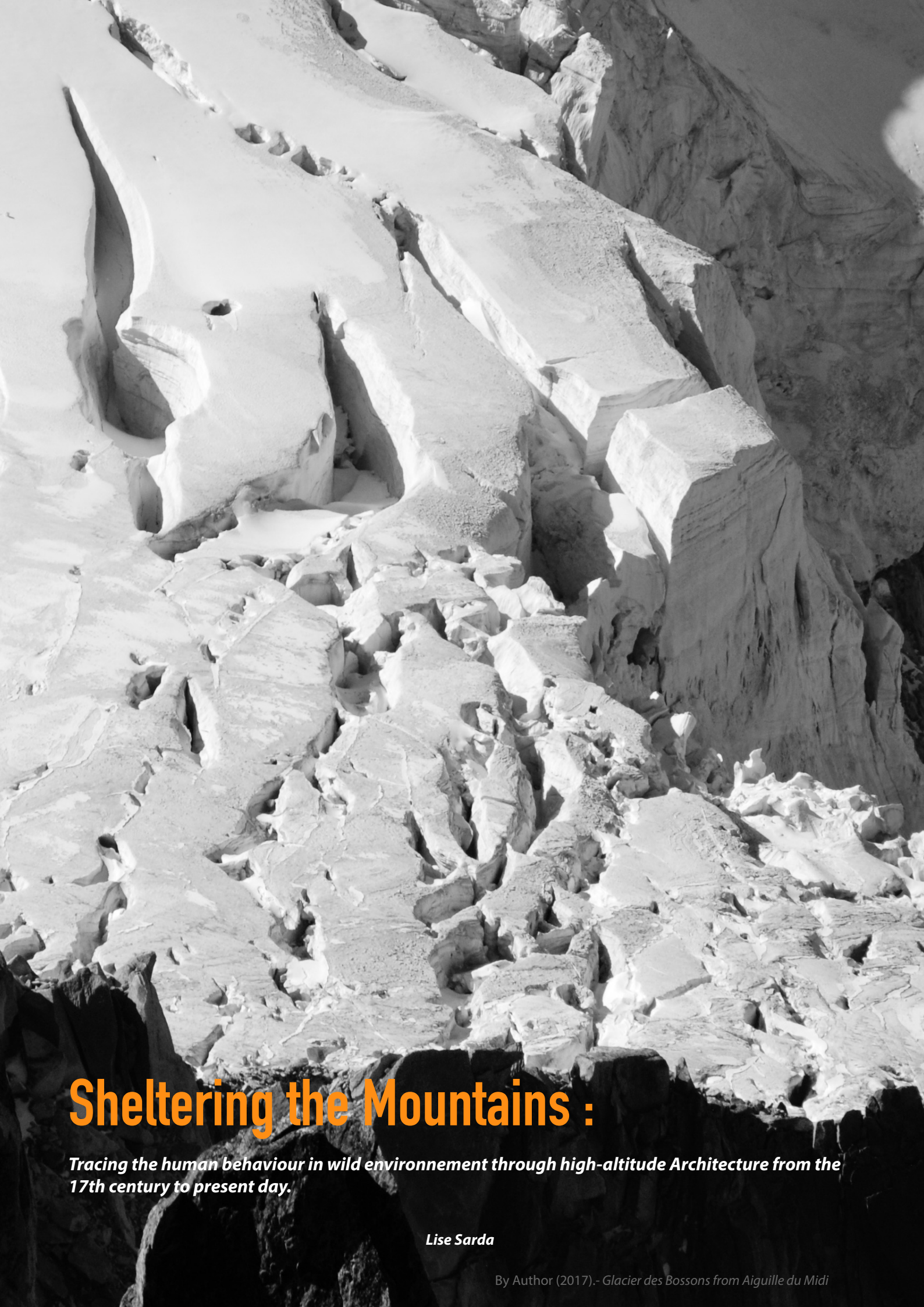

Sheltering the Mountains :

Tracing the human behaviour in wild environnement through high-altitude Architecture from the 17th century to present day.

Lise Sarda

By Author (2017).- *Glacier des Bossons from Aiguille du Midi*

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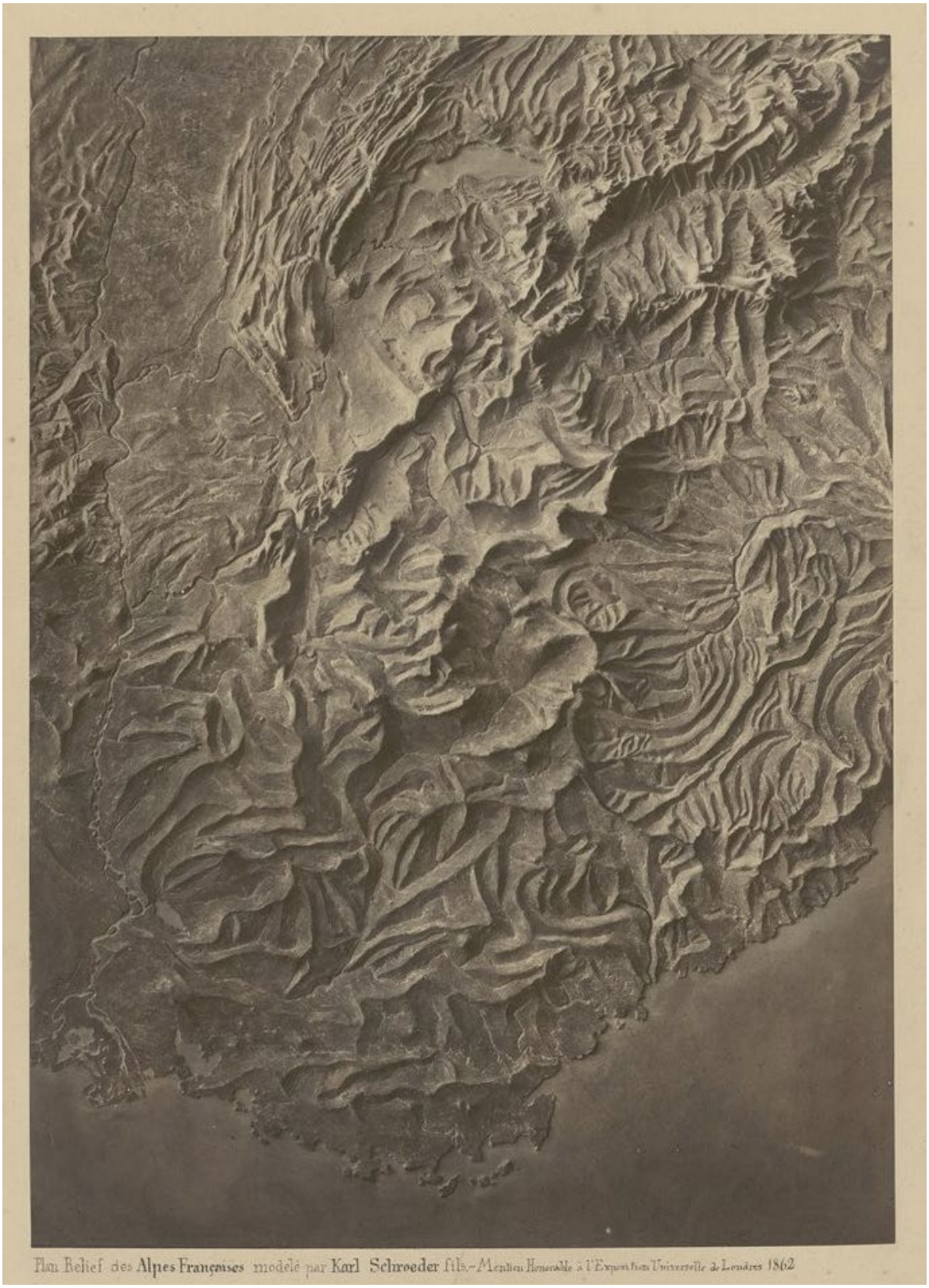
TU DELFT 2022/23
ARCHITECTURAL HISTORY THESIS
AR2A011 CATJA EDENS



Gallica .- *Plan Relief des Alpes Françaises modelé par Karl Schroeder fils. (Relief plan of the French Alps modelled by Karl Schroeder fils. Translated by Author)*

Tracing the human behaviour in wild environnement through high-altitude Architecture from the 17th century to present day.

