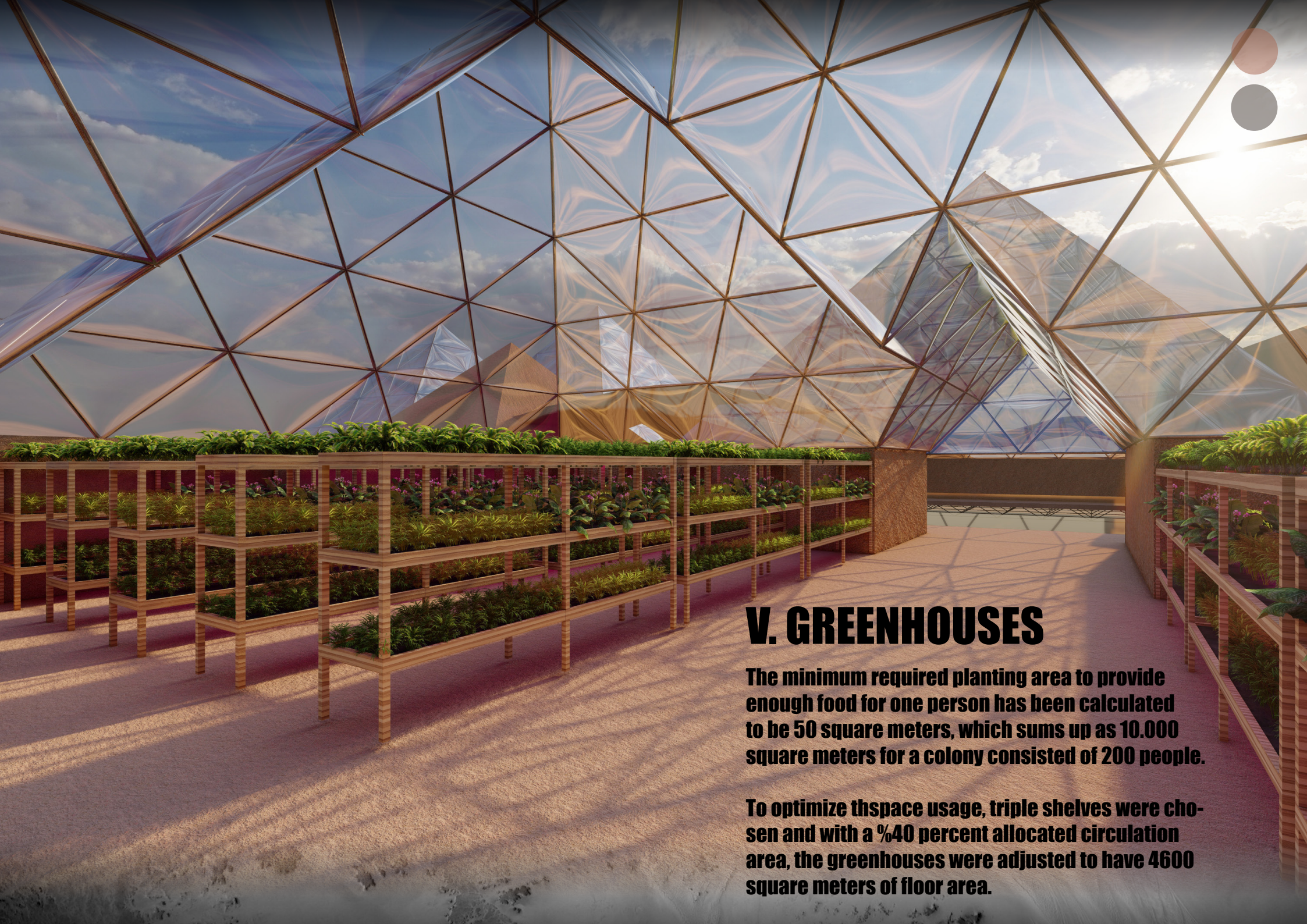
The composite has alternative application possibilities including 3D printing or being moulded/compressed. Though in either of the alternatives it is necessary to use aluminum layers to ensure the safety and ease the maintenance.