By Author (2017).- *View from Aiguille du Midi*

Abstract

Sheltering the Mountains investigates and discusses the relationship between humans and the natural environment through the lens of high-altitude architecture. Focusing on a specific period from the 17th century to the present day, the research traces the development of architectural techniques used in extreme environments and analyses how they reflect and shape human behaviour towards nature.
Through an interdisciplinary approach that combines architectural and mountaineering history, environmental psychology, and anthropology, this thesis investigates the interconnections between architecture and human adaptation to the challenges posed by high-altitude environments. Drawing on a range of case studies, including mountain shelters, refuges and observatories, the research demonstrates how the Alps have become a tourist destination and its significance for our relationship with nature.
In addition to analysing the functional aspects of high-altitude architecture, this thesis explores the aesthetic and symbolic dimensions of these structures. It argues that architecture in extreme environments not only serves practical purposes, but also embodies cultural and social values, and reflects broader attitudes towards nature and the environment.
The research concludes by reflecting on the lessons that can be drawn from the history of high-altitude architecture for contemporary debates about sustainable architecture and the relationship between humans and the natural world. It suggests that a deeper understanding of the ways in which architecture and the environment interact can inform the design of more effective and sustainable solutions for evolving in extreme environments, and contribute to a more harmonious relationship between humans and nature.

Introduction

The research focuses on high-altitude refuges located in the Swiss, French, and Italian Alps as a testing ground for the proposed hypotheses. Rather than examining architecture alone, the research endeavours to study it through the lens of attitude towards nature. By exploring a distinctive architectural style that embodies the overall societal progression and a specific geographical area, the study aims to provide a deeper insight into the interconnections between these two domains. The present paper focuses on the potential for reciprocal interaction between architecture and human mobility, and their joint role in the development of society.

The Alps are not only a geographical feature of Europe but also a uniting symbol for the Alpine population. For centuries, these majestic mountains have captivated the imagination of adventurers and tourists alike. Their challenging terrain, awe-inspiring vistas, and alpine culture have all contributed to the evolution of mountain architecture and the development of mountain tourism.
The history of mankind in the Alps takes a turn in the 17th century when the mountain became a tourist destination. Previously, the Alps was an almost impassable geological frontier, a world apart and unfamiliar, the source of many legends and beliefs that kept people away from the peaks. Territorial wars, religious pilgrimages and trade in goods were the reasons why the mountain world developed in the first place. Roads were built (Roman Empire), and the first huts and hospices, were constructed around the most popular passes. Hospices are the first refuge-like constructions. Situated at a stopover on a route or on the way to a summit they were run by monks and offered shelter, food and assistance to travellers. A great example is the Hospice du Grand Saint-Bernard, built in 1050 and still in use today (S. Jouty, 2013).

In the 17th century, a cold wave hit Europe and had severe consequences for the mountain world. This little ice age brought the glaciers down to the valleys, destroying villages and making farming impossible. Life in the valleys became very difficult (Crauwels, 2021).
At the end of the 17th century, with the end of the little ice age and the beginning of the European Enlightenment movement, the mountain world has undergone a metamorphosis. The driving forces that have led people to venture to the peaks have evolved, from a will to conquer and discover to a way of escaping reality. The philosophers and farmers that were climbing the first mounts were replaced by hordes of city dwellers rushing by train or plane for a few days of fresh air and endless views of nature. Finally, the construction techniques modernised, leading to the emergence of buildings like spaceships on the summits of the Alps. These changes have had a profound impact on the region. The evolution of high-altitude Alpine architecture is closely linked to the evolution of tourism and mountaineering. The construction of mountain Huts, Cabanes and Refuges in particular, played a vital role in facilitating mountain appropriation. They provided shelter, food, equipment for mountaineers, and served as a meeting place for travellers and locals.

This thesis aims to explore the evolution of Alpine mountain architecture since the 17th century and its links to the development of tourism and mountaineering as a way of expressing the evolution of human behaviour towards the wild environment. The research will examine how the functions of Alpine mountain huts have evolved and transformed their architectural identity between the 17th century and the present day. Additionally, the driving force behind the expansion of mountain huts will be explored, along with the links that are established with their environment, and how this translated into architecture.

The Swiss, French and Italian Alps represent a perfect study area for this study. As all three countries share a common border within the Alps, in particular over the Mont Blanc massif, which was the first to attract tourism. On a geographical level, the Alps may appear as a frontier. On a societal level, it is common ground with similar extreme conditions uniting an alpine community with similar values and concerns. Switzerland, France and Italy's high-altitude areas have had a similar development through the years, underlining the unity created by the living conditions of such an environment and the universality of thought around the exploitation of these areas. High-altitude refuges emerged with the beginning of alpine tourism and have fuelled it ever since. According to Susanne Stacher (2018), the principle of the Sublime marks the beginning of tourism and explains the evolution of the 'Why do we go into the mountains?'. The Sublime is a feeling awakened by a deep rapture mixed with terror or suffering. This feeling awakens the soul and leads to

deeper reflections. Conscious from the beginning of the 17th century, the association of this Principle with the ascent of a mountain coincides with the economic transition of the Alpine regions: « from agropastoral economy to a leisure economy » (Lyon-Caen 2003).
This new economy of leisure is based on a new perception of the world during the Age of Enlightenment and the desire for discovery and scientific understanding. Stacher attributes this change in perception and thirst for discovery, particularly of mountains, to the reconsideration of human existence following the collapse of geocentrism: «The great mountains help to make it clear that the earth is really a celestial body suspended in the ether […]. » (Théophile Gauthier 1811-1872). The pursuit of truth by scientists and the quest for the sublime by intellectuals and artists have transformed the high mountains from a shunned territory to a destination of choice that inspires and captivates many. Architecture and tourism are co-dependent in the high mountain realm. Nourishing and expressing themselves through each other, they allow us to understand the evolution of man's relationship with the mountain and more generally with nature: at first terrifying and all-powerful, it becomes an inspiring spectacle, a way for man to refocus and understand his condition. This phenomenon is very recognisable within architecture: from radically vernacular to technological landscape architecture.

The research will involve a comprehensive study of the existing literature on high-altitude architecture and the relationship between mountains and tourism. It will also involve an examination of primary sources, such as historical pictures and narratives, to provide a detailed analysis of the evolution of mountain architecture. For each stage of its development, the situation of the refuges and their transformation will be explored, to highlight the links between architecture and tourism, architecture and science, architecture and environment.
The study will begin by examining the origins of high-altitude Alpine architecture and the emergence of mountaineers in a first chapter. It will explore how and why the first huts were constructed and how they participated in the colonisation of a new world. How the architecture of refuges has been influenced by their natural environment. The study will then examine in a second chapter how the creation of Alpine Sports Societies impacted the high-altitude areas and how they contributed to creating an alpine culture around the refuges. Finally, in a third chapter, the thesis will explore the driving force behind the modernisation of refuges and their role in the expansion of new technology in architecture. This will involve examining the economic, scientific and social factors that have contributed to the growth of mountain tourism and mountaineering and how they impacted the identity of refuges.