RENDERS



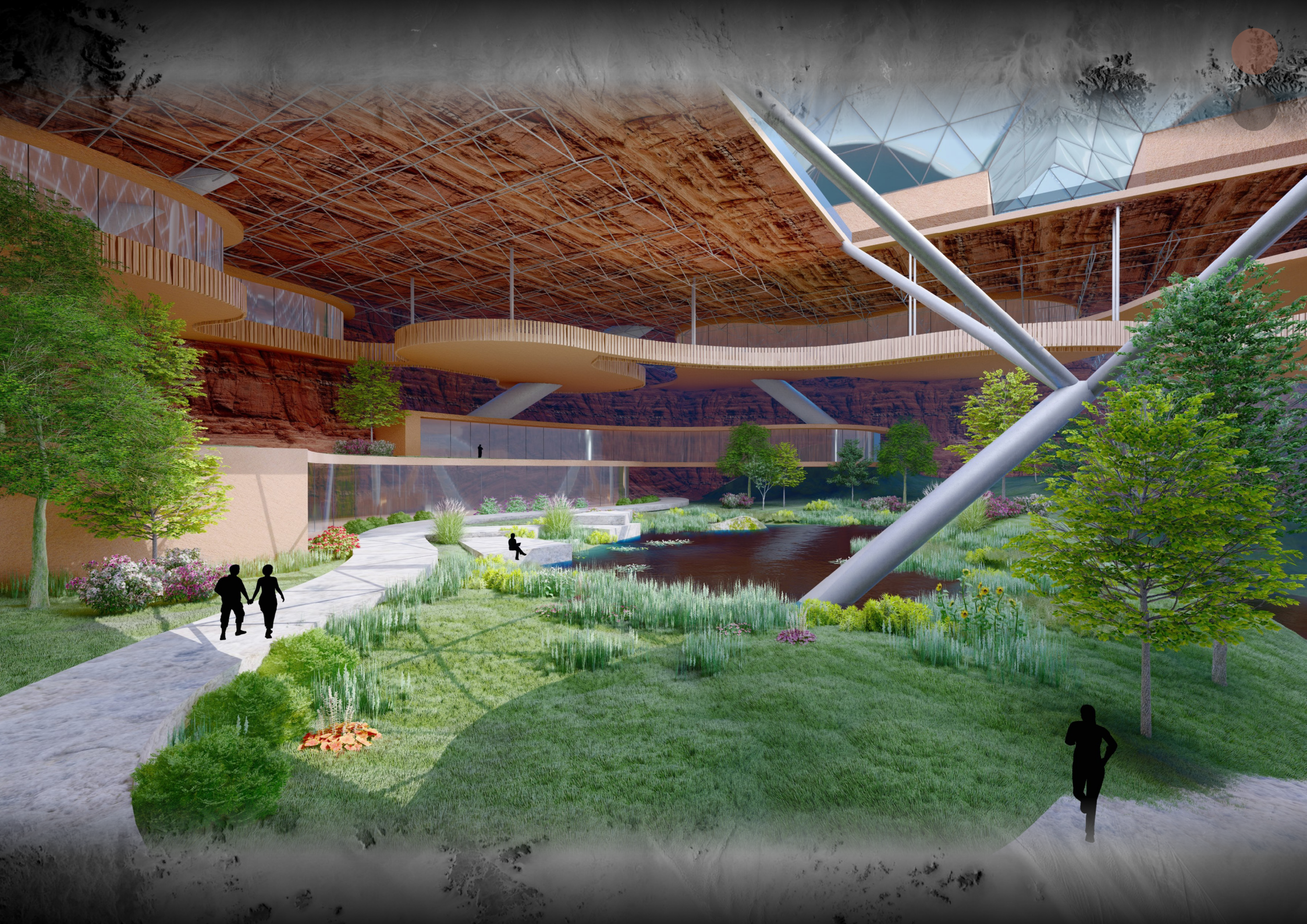


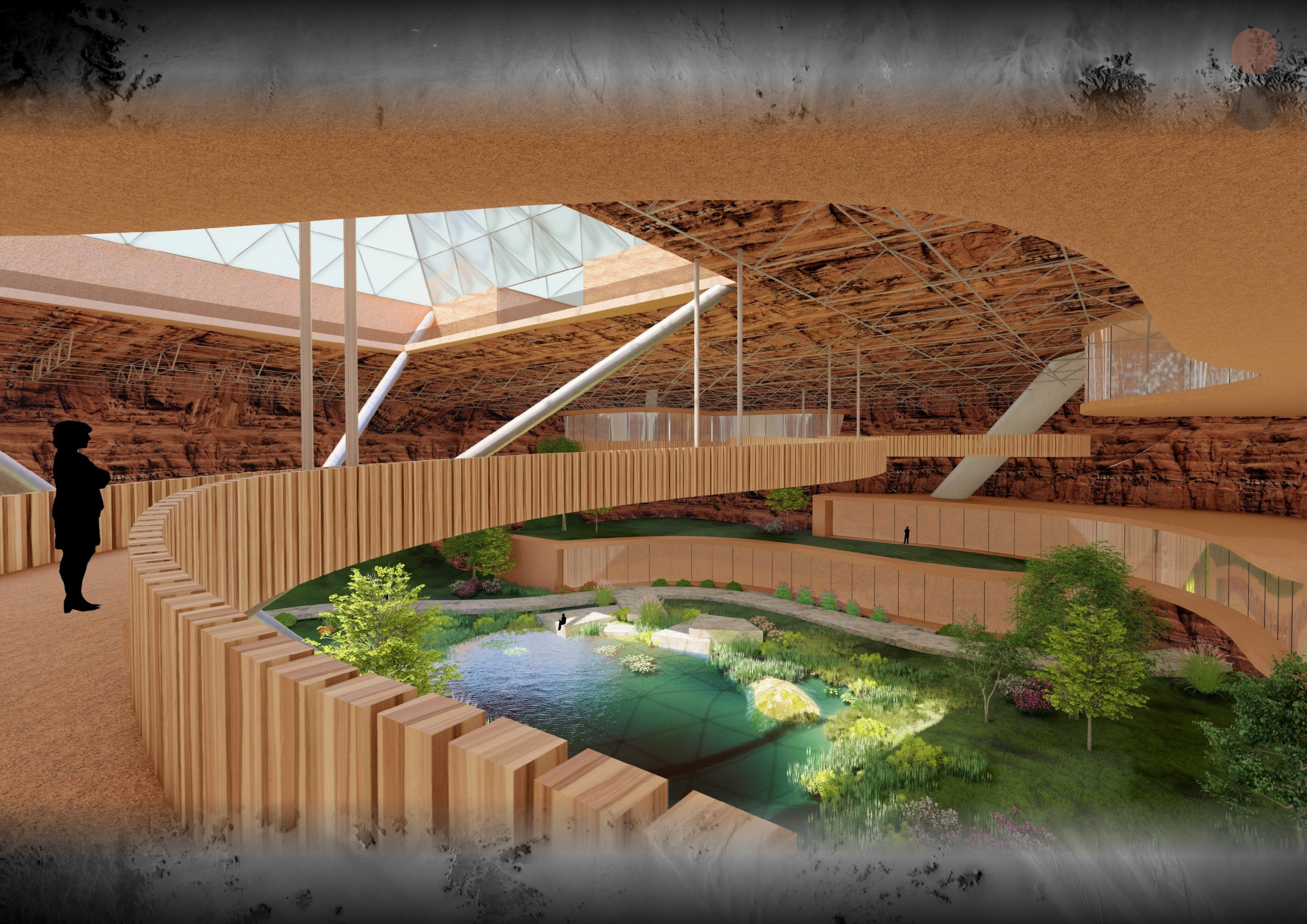
V. GREENHOUSES

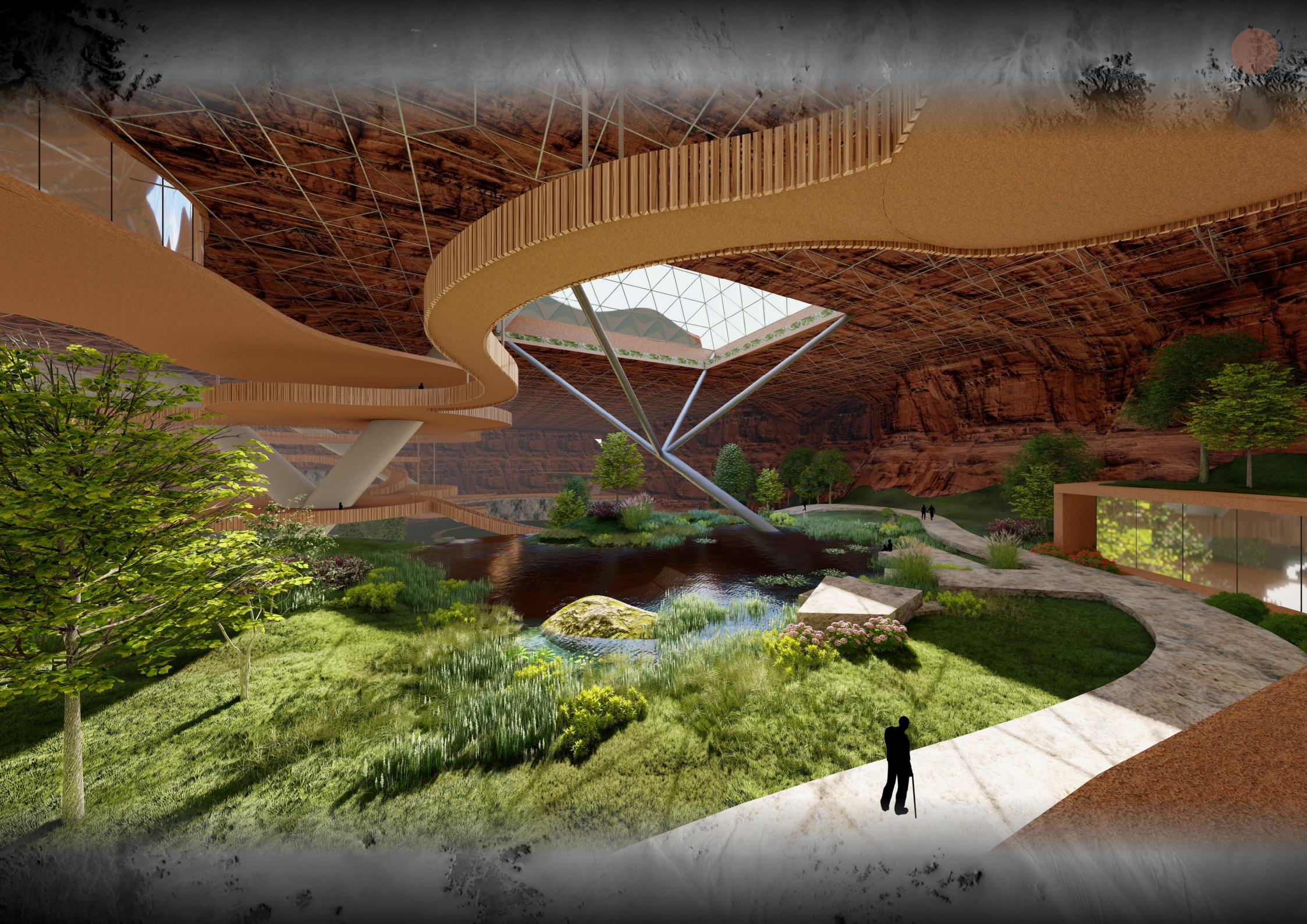
The minimum required planting area to provide enough food for one person has been calculated to be 50 square meters, which sums up as 10.000 square meters for a colony consisted of 200 people.