This paper will provide a comprehensive analysis of the evolution of high-altitude Alpine refuges and their links to tourism and mountaineering as a way of expressing the evolution of human behaviour towards the wild environment. The study will contribute to a deeper understanding of the history and cultural significance of the Alpine mountains and the role that architecture has played in shaping this unique landscape.

Fig. 1 IALPS Mountain Museums. (2020, 26 novembre). Ospizio del G. S. Bernardo E. Gonin dis. e lit. - IALP Mountain Museums. IALP Mountain Museums. https://www.mountainmuseums.org/fr/items/ospizio-del-g-s-bernardo-e-gonin-dis-e-lit/

Fig. 2 Agassiz L., 1840.– Études sur les Glaciers. Ouvrage accompagné d'un Atlas de 32 planches, Jent et Gassmann, Neuchâtel-Soleure.

Chapter I/ Discovering - 17th & 18th century

Humans have been active in the mountains since the earliest times. Archaeological evidence can be found from Roman antiquity to the Palaeolithic period. However, the conquest of the peaks is a recent concept in the history of humanity. It was at the end of the 16th century and definitely in the 17th century that the interest in the high mountains realm as of interest to discover was established in people's minds. This chapter seeks to trace the forces that brought people to this unknown and terrifying world. And to explore how these pioneers interacted and found shelter in their environment. In a second part, the paper will explore the shift in attitude from a discovery to a race for colonisation.

1.1 Sheltering the First Ascensions

. The Enlightenment, the Emergence of the Sublime

In the 17th century, the idea of geocentrism, the physical model of the Earth as the centre of the universe, was challenged. This reversal in the conception of the Universe itself leads to questioning the status of humans and everything they believe in, « The Earth is united by universal bonds to a moving cosmos that knows nothing outside itself » (S. Satcher, 2018). In particular, a new look is taken at the 'wilderness'. From appalling, it is brought to the forefront of aesthetics. The new heliocentrism is the foundation for the quest to understand the 'new world'.

The Enlightenment philosophers were the first to venture onto the uncharted paths of the mountains. They intended to overcome obscurantism and intolerance to achieve happiness, knowledge and freedom. Faced with a new perspective on man's place in the Universe and the scientific progress of the time, the human mind started to free itself from theological and formal constraints to take an interest in nature (Larousse, n.d.). This new approach to the search for knowledge led the philosophers to venture where others had never gone before. The deep oceans, the distant deserts or the high mountains. The writings resulting from these experiences describe, among other things, sensations enhanced tenfold by the physical difficulty of the exercise and a great openness of mind brought about by the image of infinity and wilderness.

The peaks and the infinite sensation brought by the landscape stimulate the intellect. The physical difficulties of the ascent help to reflect on the world on our condition as humans. Carried by the New Science movement, the mountain becomes a symbol of freedom, in contrast to the appalling appearance that surrounded them until then (S. Satcher, 2018). A key concept was emerging, thanks to the work of John Denis in 1693 in particular: the 'Sublime'. This is the first time this concept, formulated as early as 1600, has been applied to the contemplation of nature (S.Satcher, 2018). The Sublime is a conflict of feelings. Contrary sensations are encountered when confronted with 'wilderness'. This principle makes the « link between enthusiasm and reason, an enchantment heavy with tension » (S.Satcher, 2018). The Sublime gives a sentimental, artistic and gradually scientific reason to the Mountain. In particular the high mountains.

Soon scientists and artists followed the movement, inspired by the tales of the philosophers like '*La nouvelle Eloïse*' written by Rousseau (1712-1778). They were in search of new inspiration from this new world in which shapes, colours, and sensations felt like a never experienced Alpine life (Lyon-Caen, 2003). Or, driven by their thirst for knowledge, scientists were obsessed with studying the effect of altitude on the human body and searching for answers for events formerly attributed to dark or divine forces. What are the limits of the Body? Expeditions over several days took place to observe diverse phenomena. Mountains became a laboratory (Dini & Girodo, 2018). It is through these scientific expeditions that the first huts were built.

Thus, the cultural upheavals of the time drove the first brave souls to the summits of the Alps. It was a wave of curious people who wanted to discover a new world. This gave rise to a movement of arduous scientific research following the Enlightenment mindset, wishing to explain all phenomena. They had to face their fears and sought shelter to test the limits of Men with a scientific approach.

. Shelters

When the philosophers ventured into the mountains, it was an uncharted world. Many questions were unanswered: can human beings survive at high-altitude? What about spending a night in the snow and ice? The thirst for knowledge, however, was greater. Some, such as Jacques Balmat on his ascent of Mont Blanc in 1786, adventured to set up camp in the mountains, proving to the world that it was possible to survive the spirits of the high mountains (Camanni, 2005). Subsequently, the first solid shelters were built in Swiss and Italy, to accommodate overnight expeditions of scientists (Dini & Girodo, 2018).

Horace Bénédicte De Saussure (1740-1799) is an important figure in the development of the first shelters and the exploration of the mountains. The Swiss physicist and geologist cultivated a passion for the very mountains he grew up in. His ascents enabled him to carry out a thorough meteorological, botanical, geological and biological study of the Alps. To rest during his explorations, he had some of the first refuges built, like the mythic refuge des Grands-Mulets built in 1786. Located on the Mont Blanc trail, it was not unlike the modern building that can be seen in the same spot nowadays. Rebuilt several times over the centuries, it was originally a simple cave with two walls of stone cut to close the space. A simple roof protects it against the elements. This very primitive architecture reflects 'the most basic technical and distributive functionalism' as described by Dini & Girodo in their book *Shelters in the Night*, 2018. The hut is very cramped and is only intended for resting during the ascent of Mont Blanc. The location of the hut is essential so that it is protected from the weather. The small size of the hut provides a unique space for sleeping and eating (Refuges, n. d.). The spartan appearance and lack of comfort are derived from the need for quick and simple construction, using few or only locally available materials. Considering the harshness of the climate and the intensity of the weather conditions involved in the high mountains. Built by scientists or mountaineers, the huts are primitive and do not survive in time. They are merely a shelter in the immensity of the New World that is being conquered. Characteristic of the beliefs of the time, the typical hut had few or no openings, thus cutting off all contact with the outside world. Bureau, in 1977, explains the need to recreate a space free of the chaotic surroundings and of the night that is charged with mysterious power against which one must defend themselves.

The typology, appearance and construction methods of high-altitude refuges are conditioned by the unknown that characterises the alpine world and the particularity of the climatic and geological conditions of the region.

Fig. 4 Joseph Mallord William Turner, 1810.- *La Chute d'une Avalanche dans les Grisons.*

Fig. 5 Caspar Wolf/ProLitteris, 1775.- *Glacier inférieur de Grindelwald, la rivière Lütschine et le Mettenberg.*

1.2 Huts

. Conquering Mont Blanc

The resonance of Horace Bénédicte De Saussure's explorations led to the « invention of the Mont Blanc » (Stephen L., 1871). It seems difficult today to imagine that such a mountain would have gone unnoticed, although it was not named until 1742 and was not then considered the highest mountain in Europe (Joutard P., 1986). Rousseau, on the other hand, initiated a « worship of the Alps » (Stephen L., 1871). The publications on wild nature, the sublime mountains, scientific research from the first Alpine travels and the impact of De Saussure's ascent of the Mont Blanc led to a changement of sentiment toward the Alpine region. This change can be placed around the years 1760 and initiated tourism. The stories and paintings depict grandiose landscapes and powerful effects on the body and mind like in *La Nouvelle Éloïse* in which Rousseau describes « the influence of nature over the spirit » (Stephen L., 1871).
It is mainly the prospect of an unexplored world, free of human influences and where everything is to be done, that transformed the Alps into a 'public playground' for travellers as Stephen L. characterised it in *The Playground of Europe* in 1871.