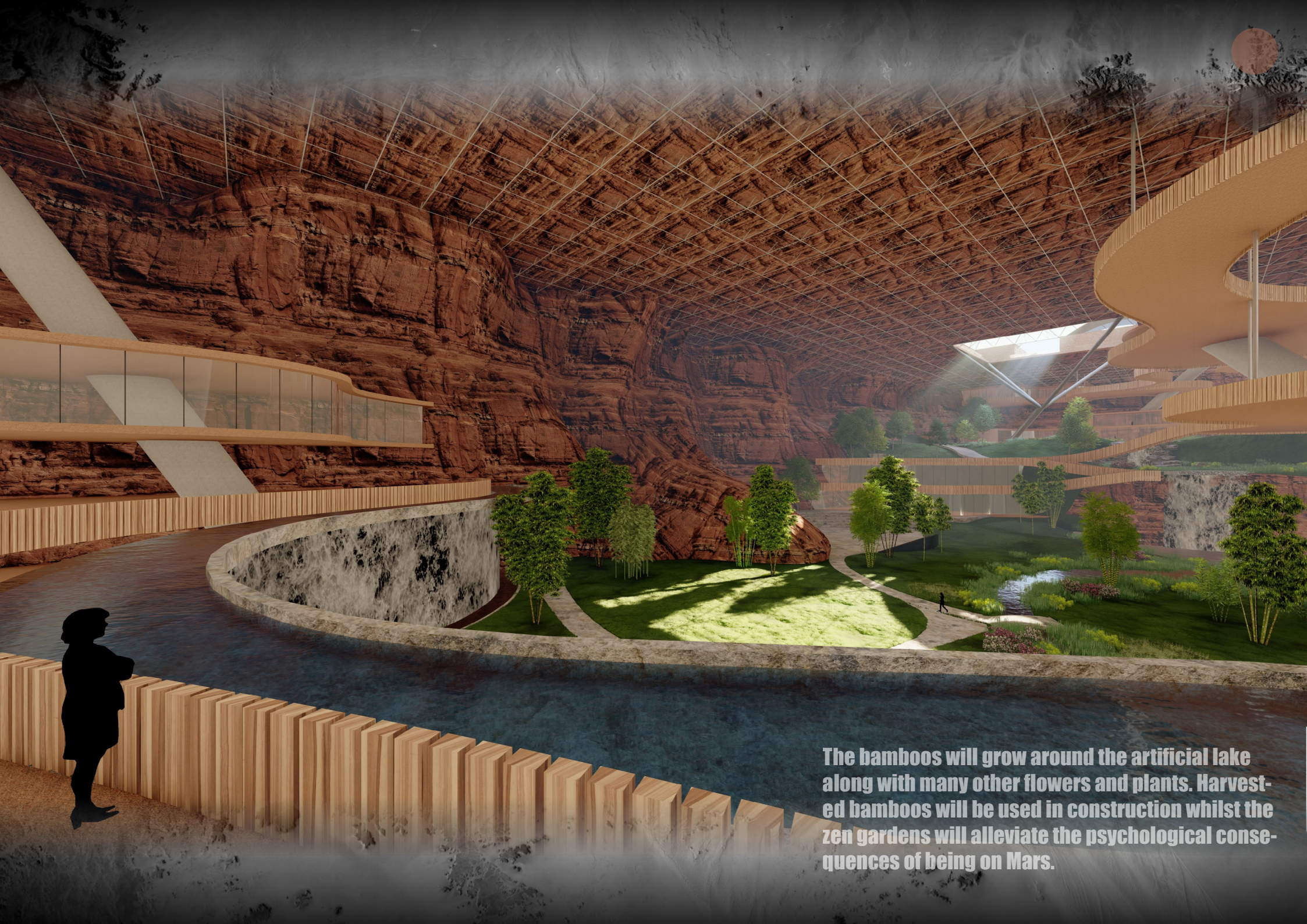
To optimize thspace usage, triple shelves were chosen and with a %40 percent allocated circulation area, the greenhouses were adjusted to have 4600 square meters of floor area.

Besides the edible plants, industrial plants such as industrial hemp, bamboo and mushrooms (for the mycellium) will be produced. Produced mycelliums will be used in arts and crafts workshops and provide the sustainability of the furnitures.









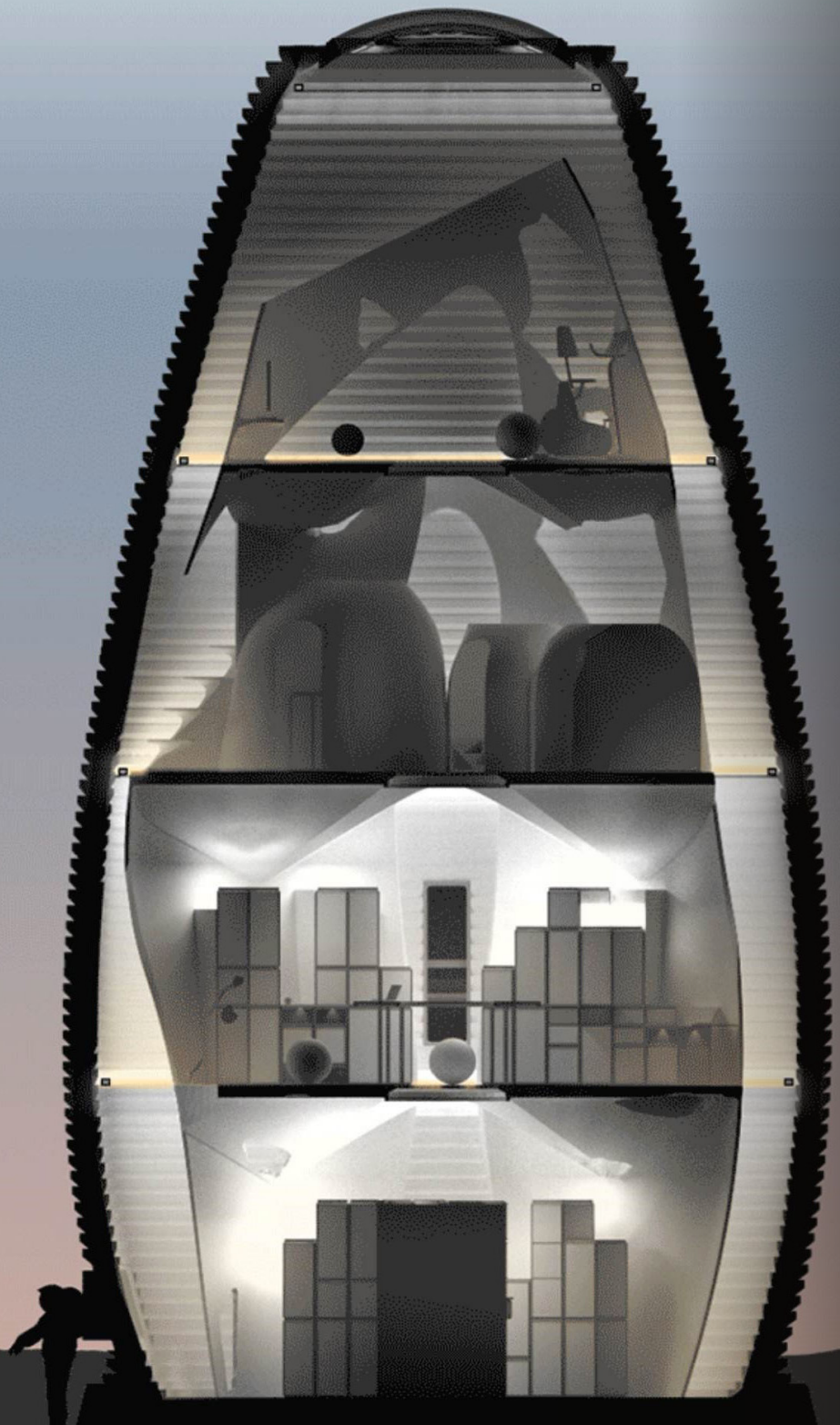
The bamboos will grow around the artificial lake along with many other flowers and plants. Harvested bamboos will be used in construction whilst the zen gardens will alleviate the psychological consequences of being on Mars.

MARSHA

Nasa Centennial Challenge - 1st Place Winner

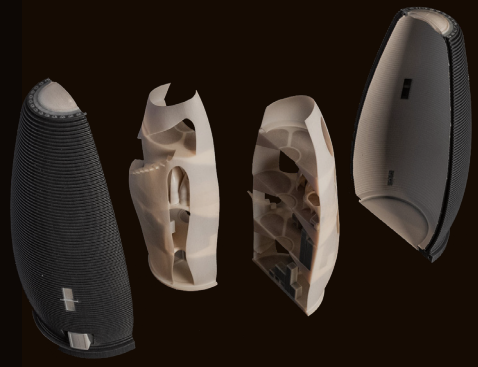
MARSHA is a 3D printed habitat project mainly focused on in-situ resource utilization. It suggests an innovative construction material composed of basalt fiber extracted from Martian rock and PLA which is a renewable thermoplastic that can be processed from plants grown on Mars. That innovative material is not only sustainable but also it could be 3D printed, is non toxic and provides high thermal insulation. It has also outperformed in structural tests and measured to be 2 to 3 times stronger than concrete.

CASE STUDIES



Within the NASA Centennial Challenge, the MARSHA Project has been built without human intervention and -except for its skylight- it was a success.

The 3D printed material was used in the outer shell of the habitat as an attempt to isolate the structural stresses from the habitable space.