The spectacular sight of the glaciers flowing down to the valley was the reason for many trips and the first permanent refuges were built. The 'Temple de la Nature', built in 1795 at Montenvers at the foot of the Mer de Glace which descends into the Chamonix valley, was the first stone and wooden refuge (Centre Fédéral de Documentation, n.d.). A « dwelling that offered scholars, naturalists, painters, travellers of all classes and all nations a safe haven » as Marc-Théodore Bourrit described his project in 1794. The travellers of the time were aristocrats and artists, mainly English, who travelled for long periods throughout the Alps (Crauwels, 2022). This construction served as a prototype for all later iterations of refuges (M. Jail, 1975).

The most adventurous attempted to climb the top of Europe, the newly discovered Mont-Blanc. A race to conquer has begun. In the 17th century, the English were the first mountaineers in the Alps. They were the first to climb Mont Blanc in 1786, as well as several important Alpine peaks in Switzerland and Savoy (Jail M., 1975). The Alpine regions, in their turn, set out to conquer the mountains, fearing that each ascent would be attributed to the English.
Thanks to the improvement and expansion of ever-faster transport networks, and the promotion of the mountain experience throughout Europe, the Alps became more popular.

As more and more people attempted to ascend the mountains, a new need for shelters arose. The first huts of the 17th century, which had to be rebuilt from one year to the next and which could only accommodate an extremely limited number of people, were no longer adapted. A new type of refuge then stands out. A solid building, made of wood carried up from the valley on the backs of men and donkeys and anchored to the mountain to resist strong winds. For the most accessible ones, stone refuges were made out of rocks cut on the spot. It could accommodate up to ten or twenty people in a single rectangular room measuring around 5 by 7 metres, which also contains a kitchen and storage area (La Pierre d'Angle, 2021).

Many of these huts are built on the various paths of Mont Blanc and its massif. They were built under the direction of the Chamonix guide company and the municipalities (Centre Fédéral de Documentation, n.d.). Napoleon also had six refuges built in 1860, remembering the difficulties he had encountered when crossing the Alps.

With the discovery of the Alps, men sought to explore and understand a new environment, full of myths and legends. This commitment soon turned into a conquest, a battle of egos between mountaineers from different countries.

Fig. 6 *IALPS Mountain Museums. (2020a, août 26).- Le temple de la nature au Montenvers et Aiguille du Dru - IALP Mountain Museums.*

Chapter II/ Imposing Power - 19th & 20th century

In the 19th century, the conquest of the Alps continued. Between the conquest of new summits, the expansion of the developed area and the popularisation of the mountains, the 19th and 20th centuries can be associated with power. Man is more and more present and seeks to impose his position in the wilderness. This second chapter seeks to explain how the Alps became a mass touristic holiday destination, and the consequences this new development brought on high-altitude architecture.

2.1 Alpine Sports Societies

. Their Goal

The 19th century saw many technical advances, particularly in the field of transport. Governments invested in the construction of new roads and railways. This democratisation of express travel, as well as the trips of personalities such as Napoleon III to the Alps, gave rise to a general infatuation with the mountains (Jail M., 1975). Access to which was no longer limited to aristocrats. The quest for new summits and the growing appeal of heights made mountaineers take more and more risks, seeking to conquer the most difficult routes or the highest summits. After a few major accidents, such as the one on the Matterhorn on 14 July 1865, individualistic mountaineering lost its intensity, leading to a desire to combine efforts to conquer. In reaction to this feeling, Alpine Sports Societies (ASS) were founded in all regions of the Alps from the 1860s onwards (Jail M., 1975).
They had different statutes depending on the country and the century, but their aim and what united them remained the same: « to encourage and promote knowledge of the mountains and their individual or collective use in all seasons » (Centre Fédéral de Documentation, n.d.). These ASS are therefore focused on the mountain as an environment and not on a specific sport. The English Alpine Club was the first to be created in 1857. In the early days of mountaineering, it was the English who popularised the practice, soon followed by the Swiss in 1863, not content to see the English take credit for the conquest of many of their country's peaks. The Italian Alpine Club also opened in 1863, followed by France in 1874 at the initiative of A. Lemercier (Centre Fédéral de Documentation, n.d.). France was the only Alpine Club to have included women from the start. The creation of Alpine Societies was partly driven by the growing importance of sport in the context of a sedentary, urban life, where during the industrial period doctors prescribed spending time in the fresh air and the mountains (Stacher S., 2018).

The main tasks of the Alpine Sports Societies are the creation of marked trails, the opening of new routes to the summits and the construction of Refuges. These works make the mountains accessible to a larger part of the population. Apart from the Mont Blanc massif, the Alpine mountains are still largely unexplored. Thus the process of mountain appropriation made it possible to lay the foundations for safety and supervision in the use of the mountain territory, allowing a more controlled development of high-altitude alpine sports (Centre Fédéral de Documentation, n.d.). A process of appropriation of the mountains is launched through this management of the mountain and race to conquer the summits (Stacher S., 2018).

The mountain, through its recent exploration, is developing at a different speed compared to the rest of the world. The architectural form and techniques are primitive, and human relations change in response to the exceptional nature of the place. As Dini & Girodo explain in 2018 in their article *Shelters in the Night*, there is no relevant housing model or building heritage of any kind on which the construction methods could be based on for the realisation of high-altitude refuges. All materials have to be carried up on the backs of men or mules and the construction time needs to be short as the climatic conditions are only favourable for a few months in summer. Thus, each new refuges is an achievement for the Alpine Societies. There are many points to consider before building: the location must be protected from the harshest elements, avalanches or landslides, to ensure its longevity. Wood and stone are always preferred. Wood has to be transported to the site, but it allows the space to warm up quickly as soon as the wood burner is lit, due to its low inertia. The stone can be carved on site but keeps the humidity and cold inside.

Fig. 7 *Bibliothèque nationale de France, département Estampes et photographie,(1986).- Recueil Vues du Dauphiné & de Savoie (Refuge de la Lauze)*

. The Multiplication Of the Number of Shelters Across The Alps

The refuges, which were then unguarded and open to all, were built one after the other, so much that before 1914, already 500 refuges, i.e. half of the refuges we find today, were built. It is a single room with a straw bed, a stove to keep warm and a simple table (Jouty, 2013). Mountaineers bring their own food prepared in the valley and sometimes leave goods such as wine for the next.
This reflects the 'Alpine mindset' of mutual support. A natural feeling that develops through the intensity and reality of the dangers of the wilderness. The difficulties encountered at altitude, such as extreme cold, strong winds, avalanches and landslides, seem to dissipate when you meet in the refuge. This confined space is where you are close to each other and exchange knowledge and experiences.

Between the various Alpine societies, a construction race is underway. Who builds and where? The impulse towards nature promoted by these societies is transformed into a « fight for the appropriation of nature » (Stacher S., 2018) through a network of paths and refuges. Some are built side by side, no longer taking into account the facilitation of mountaineering but simply the conquest of a territory.

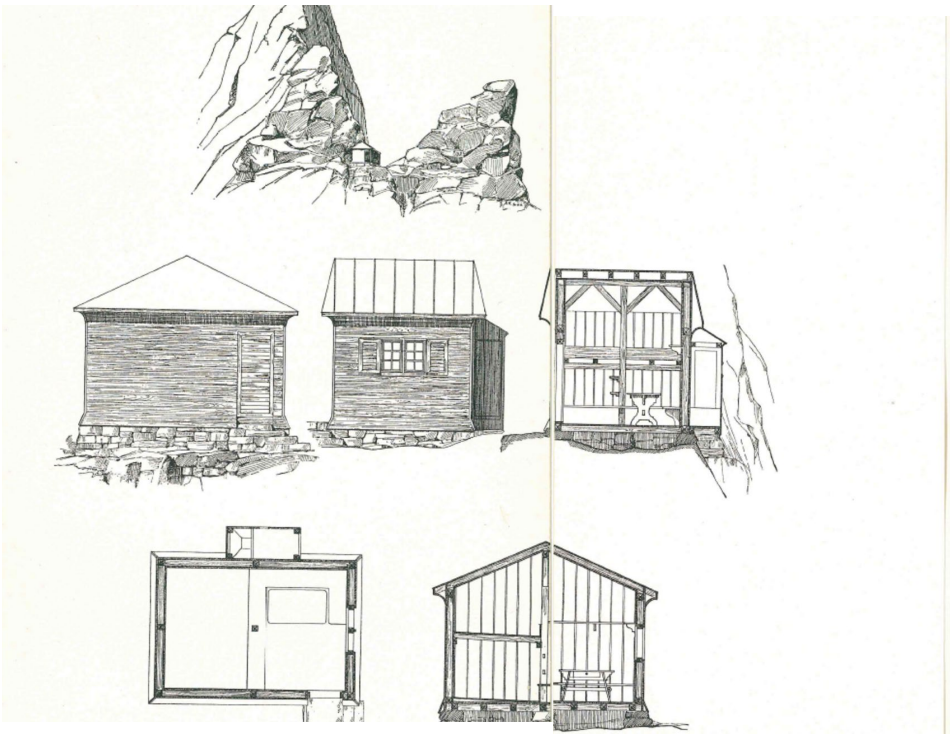
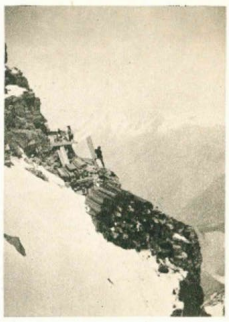


Fig. 8 (Kalbermatten Architects Archives, 1915).- *Refuge Solvay at the Cervin (4000m),* Plan , sections and elevations

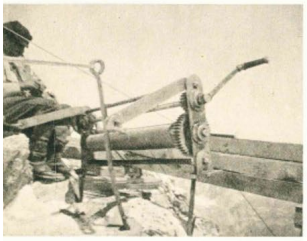
Ascension des poutres.



Au départ du point IV.

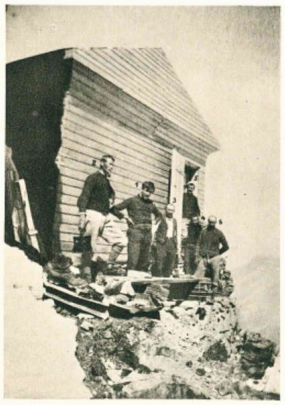
REFUGE SOLVAY (4000 m.) le 15 sept. 1915.

REFUGE SOLVAY, le Thé de la fin.



Au point VII, le treuil sur l'emplacement du Refuge.

Arrivée des bois sur la terrasse du Refuge.



REFUGE SOLVAY, 17 sept. 1915
L'équipe complète.

Signature des travailleurs.

Oscar Supersaxo, guide et entrepreneur.
1. Adolf Itten, charpentier.
2. Gustave Imseng, guide.
3. Roman Anthamatten, guide.
4. Hyeronemus Lohmatter, guide.
5. Emanuel Burgener.
6. Aloïs Lohmatter, guide.
Cyrill Supersaxo.

REFUGE SOLVAY au Cervin (4000 m.)

Architecte : M. Alphonse de Kalbermatten, C. A. S.

Phases de la construction et du transport des matériaux.

PHOT. E. DUNANT ET F. LANGENBERG.

Du point II au point III (voir page 40).

Des bois montants.

Matériaux quittant le point IV.

Empilage des bois au point III.

Fig. 9 & 10

(Kalbermatten Architects Archives, 1915).- *Refuge Solvay at the Cervin (4000m),* phases of construction and transportation of the materials.
This document shows the way materials where brought on the site of the highest refuge constructed in the Alps in the 19th century, without the use of helicopter. Seven waypoints were used to bring the wooden structure up to 4000m.

Fig. 11 (Kalbermatten Architects Archives, 1915).- *Refuge Solvay at the Cervin (4000m),* Photography of the workers on the construction site.

. Bivouacs

In parallel with the development of refuges, from 1925 onwards, bivouac refuges were built as a complement. They were placed on long and less touristy routes. Their functioning and typology are similar to the huts that could be found in the 18th century (La Pierre d'Angle, 2021). Very cramped and unguarded, they consist of one or two rooms for sleeping, cooking and dining. These bivouac refuges offer the experience of the 'first mountaineers'. In Italy in particular, in the 20th century, the engineer Giulio Appollonio had about 220 of these huts built, which he had designed. A 4 square metres shed, 1.25 metres high with an arc-shaped roof covered with a bright yellow colour. Barely able to house 5 people inside, it is prefabricated in zinc-coated sheet metal lined with wood on the inside and secured by cables to the cliff (Jouty, 2013).

At the end of the 19th century, a particular type of bivouac was erected. The « peak hut » (Dini & Girodo, 2018). Built near or on the top of mountains, they served only to signify the conquest of the peak in question. Indeed, they did not fulfil the primary purpose of the typical hut « but were conceived as a permanent stronghold and a sign of man's conquest and, [...] a privileged panoramic viewpoint […] » (Dini & Girodo, 2018).

Fig. 12 Bivacco Gino Revelli 2610 m | GEAT CAI TORINO. (s. d.). https://www.geatcaitorino.it/bivacco-gino-revelli-2610-m/

2.2 Touristic destination

. Refuge Adaptation

To secure and develop the Alpine space for sports activities, a progressive 'taming' of the Alpine space is being initiated by the ASS. This led to the widespread settlement of high-altitude real estate. In the 1960s to 1980s there was an unprecedented infrastructural expansion as a result of the post-war economic boom. Mountaineering Societies became the main tourist accommodation organisations in France (Dini & Girodo, 2018). Trails were laid out, refuges were built, and transport was pushed to its limits. In Switzerland, trains or cable cars are sometimes built right on the glaciers (J. Schwerzmann, RTS 2014).
These new means of transport, faster and more diverse, bring a flow of tourists to the highest and most remote mountains.

The attraction to a seemingly wild world isolated from human society is the main vector for its flow. After three centuries of mountaineering history, and years of work by the ASS to make the mountains accessible, the alpine world is far from wild. The grandeur of the alpine environment is still sublime, but there has been a clear change in our perception of it. Previously experienced as a magnificently chaotic entity from which one must protect oneself, high altitude is now a means of extracting oneself from the fast pace of the modern world. The mountain life within the refuges is a way of going back in time, where human relationships are welded together in the adversity and difficulty of conditions.

The typology of the refuges plays a fundamental role in the human approach to the mountain and their reasons for going to the peaks. Despite the need to adapt the buildings to the needs of comfort and new sports practices at altitude, the communal and frugal aspect of the refuge is often preserved, particularly in French refuges where a dormitory typology is more often found (Jouty S., 2013).
Some refuges have to adapt to an influx of more than a hundred people, becoming multi-storey buildings. The example of the Swiss huts shows a clear typology. The ground floor is the storage space for the mountaineering equipment and the services such as the shower or the technical equipment. The first floor houses a common dining room, the warden's kitchen and his quarters. The warden is only present in the summer. Its role is to protect the building from human damage and to manage the flow of mountaineers in a similar way to a bed and breakfast. Guests are accommodated on the second or third floor if there is one, in dormitories of 4 to 12 people.
These refuges now remain open in winter as well, as winter mountaineering is a new challenge possible through the development of ski. For this reason, insulation is added to the walls and roof (La Pierre d'Angle, 2021). To reduce the materials used, this is not applied to the whole building. Thus, only a part of the refuge can be used during winter, unguarded and functioning like a bivouac.

This new typology of refuges leads to a differentiation in mountain sports. A new category, hiking, is considered separate from mountaineering. Much more accessible to people who are unfamiliar with altitude and its dangers, this practice makes a pass or refuge the main destination. This new practice radically transformed the use of refuges and their typology. The activity of the hut changes to become mainly a buvette, offering a limited experience of the life of the hut to the hikers. The buvette becomes a minor part of the business of the refuge and has to adapt to the diversification of the visitors' activities.

During the interwar period, with the introduction of paid holidays, the popularisation of the private car and the promotion work undertaken by the Alpine Societies and governments to go to the mountains, mass tourism was established in the Alps. Today, they are the second most popular destination in the world, with some 120 million tourists per year (Stacher S., 2018).

. After the Second World War

The Second World War brought great technical advances. These were to transform the alpine landscape. After the war, the taming of the mountain slowed down considerably. Indeed, a decline in traditional mountaineering activities can be observed. This was due to the growing popularity of skiing, which eclipsed walking (Jail M. 1975). The need for equipment in the mountains is becoming weaker. The Alpine Clubs, therefore, decided to take a new approach to protecting the Alpine area. The maintenance of existing facilities and the protection of the mountain area is becoming the priority in view of the trend of over-equipping: ski resorts are being built higher and higher and infrastructure projects are getting out of proportion. In Switzerland, the SAC wants to stop the promotion of the mountains and is committed to not building any more refuges, just renovating, upgrading and replacing existing buildings (J. Schwerzmann, RTS 2014).

This process was facilitated by a decisive invention in the history of mountaineering and high-altitude architecture: the helicopter. Thanks to this vehicle, it became possible to transport materials as high as needed in record time. The weight of the materials is still a limitation, but the overall construction of the refuges is greatly facilitated. It is now possible to build bigger and stronger. A greater variety of equipment and gear could be moved to high altitudes, greatly diversifying the possibilities for the architecture of huts and bivouacs (Lyon-Caens, 2003).
These new conditions along with the exceptional environment, the same that inspired many artists in the 17th century, aroused the interest of architects.

The creation of alpine sports societies, driven by post-war nationalism, is the starting point for the high-altitude architectural landscape as we know it today. Initially being the driving force behind the assertion of human presence in the wilderness, from the 1940s onwards the ASS made it possible to maintain and protect the mountain environment. Through the network they establish, they are an essential tool for controlling the influx of tourists initiated by the popularisation of a unique nature jewel and supported by technological developments.

Fig. 13 Jean Masson, extrait de Peter Sulzer, Jean Prouvé, œuvre complète, volume4 :1954-1984, Birkhaüser éditeur 2008, p243

Chapter III/ Understanding

An important aspect of the development of high-altitude architecture is its relationship to scientific research. It is the land base for many expeditions, thanks to its location in a specific environment. But it is also the initiator of technical innovations due to the extreme conditions in which it survives. The high-altitude refuge is a unique architecture that maintains a privileged relationship with the scientific world, illustrating the need for understanding the wild mountain environment.
This chapter seeks to highlight the close links between science and mountain architecture between the 19th century and today.

3.1 Building for Science

. A Building for Research

In the early history of mountaineering, scientists played a key role in its democratisation. The research was a driving force for mountain exploration, particularly in the 19th century.
Among the first huts built in the Alps were the Observatories.
The example of the Vallot Observatory in the Mont Blanc massif is decisive. Constructed in 1890 in the Mont Blanc massif by Joseph Vallot, it was rebuilt and enlarged several times after destructive snowfalls (Arpe, 2007). However, this typology has always been adapted to scientific research. In the archive photographs, one can see a workshop, a kitchen, a guide room, a laboratory and a room dedicated to spectroscopy and photography. The building is a major factor in the scientific revolution in the Alps in the 19th century (Federal Documentation Centre, n.d.). The Observatory served as a base for numerous expeditions and as a research centre for geology, meteorology, glaciology, astronomy, botany, cartography and also for physiology and medicine. Indeed, research on the human body and its reactions to altitude was conducted in the Alps. Phenomena such as ventilatory acclimatisation or mountain sickness were examined (Arpe, 2007).
A few other similar constructions were built in the same period (Dini & Girodo, 2018). Such as the Janssen Observatory, erected in 1893 on the summit of Mont Blanc. It is a wooden construction simply placed on the summit and transported in separate pieces. The hut served to identify the origin of certain rays of the solar spectrum. For this research the elevation was essential, allowing the thickness of the atmosphere to be reduced and more sunlight to be captured. It was also used for meteorological studies (Observatoire de Paris, 2017). After a few years, it was dismantled due to ice movements.
Today, the mountain environment is still essential for scientific research. Studies on global warming, astronomy and meteorology are still carried out. The installation of huts dedicated to research allows the teams to stay in place to carry out the study.

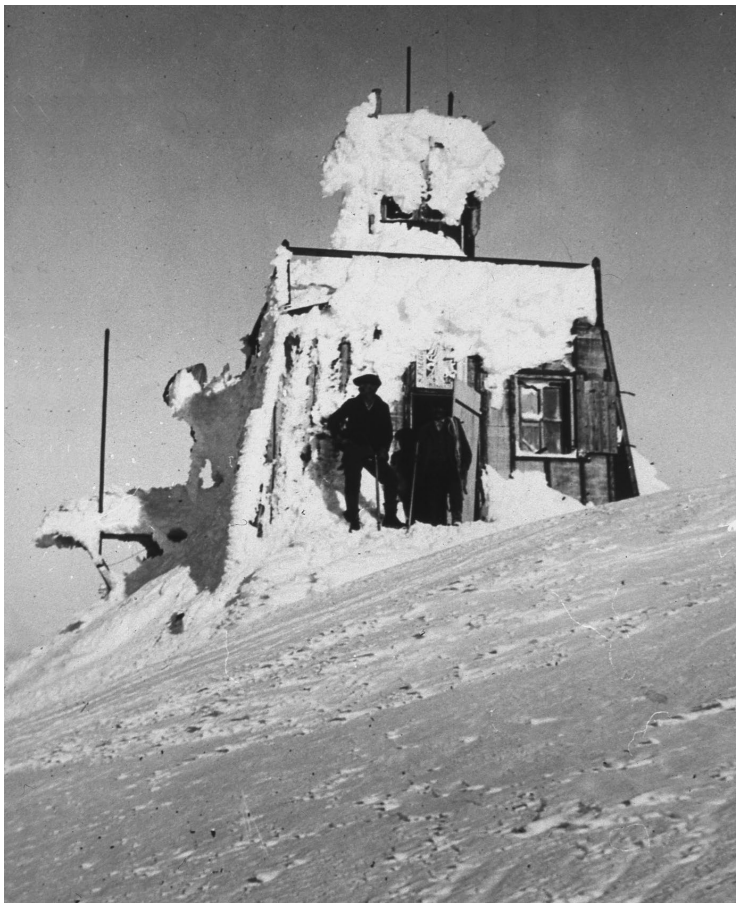


Fig. 14 Observatoire de Paris, (2017).- *Observatoire Janssen au sommet du Mont Blanc. https://lesia.obspm.fr/perso/jean-marie-malherbe/CPMB/ObsMtBlanc/index.html*

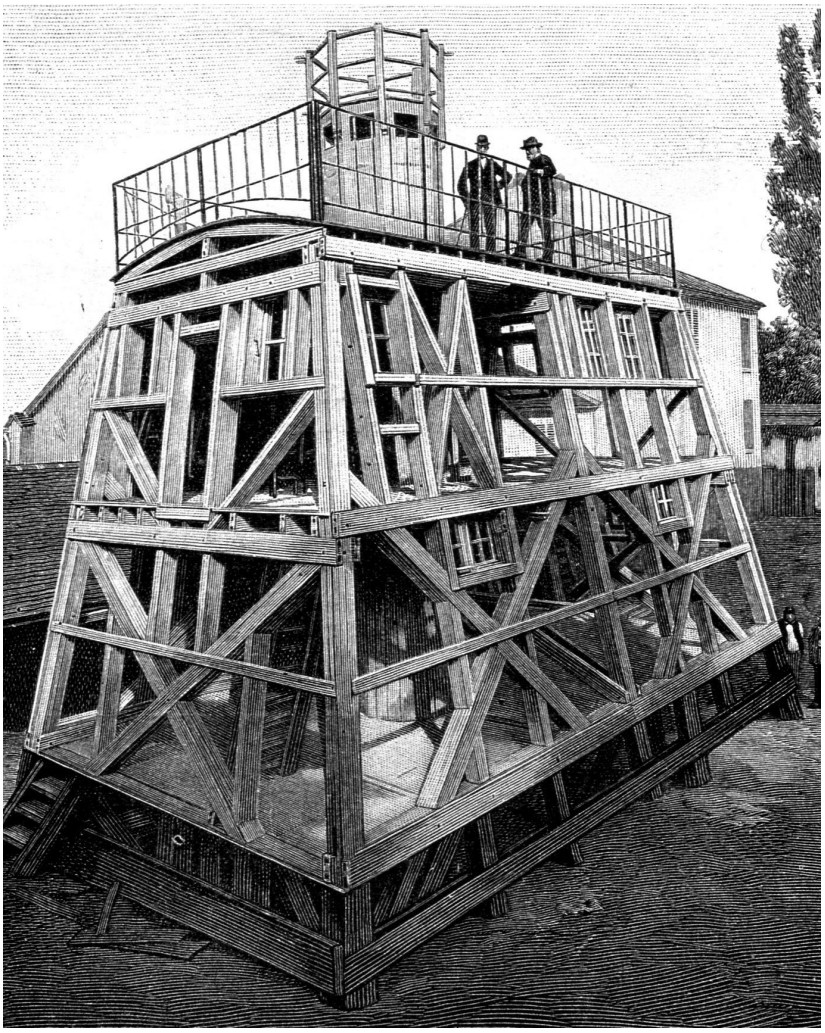


Fig. 15 Observatoire de Paris, (2017).- *Observatoire Janssen au sommet du Mont Blanc. https://lesia.obspm.fr/perso/jean-marie-malherbe/CPMB/ObsMtBlanc/index.html*

Fig. 16

Fig. 17

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Fig. 20

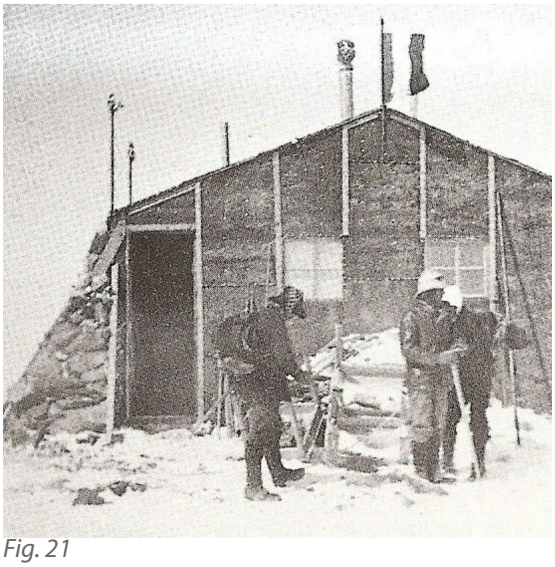

Fig. 21

Fig. 16 to 20 IALPS Mountain Museums. (2020c, March 20). *Charpente de l'observatoire Vallot* - IALP Mountain Museums. IALP Mountain Museums. https://www.mountainmuseums.org/items/charpente-de-lobservatoire-vallot/ The photographs show the construction of the Observatory.

Fig. 21

CENTRE FÉDÉRAL DE DOCUMENTATION LUCIEN DEVIES, 1890.- Le premier Refuge-Observatoire Vallot

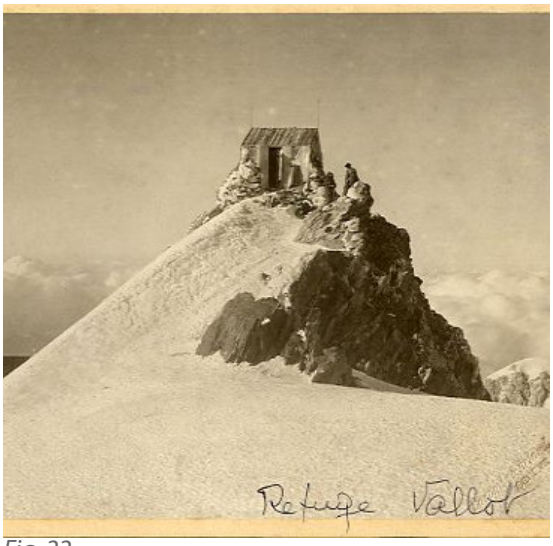

Fig. 22

Fig. 23

Fig. 24

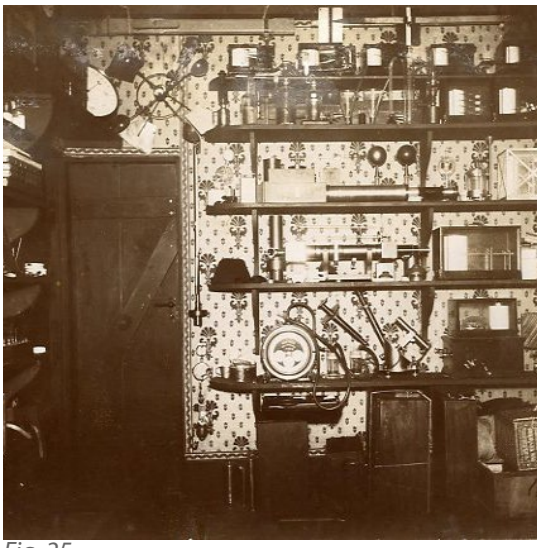

Fig. 25

Fig. 26

Fig. 27

Fig. 22 to 27 *IALPS Mountain Museums. (2020, March 20). Laboratoire de l'observatoire Vallot - IALP Mountain Museums. IALP Mountain Museums. https://www.mountainmuseums.org/items/laboratoire-de-lobservatoire-vallot/*
The photographs show the interior of the Observatory

. Towards Self-Sufficiency

The mountain is an interesting place for research on human capacities and a better understanding of the Earth. It is also a place where many buildings and material technologies have been experimented with, seeking to achieve comfort and autonomy in this extreme environment.
In the 20th century, architects and engineers became interested in mountain hut architecture (Jouty S., 2013). Like the painters and philosophers of the 17th century before them, architects are fascinated by the majesty of the high-altitude landscape and the constraints it implies.
These conditions enlighten architectural challenges. To begin with, it is the conditions of construction and the challenges that the environment inflicts on it that are of interest. With the invention of the helicopters, innovative technologies were tested on refuges.
As a result of the change in the objectives of the Alpine societies facing the influx of tourists, the planning of the mountains no longer seeks to expand but to improve both in terms of comfort and towards responsible exploitation of ecological resources. The search for self-sufficient buildings started.
In high-altitude areas, there is no running water, no electricity, no accessible food and no treatment of waste is possible as we know it in cities. The challenge of providing self-sufficiency to a building engages architects in the creation of innovative buildings.
Refuges like The Vittorio Emanuelle II Refuggio were constructed. Built in 1961 on the Gran Paradiso ascent route, in Italy, this refuge has an unprecedented aspect with its curved aluminium roof, designed to cope with snowfall.
In addition to building experiments, self-sufficiency technologies have been tested on refuges, some of which are now used more generally in practice (J. Schwerzmann, RTS 2014). Solar panels, for example, allow for electrical autonomy. The first residential solar panels were installed in 1979 on the Evettes refuge (Jouty S., 2013).
Tests of various insulating materials, sanitary arrangements, heating devices and water supplies are also explored. The most recent version of the Refuge du Goûter, in the Mont-Blanc massif, combines many innovations. Its egg shape is laboratory-tested to cope with winds up to 300km/h and its water recovery system melts the snow that accumulates at the back of the refuge. Sanitary waste is treated by adding bacteria (FFCAM, n.d.).
Since the 20th century, Alpine architecture has been a goldmine of technical innovation, which sometimes meets its limits due to mass tourism. The technologies in place are not always sufficient to achieve autonomy due to the number of visitors to be accommodated.
The Alps have a pioneering role in development and innovation.

Fig. 28 By Author (2022).- *Rifuggio Vittorio Emanuelle II*

Fig. 29

Sarda B. (2022).- *Refuge Quintino Sella*

Fig. 30

Sarda B. (2022).- *Refuge du Couvercle (Old and New)*

Fig. 31 Sarda B. (2022).- *Refuge d'Argentière*

Fig. 32 Philetjosie, CC BY-SA 4.0. - *Panorama du refuge des Evettes* https://creativecommons.org/licenses/by-sa/4.0

Fig. 33 Sarda B. (2022).- *Refuge des Conscrits*

3.2 Building as Experimentation

. Landscape Architecture

The extreme mountain environment and the wilderness it embodies also fascinate as a way of experimenting with volumes.
In this search for innovation, the refuge, in addition to being an environment for research and testing, becomes a place for architectural innovation in its shape.
To begin with, the relationship between the refuge and its environment is changing. Previously closed, creating a cocoon of humanity in the heart of wild nature, there is now an urge to open up. Large windows are cut out, framing the panorama (Roberto Dini & Stefano Girodo, 2018).
The Alps is a land of contrasts and oppositions that unite in a moving picture, exacerbated by the physical conditions in which man finds himself in the high mountains, faced with the danger of this hostile environment and the long ascents involved to reach it. The act of opening up allows the visitors to experience the wild nature or the pittoresque en un parcours préparé (Stacher S., 2018).This satisfies the desire to be part of the experience while being protected in urban comfort. Indeed, this search for modernity in high-altitude architecture is also linked to the diversification of the clientele visiting the refuge. A minimum comfort is expected from the new generation of mountaineers and hikers.

The extreme beauty and difficulty that mountaineers seek in the Alps is reflected in the conditions of the refuge and highlights wider interests in architecture such as the relationship of a building to its environment and the surrounding landscape. Aesthetic innovation, more recent than technical innovation (Jouty S., 2013), generates 'architecture spectacle' or landscape architecture that resonates with the already present spectacle of nature (Lyon-Caen, 2003). This new architectural typology is « characterised by an architectural bias in which the enhancement of the site occupies an important place and opens up various attitudes: mimicry, landmark/signal, integration, contrast. » (La Pierre d'Angle, 2021).

From the middle of the 20th century, the architecture of high-altitude areas is inspired by other great conquests of the time. Built as spaceships, elements of modernity in the picturesque mountain scenery, they are reshaping the infrastructural landscape of the Alps and pushing the limits of innovation in architecture (Roberto Dini & Stefano Girodo, 2018).
Bivouacs such as the Ferrario Bivouac designed by Mario Cereghini, the Dolent Bivouac or the Gervasutti Bivouac express their «technological character in contrast with the irregularity of Alpine land». They express in their architecture technical innovation mixed with a sense of the sublime. Their ship-like shape is a metaphor for the initial shelter, a shell of tranquillity in the infinite space of the wilderness where night is feared.

More and more futuristic buildings are being erected across the Alps. Their appearance as well as the comfort integrated by the various technologies illustrates a new dynamic of man towards the mountain. The majority of those who go to the mountains are curious city dwellers, and tourists in search of nature and spectacle. In contrast to the pioneering mountaineers who travelled the Alps for months or years, modern society is characterised by the rapidity of its interactions. Despite the accessibility of the mountains through transport and more flexible working conditions, the stays in the mountains are very short. The planning of the mountain by the Alpine Societies has adapted to the influx of tourism and attempts to retain its original function of hospitality and shelter for climbers. These characteristics have led to the evolution of the refuge typology towards a comfortable architecture designed to satisfy tourism. From its appearance as a work of art in the middle of the flamboyant landscape, and its new openness to the world, made to frame a landscape as part of guided tours.

Fig. 34 Club Alpino Svizzero (n.d),- *Bivouac Dolent*

Fig. 35 Martin & Werner Feiersinger (n.d.),- *Bivouac Ferrario*

Fig. 36 Leap Factory. (2021, November 23). *Extreme: Building beyond the breathtaking on the toughest environments*. LeapFactory. https://www.leapfactory.it/extreme-building-beyond-the-breathtaking/

Conclusion

In conclusion, this study has provided a deeper insight into the interconnections between architecture and attitude towards nature in the context of high-altitude Alpine architecture. Through a comprehensive analysis of historical and contemporary case studies, we have traced how the evolution of refuges has been closely linked to the evolution of tourism and mountaineering and reflects the changing attitudes towards the wild environment.

One of the developments of this study is that the architecture of high-altitude environments has not only served practical functions such as providing shelter and safety, but has also been the reflection of human approach to the Alps. As well as a mean of containing certain behaviours. From the early mountaineering huts of the 17th century to the contemporary hut vessels, the design and layout of these structures have translated mentalities while adapting to the modernisation of the mountain world.
Moreover, the study also highlights how the history of mountain Huts, mountaineering and tourism are closely related and worked together to reshape this specific environment.
In addition, this paper sheds light on the role of architectural innovations in high-altitude environments as a starting point for today's construction techniques and sustainability-related technologies. For instance, the need for energy-efficient and low-impact structures that minimise the ecological footprint of human settlements in these fragile environments has led to the emergence of sustainable and environmentally-conscious design in contemporary architecture. As well as the development of pioneering technologies such as solar panels.
Another aspect of the research is highlighting the challenges and opportunities that arise when designing and inhabiting high-altitude architecture. The extreme conditions of these environments require architects and visitors to be highly adaptable, resourceful, and resilient. This often involves striking a delicate balance between providing essential amenities for human comfort and minimising the impact on the natural environment.
Finally, this study underscores the importance of high-altitude architecture in shaping our understanding of human behaviour and our relationship with the natural world. As we continue to face unprecedented environmental challenges, the lessons learned from the evolution of high-altitude architecture can serve as a source of inspiration for future interactions.

By tracing the historical and contemporary evolution of this field, we have gained valuable insights on the interconnections putting together a specific typology and its user and how it can continue to inform for a more respectful use of the Alpine realm in the future. Further research could be conducted to explore the links between architecture, attitude towards nature, and the development of society in other mountainous regions around the world.

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