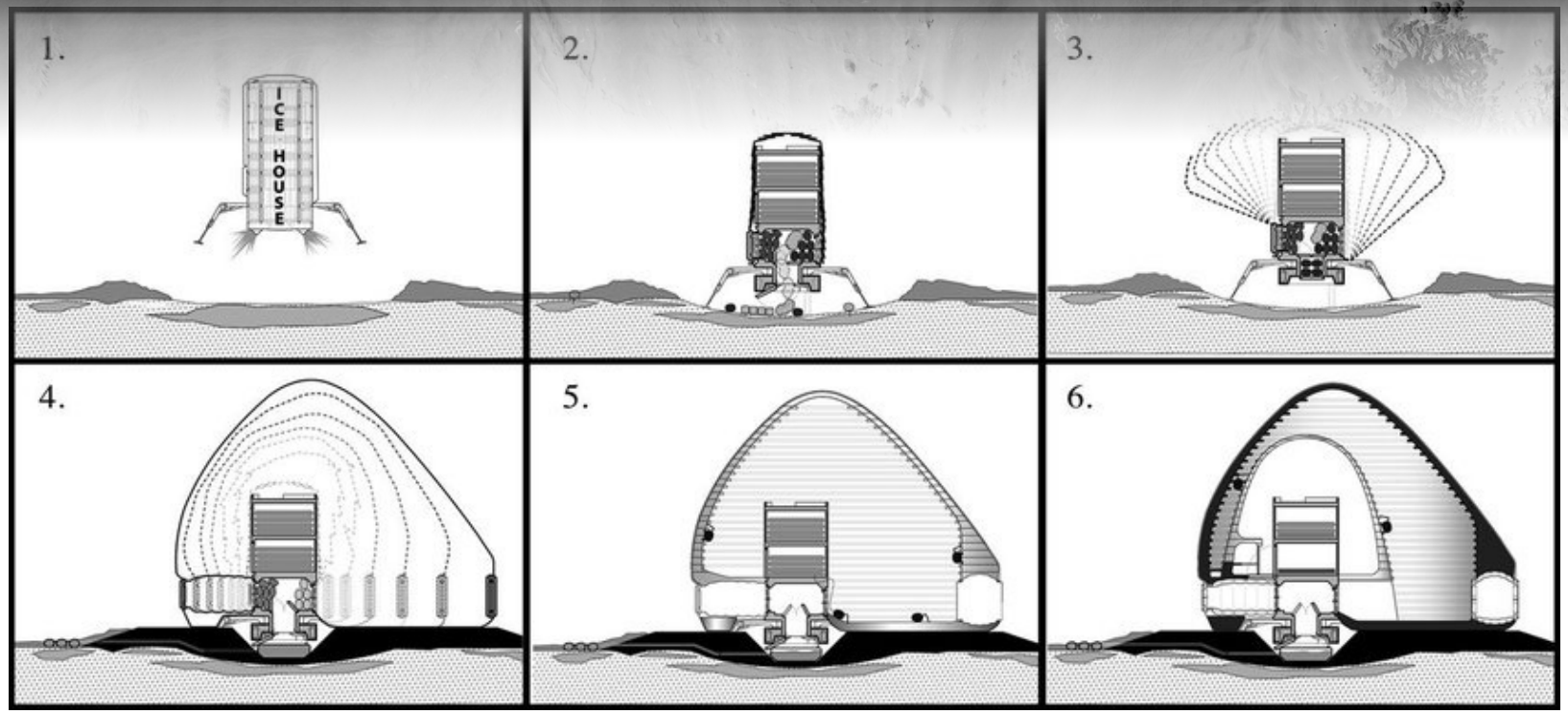


II. Mars Ice House

Nasa Centennial Challenge Winner

Mars Ice House is an innovative project designed by SEArch+ (Space Exploration Architecture) and Clouds AO for the 3D Printed Habitat Challenge for Mars. It has provided a new and innovative solution for ISRU material use within the framework of 3D printing.

The use of ice has allowed the design to allow the sunlight to the interior space while ceasing the radiation considerably.



The Mars Ice House Project proposed an inflatable translucent material brought from Earth to be pressurised and filled with ice. Along with the proposed construction technique, the design team also proposed alternative ways to harvest the ice from the soil. Due to the low atmospheric pressure on Mars, the ice sublimates when brought to the surface, and therefore could be harvested as water vapour, which is also partially purifies it.

Structure: