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# The 19th century Industrial Architecture in Europe and the Monteponi case. From the Construction History to the guidelines for the recovery.

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# PART I

## STATE OF THE ART

## METHODOLOGY

## OBJECTIVES

## Introduction

The main purposes of this dissertation concern the acknowledgment and the identification of the great Monteponi Mine (a fundamental promoter of the mining epopee in Sardinia between the 19th and the 20th centuries) within the European process of industrialization and its Construction History, focusing this case study at the light of the systems of contemporary values of the Industrial Archaeology and of the principles of safety and protection. The investigation on an European scale of the emerging cases to which Monteponi is compared has been developed through both the intrinsic relevance of the studied cases and the contribution that the experiences of their recovery could provide to define basic guidelines related to Monteponi.

From an academic point of view the thesis belongs to the field of the Construction History as a researching and approaching methodology to study the architectural elements through the definition of their building processes. The knowledge of the buildings is therefore achieved through the deepening of the constructive and technical expedients, of the *know-hows*, the materials and the stratifications that turned into the final configuration of the industrial architectures, the phases of edification and the morphologies of the main features of the analyzed heritage.

The development of the dissertation starts then from the theoretical definition of the contents of the Industrial Archaeology and the Construction History, through their academic and institutional recognition, and further analyzing both the international examples of preservation and reuse and one of the most important branches of the category: the mining heritage.

We aim in fact to produce a research that contains the methodological and the theoretical aspects referring to the industrial heritage – and moreover to the industrial archaeology – intended as means to achieve a knowledge about how the European heritage has been preserved and valorised in a optic of restitution to the local communities and to the international audience. The inner values of the industrial heritage are intimately linked to the birth and the development of the social groups, of the people living in specific regions and territories, to the modifications of landscapes and urban physiognomies, to the evolution of architectural and constructive criteria involved in the technological processes derived from the industrialization. This investigation is therefore aiming to deepen these elements in order to present a rational picture of the past characterization of the European heritage and of a local case study – the Sardinian Monteponi mine – which suffers from the lack of an adequate safeguard and promotion of its historical and social values: the case study – inserted in the large declination of the industrial heritage consisting of mining heritage, mining facilities and development of mining sites – represents therefore an unexplored territory, a virgin landscape where the possibilities, the results and the theoretical approaches related to the use and the preservation of the expression of human work could be applied. Dramatically, the case study suffers from the almost total lacking of preventive solutions and investigations of its heritage that consequently need the contemporary reinterpretation of its consistency and rehabilitation through practical strategies of contextualised approaches, which put in a new light the identity and the memory of the industrial past.

The ambition goes even forward, since we aim to achieve these results through two parallel methods: one is focused on the research of the Construction History both of the European realities and of the case study, in order to analyze the constructive stratification of their heritage and to confront the mutual influences of the technical culture in the design of their architectural palimpsest, from a typological and material point of view. The second is the investigation of the rehabilitative programs that interested the international examples, which are similar to the Sardinian case study thanks to the affinities among the mining scenarios that featured the European heritage in the passage from the pre – industrial era to the 20$^{th}$ century modernization.

The thesis follows then a gradual identification of its theoretical bases, starting from the investigation of the state of the art in the field of the industrial archaeology and of the industrial heritage that constitute the scientific support to the research: we are then in front of the significance of the discipline itself and to the researching methodology, which counts on the reconstructive approaches proper of the Anglo – Saxon matrix known as "Construction History" and on the documentary and archival sources to reconstruct the historical and the architectural events.
Secondly the dissertation focuses on the most important cases of mining heritage that have undergone experiences of valorisation based on a first characterization of their historical background and then on the presentation of their peculiarities. These cases are chosen in virtue of their temporal and constructive affinities to the Sardinian case, mainly due to the international influences of the technological expressions in the European industrial context.

Furthermore there is the presentation of the case study, as said the Monteponi mine in Sardinia, explored in the same way of the other case studies, i.e. through the historical evolution and the features of the industrial heritage intended to explicate both the development of the mining industry in Sardinia and the transformation of the architectural and technological scenario. The collection of buildings and events describes therefore the main events that led to the modern configuration of the mine, enriched by important cultural and technological facts reflected in the architectural features of the mining heritage: we refer in particular to the linguistic and stylistic influences derived from the sensibility towards specific architectural expressions and to the gradual mutation of the latter into new formalism that characterize the last period of Monteponi's edification.
The final part proposes a duplicity of intentions: on one side there is a deeper investigation of the most emblematic elements of the European and the Sardinian heritage, led through the architectural and the constructive analysis of several buildings – belonging to Monteponi mine and to one or more international examples – at the light of the researches on the constructive principles and the linguistic characterization of the 19$^{th}$ century building culture. On the other we aim to translate the procedures and the initiatives of preservation and safeguard of the cultural and social values analyzed in the international cases to the context of Monteponi mine, in order to set a sort of guidelines for its recovery and restitution to the local communities in an optic of sustainable reuse and development. The architectural inventory and the confrontation between emblematic buildings would be therefore useful to investigate the best practice to survey and

valorise the historical and technological meanings of this heritage and to enlighten them through proposals of functional reconversion.

In the first phase, it was fundamental to determine what the criteria for the identification of the industrial heritage and the underlying principles for its recognition are and what the main difficulties for its recovery. The recovery of mining sites and complexes became a serious matter of discussion only in the last three decades, both because up to the 1980s caves were still widely used to produce fuel and mineral components, and because, after their closure, national and international organizations focused mainly on the subsequent stagnation phase, rather than on their recovery.

Considering the general remarks on the concept of industrial heritage and the normative, disciplinary and institutional progress on mining heritage recovery, the dissertation analyses some cases – exemplifying internationally and compared to different intervention and promotion procedures –similar to the case study. That is, instances of recovery of mining sites in France, Belgium and Spain, that represented the application of theories and regulations that are the cutting edge of the discipline. Therefore, in the examples proposed here can be observed how different method trends and guidelines promoted by different institutes, such as TICCIH[1] and UNESCO, and national and regional administrations affect the recovery.

The dissertation, nevertheless, needed also more specific studies aimed at focusing research on the recovery of the mining heritage directly and concretely in relation to buildings and artefacts that represent its application. This direction represents both the method on which the knowledge is based and the scientific background in which this work should be included. This essay aims to be part of the academic field of *Construction History* that is an inquiry and study method – founded in the Architecture Department of Cambridge University[2] – that bases the analysis of buildings on the *how it's made*. In that way, the study of the building – or complex of buildings – starts from the construction phase, through the analysis of techniques and technologies adopted during the edification, the knowledge so implied, the material used and the stratification that shaped the structural and architectural appearance over time.

Otherwise it would be impossible to set up a dissertation beginning from such a wide field – as it is that of the mining heritage recovery – and ending to the analysis of application the case study, which shall be investigated through its architectural physiognomy and conditions of possible recovery.

## Industrial archaeology and the concept of heritage

[1] The International Committee for the Conservation of the Industrial Heritage.

[2] The Construction History Society was founded in the Architecture Department at University of Cambridge: http://www.constructionhistory.co.uk/

Local, national and international organizations became, over the years, increasingly concerned with studies and research on the recovery of industrial archaeology – initially defined as archaeology but only recognized as heritage in the last thirty years – and the need to preserve the historical and cultural value of industrial areas.

In the majority of publications about the Industrial Archaeology, its origins and its purposes, there is often the claim that it is a discipline focusing on the past of the industrial society through the investigation of its material inheritance. What keeps unclear is how this is done, through which techniques and what the aims of these investigations are. The main problem regarding the Industrial Archaeology is therefore that, after fifty years of a variety of publications and researches, a whole accepted theory and methodology are still missing. At the base of this situation there are different causes, among which we suggest these three: the conditions that led to the disciplinary definition; the suspicious attitude of historians and archaeologists in front of proposals that question the traditional inscription in different historical periods functional to the approach the investigation of the industrial heritage and the consequent absence of an academic acknowledgment, and the misunderstanding between the industrial archaeology and the industrial heritage. We must consider that the main aim is the investigations on factories and public works of the industrial era, which are directly related to the inventory and the catalogue of the industrial heritage or to a methodology which allows to deepen into the knowledge of the industrial – capitalist society starting from its remains as well as the archaeology does referring to different historical epochs. This consideration is clearly stated in a wide amount of publications and articles referring to the theoretical aspects of the industrial archaeology as well as in the first definitions of this discipline from the 1950s: Michael Rix, author of the first article in which this term appeared, stated that the methodology and the aims are "the registration, the preservation in some cases and the interpretation of the places and of the structures of the first industrial activity, in particular the monuments of the Industrial Revolution.[3]"(Cerdà Pérez, 2011)

The perception of preservation and recovery endured a period of deep uncertainty after the end of the Second World War, when, due to the critical post-war situation, the urge was to build again housing and industry, rather than recover abandoned industrial buildings.

At that time buildings were often demolished even in industrial cities such as Barcelona, Paris or Hamburg[4]. This "erasing" policy was linked to the lack of recognition of the specific architectural identity of the edifices, frequently placed in areas that, when disencumbered, would allow the

[3] Cerdà Pérez, M. *Arqueologîa industrial : teorîa y práctica*. Edited by Universitat de València. Valencia, 2011, p.18.

[4] In Barcelona, the industrial buildings of the Locomotive Factory "La Maquinista" – shut down in 1965 – were transformed into 250 lodgings, designed in 1979-1980 and realized in 1988. From: Del Gallo, P. Il progetto di recupero di Ciutad Vella a Barcellona, in Costruire in laterizio 63/1988, pp. 188-193

In Paris, the instance of Les Halles – the old central market – was exemplifying, demolished in 1971. In its place, an underground mall was built in 1979, called Forum des Halles.

In Hamburg, from the 1980s, the enlargement of the harbour involved also ancient areas with demolitions and transformations, such as Altenwerder, Moorburg and Finkenwerder. From: Caja, M. G. La HafenCity Hamburg: Una città – porto tra continuità e innovazione. In: *Portus Plus* vol. 1/2011, pp. 1 – 10.

development of new the residential or industrial zones so strongly needed at that time. Usually perceived as short-lived architecture, linked to production cycles and rapid mechanization, industrial archaeology had its revenge before the society and the perception of the modern scientific community in the 1950sin the United Kingdom. The transition from its perception as that of a hybrid field of archaeology to that much wider of heritage took a long time and was often difficult, but understanding its historical and academic history is essential to get a full and thorough picture of the scope of the study.

The first mention of industrial archaeology dates back to 1955 when Michael Rix[5], professor at University of Birmingham, began using this term on the occasion of various conventions, courses and publications. His work itself, together with the courses of Workers' Educational Association at University of Birmingham, drew attention to the rapid transformation of the main districts related with iron and coal factories in the Black Country[6], perhaps for the very first time. In the article *Industrial Archaeology* published on *The Amateur Historian*[7] he wrote:

*"Great Britain as the birthplace of the Industrial Revolution is full of monuments left by this remarkable series of events. Any other country would have set up machinery for the scheduling and preservation of these memorials that symbolise the movement which is changing the face of the globe, but we are so obvious of our national heritage that apart from a few museum pieces, the majority of these landmarks are neglected or unwittingly destroyed."* (Rix 1955: 225)

Unlike the previous industry historians, Rix stressed what can be retraced through the still existing remains of industrialization. His use of the term "archaeology" inspired the Council for British Archaeology to establish an Industrial Archaeology Committee in 1959. In the same year the first convention on Industrial Archaeology was organized in the United Kingdom: even if the subject of the first convention was the remains of the First Industrial Revolution – quite different from the 20th Century architectural objects – it is not wrong to say that this was the first step towards the academic recognition of industrial archaeology.

The Newcomen Society, founded in 1920 and concerned with the study of engineering and technology history, encouraged the new discipline and supported the *Journal of Industrial Archaeology*, published for the first time in 1964[8].

Another definition is proposed by Angus Buchanan[9] in 1974: we talk of archaeology because its investigation requires a field work and sometimes the excavating techniques of the

[5] Michael Rix, Historical Archeology, London, *The Historical Association*, 1967. In Negri, A, Negri, M. *L'archeologia industriale*. Messina-Firenze: ed. D'Anna, 1978, pp. 114-120.

[6] The Black Country is an area in the West Midlands conurbation, between Birmingham and Wolverhampton. From the late 19th Century it became one of the most industrialized areas in the UK, with spreading coal mines and mineral handling centres, iron foundries and industries for steel production. It is one of the most polluted areas on Earth.

[7] Rix, M. Industrial archaeology. In: *The Amateur Historian* (2, 8), 1955:225–9.

[8] Palmer, M. Neaverson, P. *Industrial Archaeology. Principles and practice*. London: Routledge, 1998.

archaeologists and he defines it as a discipline that investigates (with a systematic search and further evaluation of the found materials), analyses (evaluating, photographing, dating the monument) and preserves the industrial remains from the past.

For Kenneth Hudson, who published the first book on industrial archaeology in 1963, it is the discovery, the recording and the study of the physical remains of the past; moreover Hudson stated that the reconstruction of the material working conditions in the industry starting from the remain of a factory is, basically, the same reconstruction of the life of a prehistoric community.

Finally for Neil Cossons[10] the industrial archaeology must be considered in the same way as the Neolithic, Roman or Medieval archaeology.

The further definitions have focused mostly on this aspect, the link of the aims to the localization of the physical remains in order to safeguard them and not to merely analyze and interpretating. As Dianne Newell stated during the first Conference of Industrial Archaeology in Valencia with her intervention titled "*Industrial Archaeology. Will it ever be a historical science?*"[11] the main problem in this investigation is that "the work in this field unfortunately is limited to the discovery and the conservation of local industrial monuments and – during her researches in the Catalogue of the Library of the British Museum in London to prepare the essay for the Conference – she did not found "publications about the methodological and the theoretical principles of this discipline neither about the main questions of the industrial archaeology."[12]

A series of public lectures, mainly organized at the University of Bath, brought in 1973 to the foundation of the Association for Industrial Archaeology (AIA), whose president became Lionel Thomas Caswall Roth, writer and biographer of some of the most important civil engineers. The AIA advocated for better standards in registration, research, preservation and publication, in order to contribute and support regional surveys, specific studies, research groups and organizations involved in the preservation of industrial memorials, and in 1976 published the *Industrial Archaeology Review* which, after some years being published by Oxford University Press, became the official journal of the AIA in 1984.

Kenneth Hudson was one of the scholars mainly interested in this new matter, publishing one of the first summaries[13]about Industrial Archaeology. One of the first commentaries on the subject, entitled *The Industrial Archaeology of County Down*[14] was written in 1963 by E.R.R. Green. In the book, he insisted on the importance of a catalogue of the evidences of the First Industrial

[9] Buchanan, A. *Industrial Archaeology in Britain*. Hardmondsworth: Penguin Books, 1974. Op. cit. in Cerdà Pérez, M. *Arqueologîa industrial : teorîa y práctica*. Edited by Universitat de València. Valencia, 2011, p.18.

[10] Cossons, N. *BP Book of Industrial Archaeology*. New Abbott: David & Charles; 1St Edition edition, 1975. Op. cit. in Op. cit. in Cerdà Pérez, M. *Arqueologîa industrial : teorîa y práctica*. Edited by Universitat de València. Valencia, 2011, p.19.

[11] Ibidem, p. 19.

[12] Ibidem, p. 19.

[13] Hudson, K. *Industrial archaeology: an introduction*. London: J. Bake, 1963.

[14] Green, E. R. R. *The Industrial Archaeology of County Down*. Belfast: Her Majesty's Stationery Office, 1963.

Revolution in Great Britain – 18th and 19th Century – suggesting the use of techniques employed in "traditional" archaeology, such as excavations and scrupulous study of the buildings[15].

In that period, the main interest of industrial archaeologists was still merely conservative, intended to preserve – before their destruction – traces of the past, which were catalogued and listed in inventories. In a first phase, in fact, industrial archaeology concerned almost uniquely buildings of the First Industrial Revolution, and the definition itself of archaeological record is still quite reductive: it is considered as archaeological element an object – belonging to a past civilization – when a conceptual and identity gap exists between the historically bound industrial element and the current economical-social life. Some of the first buildings recognized by industrial archaeologists as archaeological record corresponded to the criteria used in traditional archaeology to choose the constructions to preserve – such as in the case of ancient ruins – which explains why they often have a decadent appearance, as in the Romantic period and according to Ruskin's ideas[16]. Soon after, however, the definition developed towards less picturesque and nostalgic aspects, including considerations on the evolution of the industrial society and on its effects on architecture. This was mainly caused, perhaps, by a stimulus coming from the United States, where in 1969 was founded the *Historic American Engineering Record* and, in 1971, the *Society for Industrial Archaeology*.

While at the beginning the theoretical background of the American school of thought did not distance itself much from its English counterpart, it was an American the one who introduced the concept of *Heritage*: Theodore Sande[17]. His concept of heritage replaced soon after the term "archaeology", and at the same time inquiries promoted by the USA were the first to consider social and economic life as part and parcel of the safeguard process, marking that the industrial record began to represent an identity-making element and focus of the current reality.

*The origins of the industrial archaeology: the Great Britain*

Is commonly known that the Great Britain of 1950s is the motherland of the industrial archaeology as a reaction to the systematic demolition of the most representative elements of the industrial era, in particular those of the First Industrial Revolution. In those years of urban and industrial renovation after the bombing of the Second World War we assisted to the improvements of the building and technological concepts, mainly due to the obsolescence of the machineries and infrastructures during the crisis of the manufacturing factories and the coming crisis of the mining industry. At the beginning of 1950s Donald Dudley of the University of Birmingham brought his students to visit antique industrial facilities, starting in some way the first approach to the industrial issue and to the development of the concepts about the preservation of the industrial heritage. A little later *The Amateur Historian* republished the article *Industrial Archaeology* by Michael Rix, stating for the first time this term and his concern about the

[15] Mainardi, M. La conservazione del patrimonio industriale in Italia: tracce di storia, interpretazione, metodi. In Storia e Futuro, N. 29 - June 2012.

[16] Ruskin, J. *Le sette lampade dell'architettura* (Edition in Italian). Milano: Jaca Book, 1982.

[17] Sande, T. Industrial Archaeology: a New Look at the American Heritage. Brattleboro, Vermont: Greene Press, 1976.

destruction of the remains from the epoch of the first British industrialization: this Country had in fact numerous monuments that deserved to be reminded and Great Britain should had prepared appropriate tools to inventory and to preserve them as symbols of the great changes in its history, however the majority of this heritage versed in precarious conditions or had been demolished due to the common indifference.[18]

The first interventions by public initiatives were made by the Council of British Archaeology in 1958 with the creation of the Industrial Archaeology Research Committee, which in turn started the Survey of Industrial Monuments and the consequent National Register of Industrial Monuments, the latter directed by Buchanan since 1965. In 1962 on the opposite front there was the demolition of the Neoclassic Doric porch designed by Philip Hardwick in 1837 for the Euston Station in London, replaced by a new building for the same Station, which generated a strong protest by the public and the academic opinion: this fact led therefore to a formal quest for a more sensible attention towards the remains of the British Industrial Revolution that started to be considered as a part of national he cultural heritage. This interest was certainly more civic than academic or scientific but it was connected to the strong tradition of associations dedicated to the local studies and investigations in different areas of the cultural society, as it happened with Michael Rix, who was a teacher of Literature; Kenneth Hudson a BBC reporter; Neil Cossons who worked in the Bristol Museum and Angus Buchanan who taught at the Bristol College of Science and Technology. Buchanan himself explained the reasons of this interest, as reported by Cossons[19]: "*a feeling of urgency was growing, stimulated by the fear that something from the past was disappearing, and it converted into the modern movement of industrial conservation*". As we can see initially the issue of the origins of the industrial archaeology was connected to the need to preserve and to conserve the industrial monuments, than to the theoretical or methodological definitions of its natural genesis, i.e. the (social) contemporary history and the archaeology. Since then the industrial archaeology started to be a habitual practice in the local people who visited and photographed the industrial buildings and similar vestiges, documenting and testifying their status: this investigation led therefore to the production of a huge amount of information, data and photographs which constituted a proper survey of the industrial heritage that could not be ignored by the Public Organs. *De facto* the Council for British Archaeology created a group to investigate and coordinate the actions directed to the survey and the record of these monuments, lacking however of a standardization of the methods and of a common objective and thus leading to many mistakes in this work.

In 1963 the first book dedicated to this topic was written by Kenneth Hudson, on charge of the Industrial Archaeology Research Committee: it was titled *Industrial Archaeology: an Introduction* and it was defined as a discipline studying the physical remains of the past industries. A year after Hudson amplified his investigations on the industrial archaeology, founding also *The*

[18] Rix, M. Industrial Archaeology. *The Amateur Historian* vol. 2, no. 8, 1955. Op. Cit. In Cerdà Pérez, M. *Arqueologîa industrial: teorîa y práctica*. Edited by Universitat de València. Valencia, 2011, p. 24.

[19] Cossons, N. *Perspectives on Industrial Archaeology*. London: Science Museum, 2000, pp. 18 – 38. Op. Cit. In In Cerdà Pérez, M. *Arqueologîa industrial: teorîa y práctica*. Edited by Universitat de València. Valencia, 2011, p. 26.

*Journal of Industrial Archaeology* then named Industrial Archaeology: the Journal of the History of Industry and Technology. On the academic front, however, the reticence towards this matter stood due mainly to the conservative approach and the lack of a scientific and methodological approach to the objects of the industrial production[20].

Few years later in 1967 was inaugurated the Ironbridge Museum, which conserved the furnaces of Coalbrookdale (the former name of the area before the building of the iron bridge) and the first metallic bridge in the world designed by Telford between 1776 and 1779. This initiative promoted new associations and local actions dedicated to the research and to the preservation of industrial monuments, followed by a proficient period of publications and essays about these themes and by one of the most important series of Conferences, held in Bath[21]. In this eight conferences, between 1964 and 1974, were presented the investigation on the aims and the methods of this "discipline" with the contributions of Hudson and Buchanan among the others. The Congresses put also the bases for a national association, the Association for Industrial Archaeology, and for its publications named Industrial Archaeology Review: thanks to this initiative in 1970s the British industrial monuments were formerly incorporated in the cultural heritage and claimed a stronger attention by the literature and the publishing worlds, which focuses on the industrial remains as a result of the work done in the past decade. They started also to reuse old industrial buildings for new purposes in order to preserve them from the destroy: Bush House in Bristol became the *Arnolfini* Gallery in 1975, while the Albert Dock in Liverpool, left abandoned, was converted into a civic leisure centre at the end of 1970s. Unfortunately, parallel to these actions of reuse and safeguard, the theoretical definitions were still feeble, mainly because the examples of Bath and Birmingham had not been followed by other academic initiatives.

The British experience, as it was divulgated, implied that the material remains of the industrial era were perceived in a different way even in other Countries: Germany was one of the first receptor of this approach, thanks to the Second International Conference for the Conservation of Industrial Monuments, held in Bochum in 1975 and attended by numerous representatives from Great Britain, West and East Germany, France, Belgium, Austria, Holland, Sweden, United States, Poland and Czechoslovakia, Japan: this Congress testified the necessity of an international coordination both in the survey and in the interventions over the industrial heritage in order to avoid its dispersion. Therefore the study and the conservation of the industrial remains was felt as a collective urgency, since the industrialization process had interested the whole world since its origins: during the following Congress, held in Sweden in 1978, was founded The International Committee for the Conservation of the Industrial Heritage (TICCIH), already proposed during the Conference of Ironbridge in 1973, as a permanent Organization devoted to the study, the conservation and the valorisation of this heritage.

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[20] Cossons, N. *Perspectives on Industrial Archaeology*. London: Science Museum, 2000, pp. 21 – 22. Op. Cit. In In Cerdà Pérez, M. *Arqueologîa industrial: teorîa y práctica*. Edited by Universitat de València. Valencia, 2011, p. 27.

[21] Cerdà Pérez, M. *Arqueologîa industrial: teorîa y práctica*. Edited by Universitat de València. Valencia, 2011, p. 29.

*The Industrial architecture outside the U.K.*

In France the concern for industrial sites developed independently. The English and American authors that wrote on the matter were not translated into French (In Italy, the first edition of Hudson's masterpiece was published in 1979[22]), and it wasn't until the 1970s, when some French academics specialized in history of Economy took part to industrial archaeology convention, that the first attempts to organize events on the same theme were made. Generally, here the different fields of knowledge were distinct and independent: historians on one side, on the other architects, converging towards one and only one discipline, academically, practically and conceptually.

The concern for the industrial heritage began, in France like in other countries, together with the reflection on the crisis affecting the West from the 1970s. Industrial archaeology is not a kind of archaeology focused on the transformation and aiming to save the traces of the past as they are erased to make room for the new machinery, but it is more of a kind of awareness deeply bound to the sense of uncertainty and to the stasis cause by the crisis: the old was not menaced by the new, but by the emptiness that risked taking its place[23].

In French-speaking Belgium the concept of industrial archaeology was introduced by George van den Abeelen in 1968[24] Bath Conference, while the first French convention was held in Le Creusot in 1976; in the same year the periodical *L'archéologie industrielle en France* was founded thanks to Maurice Daumas[25], historian of the Centre de Documentation d'Histoire des Techniques. He was the one who warned that the traces of the first phases of industrial period were going missing and that it was fundamental to preserve them, even if he still defined them industrial archaeology and not industrial heritage. This acknowledgement lead him to consider the material testimony of the industrial record more valuable for its historical importance than its financial profit in the widest and most dynamic sense, which explains the French-speaking – or more in general, academic – tendency to consider the industrial heritage as mainly belonging to historians field of research, at least in the first instance.

In Germany heavy industry was early recognized as fundamental for German economy in 1930, when the *Deutsches Bergbau* – Museum was founded in Bochum at the discretion of the mining industry. This important collection, now preserved in a modern building, includes artefacts from every period of the mining activity. The area of the Ruhr, which was highly industrialized, was cardinal for the economic growth of Germany in the second half of 19th Century and the state of North Rhine-Westphalia supported the preservation of some important monuments, such as the striking Zollern II-IV mining complex, the Heinrichenburg boat lift on pier 5 of the Dortmund-

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[22] Hudson, K. 1979. Archeologia dell'industria. Roma: Newton & Compton Editori.

[23] Bocquet, D. Il patrimonio industriale in Francia: i territori del post-industrialismo tra memoria e valorizzazione. In: Ronchetta, C. Trisciuoglio, M. Progettare per il patrimonio industriale. Torino: Celid, 2008.

[24] Van Den Abeelen ,G. L'archéologie industrielle pourquoi? In *Actes du colloque d'Archéologie industrielle*. University of Mons,1971.

[25] Daumas, M. L'objectif d'une action. In *L'archéologie industrielle en France* (1)marzo1976,pp.1-7.Op.cit.in Ronchetta, C. Trisciuoglio, M. Progettare per il patrimonio industriale. Torino: Celid,2008.

Ems Canal and some of the Malakoff wind towers that overlooked the mining site, as well as the iron furnaces in Völkingen (Saarland) and the Thyssen AG plant in Duisburg-Meiderich.

Industrial archaeologists in Europe have drawn attention to the need to consider the human dimension of the past industrial activity. Manuel Cerdà, president of the Asociació Valenciana d'Arqueologia Industrial, would go so far as to suggest that the study of industrial archaeology is mainly concerned with the period when worker-master social relationships changes as a result of the beginning of factory production, a view echoed in the policy statement on industrial archaeology published by *English Heritage*[26] in 1995, in which Cerdà stated that:

*"Industrial archaeology must treat the study of the physical remains of a specific historical period of capitalist industrialisation, since it is from this moment on that society establishes new forms of organization based upon new relationships anon the main factors affecting production, i.e., capital and labour, which allow for the formation of new social classes."* (Cerdà 1991: 407)

In general, it can be said that in the 1980s industrial archaeology was influenced by the theoretical work of historians, and their proposition was to reinforce the central notion of industrial heritage as a historical issue. Roughly in the same period, the work lead by Louis Bergeron and the academics – such as Denis Toronoff – that shared his ideas lead to a new view on the topic and to the foundation of institutions and authorities – both in France and in the rest of the world – that studied the industrial heritage not as subject of study circumscribed within only one discipline, but as a heritage associated to the social, architectural and productive history of the community. The proof of this change lies in the foundation of journals – such as Jacques Pinard's *L'Archéologie Industrielle*[27] in 1985, which despite the title concerns manifestly of the heritage as a whole – and institutes such as the TICCIH (The International Committee for the Conservation of the Industrial Heritage), founded in 1973 on the occasion of the Ironbridge Conference on Industrial Archaeology (Bergeron will later be president of the TICCIH, and one of the most influential advocates of its views). Furthermore, the discipline-based differentiation in the field of industrial heritage and its recovery was removed and the academic and its scientific aggregation varied, including historians, conservators, curators, architects, archaeologists, students, teachers, and heritage professionals with an interest in the development and conservation of the industrial remains. The purpose of the Committee was in fact the promotion of the international cooperation in "preserving, conserving, investigating, documenting, researching, interpreting and advancing education of industrial heritage"[28].Its charter specifies the objects that are fully recognized as industrial heritage, despite the initial restrictions and the temporal and conceptual chasm aforesaid: the remains of industry – industrial sites, structures and infrastructure, machinery and equipment, housing, settlements, landscapes, products, processes, embedded knowledge and skills, documents etc –adhering to the productive role they

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[26] Cerdà, M. Industrial archaeology and the working class.(1991). In: Cerdà, M. Torro, J. (eds). *Arquelogia Industrial*. València: Diputació deValència,1995.

[27] Pinard, J. *L'archéologie industrielle*. Parigi:PUF,1985.

[28] Memorandum of Understanding between ICOMOS (International Council on Monuments and Sites) and TICCIH (The International Committee for the Conservation of the Industrial Heritage).

had in the past as well as the use and treatment of this heritage in the present. In confirmation of the absence of historical restrictions around the survey, TICCIH itself clarifies that it doesn't focus only on the remains of the Industrial Revolution, but also of the precursors and successors of industrial and productive history of a region or country.

More recent than the TICCIH, but undoubtedly deep-rooted to the 1980s conceptual and methodological progress, Docomomo International is a good candidate as inspector and defender of the Modern Movement. Even if it focused on a wider survey and application area – fixed on the first half of 20th Century–, Docomomo's commitment converged at the study on industrial heritage recovery, as it represented generally its architectural expression, often created by the most popular designers who made the compositional and executive traits of the Modern Movement represent the supreme manifestation of the International Style.

Docomomo International – founded in 1988 by Houbert Jan Henket and Wessel de Jonge[29] – concentrated its action area on the masterpieces of 20th Century architecture, and revealed awareness of the risks related to transformation, loss or demolition of the remains of the glorious past of the Machine Age. During their task they were aware of the difficulty of including in the concept of heritage not only of the human production preceding and successive to the Industrial Revolution, but also and especially that near the academic and cultural community. This attitude – openly oriented towards the modern architectural heritage – made of this organism the first aid for the buildings in critical conditions, such as most of industrial constructions built from the 1920s to the 1940s. The multidisciplinary experience, in this case too, and the variety of experts involved, was advantageous, as it happened with the variation in the academic composition of TICCIH, thanks to the collaboration in the monitoring, intervention and debate phase of different experts: architects, historians, conservators, landscapers, town planners, professors and international faculty members.

*Industrial archaeology in Italy*

The industrial archaeology found a fertile ground also in Italy, where there was a long tradition of protection and conservation of the industrial vestiges. In 1976 was constituted the Centre for the Documentation and the Research of Industrial Archeology in Milan and in 1977 there was the International Conference of Industrial Archaeology, to which followed the first Italian publication on this theme – *L'Archeologia Industriale*[30] written by Antonello and Massimo Negri – and the Italian Society for the Industrial Archaeology (replaced by the Italian Association for the Industrial Archaeological Heritage in 1997). In Negri's book they stated that the methodological approach was still undeveloped despite the diffusion of the discipline: they refer to the archaeological aspect, such as the investigation in the field, the importance of the physical remains intended to explicate the material objects as testimonies of the industrial deeds; the definition of this discipline strictly connected to the history of technology and economy and

[29] Henket, H. J. *Back from Utopia: The Challenge of the Modern Movement*. Rotterdam: nai010 Publishers, 2002.

[30] Negri, A., Negri, M. L 'archeologia industriale. Florence: G. D'Anna, 1978.

the distinction among the different phases, from the observation to the catalogue and the conservation[31]. They consequently aimed to underline the fact that the industrial archaeology must not focus on merely quantitative aspects or on the singularity of the industrial objects, but on the *explication of the capitalist production*[32] represented by the building or the machineries as material expressions of the capital. The workers' housing is therefore the concretion of the manpower, which has nothing more than its physical force, while the raw materials represent exchangeable trade goods. To Negri and Negri the industrial archaeology must therefore face with the physical expressions of the ways of productions typical of the industrial society, inserting this discipline in the academic field of the social history and underling the importance of paying attention to the people and the objects involved in the industrial development.

At the end of 1970s and the beginning of 1980s the Italian industrial archaeology was particularly interested in its publications and divulgation, focusing on its true significance: in 1983 the magazine *Archeologia Industriale* started its publications about the economical and industrial history and about the architectural values of the industrial sites and buildings; in 1985 was founded the Institute of Material Culture and Industrial Archaeology that two years later started to publish the magazine *Il coltello di Delfo. Rivista di cultura materiale e archeologia industriale* (*The Delfo's knife. Magazine of material culture and industrial archaeology*) to promote the inventory of the cultural heritage from the industrial era.

From the archaeological world Andrea Carandini[33] [34] proposed his definition of the character of the industrial archaeology stating, during the Industrial Symposium of Archaeology of Industry and Industrial Archaeology of Rome in 1978, that to understand the aims and the objects of this disciple it was necessary to determine a new significance to the word "industrial", intended only as a synonym of capitalist industrialization. Carandini's observations, however, were not put in

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[31] Cerdà Pérez, M. *Arqueologîa industrial: teorîa y práctica*. Edited by Universitat de València. Valencia, 2011, p. 32

[32] Ibidem, p.32.

[33] Andrea Carandini(Roma,1937) is an Italian archaeologist, mainly known for discovering, during excavations on the northern slopes of the Palatine Hill, in Rome, the ruins of a fortification the defensive walls. Student of Ranuccio Bianchi Bandinelli, he graduated disserting with him in 1962.He started his academic career the following year, at the tenure of Archaeology and History of Greek Art at University of Rome La Sapienza, between 1971 and 1981 he was professor of Archaeology and History of Roman and Greek Art at University of Siena. From 1983 to 1992 he was tenured professor in Archaeology and History of Roman and Greek Art at University of Pisa, and in 1984 he was appointed director and holder of the teaching in Archaeology and History of Roman and Greek Art at Graduate Archaeology School in University of Pisa. From 1992 he was tenured professor of Archaeology and History of Roman and Greek Art at University of Rome La Sapienza. He was also professor of Methodology and Excavation Technique and Archaeology and History of Roman and Greek Art at the Graduate Archaeology School in University of Rome La Sapienza. Between 2009 and 2012 he was President of the Council for the Cultural Heritage, substituting Salvatore Settis, who had previously resigned. Since 2013 he is the president of the Fondo AmbienteItaliano (FAI). Source: http://www.rizzolilibri.it/autori/andrea-carandini/

[34] Carandini, A. *Archeologia e cultura materiale. Lavori senza gloria nell'antichità classica*. Bari: De Donato, 1984. Op. cit. in Cerdà Pérez, M. *Arqueologîa industrial: teorîa y práctica*. Edited by Universitat de València. Valencia, 2011, p.33.

practice and in the following years the industrial archaeology progressively abandoned its ambitions for a theoretical and methodological definition, focusing merely on the issues of protection and conservation of the industrial heritage.

The founding circumstance of Industrial Archaeology in Italy is conventionally recognised in the first international convention[35] on the matter, held in Milan in 1977, as part of the exposition «San Leucio: archaeology, history, project» in *Rotonda della Besana*. The meeting, during which Kenneth Hudson and Eugenio Battisti – who was at the time introducing in Italy the theory of Industrial archaeology–debated, lead to the institution of the Italian Society for Industrial Archaeology (SIAI).

In the following years many other events and conventions were organized, to which many academics of the matter took part. Although that, Italy still lacked a national regulation of the preservation of industrial records, perhaps because the safeguard from destruction and loss of movable and immovable heritage – often consisting in considerable buildings – was more difficult because of State intervention rather than for works of art or architecture of historic-artistic interest.

In Italy, many situations lied behind such a slow development of the discipline.

The first one had an objective nature: progressively, many production sites – often placed in the historic centres or in the surroundings –were neglected and subjected to urban decline and urban speculation; protecting and promoting them meant both defending cities and landscapes, and fighting side by side with environmentalist and cultural associations against ruin and alteration. The second reason is more complicated and comes from the mutation of the concept of cultural heritage and the heuristic opportunities acquired through production objects and of everyday use. The spread of industrial archaeology derived from the awareness that objects can carry information as much as any archive document, book or picture; they are the result of human actions in which abilities and skills – otherwise unknown – are embedded. That is how they become an instrument to recreate different kinds of knowledge– often endangered –that needed protection as any other cultural heritage.

Unquestionably the influence of the French theories affected also the Italian epistemology. One of the main and most influential authors was Fernand Braudel[36] – French historian member of the *Longue Durée*[37]and director of the journal *Annales*[38]–, who emphasized, in *Civilisation*

[35] Negri, M. (eds). *Atti del Convegno Internazionale di Archeologia Industriale*. Milano: CLUP, 1978.

[36] Fernand Paul Braudel (1902 – 1985) was a French historian and follower of Bloch and Febvre, director of the journal Annales (1956 – 1972), one of the main representatives of the 20th French historiography. He became professor at *École pratique des hautes études*, and under the influence of Febvre directed his research towards Philip II of Spain and preferring, to the political events, the geographical situation and the re-enactment of the economic and commercial structures in the Mediterranean Sea. (From Online Encyclopaedia Treccani, in:http://www.treccani.it/enciclopedia/fernand-paul-braudel).

[37] The *longue durée* is a concept introduced in the historical field by historian Fernand Braudel in 1949, in his dissertation on the Mediterranean Sea and the Mediterranean world at the time of Philip II of Spain. The introduction of this concept allowed a new approach to historical facts: besides the traditional history (defined as

*matérielle, économie et capitalisme* (Material civilization, economy and capitalism)[39] – translated into Italian in 1977 –, the importance of means, working procedures, monuments and sites of the industrial civilization as irreplaceable records to understand the mechanisms of human societies. Although Braundel focused his reflection to the field of history, he did consider objects of the material culture as fundamental sources for the historical research, refusing the idea of the written records as only instrument of knowledge for historians. The formation of knowledge developed through objects of the material culture and productive procedures of the society, providing facts that written sources could not grant.

The Italian counterpart of Braudel was Alberto Caracciolo, who gathered the concepts of the French historian and defined the cognitive role and value of places and machinery of the industrial civilization for the comprehension of past and present societies. Moreover, Caracciolo[40] posed the issue of the multidisciplinary method – that is essential for the complete understanding of such events – and stressed the importance of the collaboration between scholars of different disciplines to complete the epistemology of industrial archaeology. This basic question for industrial archaeology in Italy over time shifted the interest of scholars from the specific industrial monument (one single building, machinery or factory) to the site (that is, the correlation between place, infrastructure, factory, machinery and man), evolving, finally, – in the last fifteen years – into the concept of an environmental stage where such bonds shape a territory or a whole region – through superimpositions, differentiations and interconnections – that is, the industrial landscape[41].

Further essential contributions for the development of industrial archaeology were made by Eugenio Battisti[42], who was the first to start studies on the matter[43], and Andrea Carandini, who broke the bound to history of art and classical archaeology and conducted studies on the most common materials in use in order to understand the ancient society through the material

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"eventual" and criticized by the *École des Annales*) made of short and fast variations, and besides the (economic and social) periodic and cyclical history, he described the almost-static history, concerning the long-lasting processes (the evolution of the landscapes, the relation between man and its context, etc), defining it as *la longue durée*.

[38] Annales d'histoire économique et sociale: revue trimestrielle, edited by Marc Bloch, Lucien Febvre and Fernand Braudel, published between 1929 and 1938.

[39] Braudel, F. *Capitalismo e civiltà materiale (secoli XV-XVIII)*. Torino: Einaudi, 1977.

[40] Caracciolo, A. (a cura di). *La formazione dell'Italia industriale*. Milano: Laterza, 1977. See also:
Covino, R. Lo storico, l'archeologo industriale e il patrimonio. In *Il capital culturale. Studies on the Value of Cultural Heritage*. *Journal of the Department of Cultural Heritage* (3/2011). Macerata: eum edizioni, Università di Macerata, 2011.

[41] Tognarini, I. Nesti, A. *Archeologia industriale. L'oggetto, i metodi, le figure professionali*. Carocci ed. 2003, in part. pp. 158-168.

[42] Eugenio Battisti (Turin, 1924 – Rome, 17 October 1989) was an Italian art historian and critic.

[43] Battisti, E., Battisti, F. M. (eds.). *Archeologia industriale. Architettura, lavoro, tecnologia, economia e la vera archeologia industriale*. Milano: Jaca Book, 2001.

culture[44]. Carandini posed clearly the issue of what is to be considered cultural heritage, and his definition became then the criterion to interpret the discipline itself: the benchmark of heritage is not to be set only through its historic and artistic value, neither through the concept of *beauty* – as it was common in the Italian tradition –, but it has to be completed with instruments that allow an interpretation of the economic, social and infrastructural modification of a country or – in its small way – of the analysed community.

In the 1970s Massimo Negri introduced in Italy the English theories on industrial archaeology. He so defined[45] industrial archaeology:

*"Industrial archaeology is the discovery, recording and study of the physical remains of industrial activities and the routes of the past. In every decade [scholars] will interpret the word study in their own way, with their criteria about what is to be investigated and which details are worth recording."*

Furthermore, he explained briefly the development connected to the introduction and the interest for this discipline by saying:

*"In Italy, the adoption of the term industrial archaeology in the common speech came after a long period of transition full of industrial monuments cataloguing in the various regions, the creation of a considerable corpus of art house photography (mainly inspired by the work of Gabriele Basilico[46]), the realization of countless photo shoots and TV reports that found the perfect set in industrial archaeology sites. […]The industrial and modernist epic of those last cultural milieus were progressively replaced by the re-elaborated version of physical and visual material of the bygone, neglected or even dead industry. Thus, we can say that the perception of the industrial archaeological sites in the terms of a monument spread throughout the common cognizance, first of all in the aesthetic field, and moreover in the awareness of the technological or historical-social values it bears."*[47]

Few years later, in 1975, the constitution of the Ministry of Cultural Heritage[48]helped, even though indirectly, the recognition of industrial heritage. In fact, the Ministry had the objective of

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[44] Carandini, A. *Archeologia e cultura materiale. Dai "lavori senza gloria" dell'antichità a una politica dei beni culturali*. Bari: De Donato, 1979. Op. cit. in Covino, R. *Archeologia Industriale: usi impropri e potenzialità euristiche*. In Notiziario Semestrale AIPAI (II/3) December 2008, pp. 15 – 17.

[45] Negri, M. L'archeologia industriale si è persa per strada? Sintesi e commento di un dattiloscritto di Kenneth Hudson. In: *Culture e Impresa*, online journal n.2 2005, p. 1.

[46] Negri, M. Gabriele Basilico e l'archeologia industriale italiana. In: *Aree industriali dismesse tra memoria e futuro*, edizione bilingue a cura dell'Ecomuseo di Le Creusot, 2002, available on www.euroinpat.org

[47] Negri, M. L'archeologia industriale si è persa per strada? Sintesi e commento di un dattiloscritto di Kenneth Hudson. In: *Culture e Impresa*, online magazine n.2 2005, p. 2.

[48] The Ministry for Cultural Assets and Environments was set up by Giovanni Spadolini with the Legislative Decree n. 657, dated 14th December 1974, becoming law n.5 dated 29thJanuary 1975. It was established so as to entrust the management of the cultural and environmental heritage unitedly to the specific jurisdiction of a Ministry expressly set up, directed to the systematic protection of extremely relevant interests internally and nationally. Authorities coming from the Ministry of Public Education (Antiquities and Fine Arts, Academies and Libraries), Ministry of Interior (National Archives) and of the Presidency of the Council of Ministers (Institute for the Auditory

creating a single State body for the protection, the safeguard and the promotion of the cultural heritage, in light ofthe goals reached during the World Heritage Convention in 1972. It should not be underestimated that the only legal expressions on the Italian cultural heritage dated back to thirty years earlier, with law 1089/39 "Things artistically and historically of interest" and 1497/39 on the safeguard of "Panoramic and natural beauty", but in both cases, they were a list of "things" that needed being safeguarded, still with the concept of cultural heritage that will later on merge in the Constitution of the first Italian Republic.

The promotion of industrial archaeology, at that time pursued both institutionally and academically, responded to the demand for forming knowledge through the actual expression of the different abilities, to the materials, the procedures and the working sites. This need was supported also by the awareness that the knowledge of past bound to productive and socio-economical elements – affecting the current cultural and ethnological conditions – had to consider also the materiality of the objects, of the technological processes, of the sites and the working sites. Carandini[49] defined industrial archaeology as archaeology of the contemporaneity, subsequently including sites and production tools that are a part of the productive and industrial context from the 19th Century up to nowadays.

In Italy the research began with the study of manufacture plants (i.e., silk mills, wool or paper water-powered fulling mills) of the 16th Century, that decayed rapidly, not so much and not just "[because of] the general crisis of the medieval communes, the downfall of princedoms and *Signorie* and eventually the foreign occupations"[50], but mainly because of the scarce openness of the market, that limited the technical implementation until the 19th Century. This understanding originated the "Italian way" of industrial archaeology, in the 1970s, followed and scientifically promoted by economy[51] and architecture[52] historians.

The fate of the discipline suffered the effects of the contradictive politics from 1980s and on: the initial success in the 1970s was succeeded by an almost total eclipse in the following decade. It was not until the 1990s and the first half of the 2000s that the concepts of recovery of the socio-cultural and identity-making value of the factory in the context of the collective heritage were restored. The reasons behind this deceptive behaviour lied chiefly in the fact that the concept of factory underwent an essential shift in the 1980s: from a symbol of innovation, efficiency and

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and Audio-visual Heritage, publishing industry and cultural distribution). With the Legislative Degree n.368 dated 20th October 1998 the new Ministry of Cultural Heritage and Activities and Tourism was set up, that gathered the duties of the Ministry for Cultural Assets and Environments, plus the promotion of sport and shows. Source: MiBACT.

[49] Carandini, A. *Momenti dell'archeologia italiana*. Bari: De Donato, 1979, pp. 300-328. Op cit. in Covino, R. *Archeologia Industriale: usi impropri e potenzialità euristiche*. In Notiziario Semestrale AIPAI (II/3) Dicembre 2008, pp. 15 – 17.

[50] Covino, R. Le seduzioni del dismesso. L'Archeologia Industriale. In *Le variazioni grandi – Quaderno di comunicazione* n. 8, 2008, pp. 101-108.

[51] See: Poni, C. Archeologie de la fabrique: la diffusion des moulins de soie alla bolognese dans les Etats vénetiens de XVI au XVIII siécle. In *Annales. Economies, Societés, Civilisation*, n. 6, 1972, pp. 1475-1496.

[52] See: Borsi, F. Una via italiana per l'archeologia industriale. In *Patrimonio architettonico industriale*, numero monografico di Restauro n.38-39, 1978, pp. 19-32.

economic growth, it turned into a wreck from the past[53], abundant with allure and fascination from the moment it stopped being a place of production. Similar places, in fact, represent a real opportunity only when emptied by their usual inhabitants: the equipment leaves room for cultural events, for spaces whose adaptability and dimensions are available for different purposes, difficult to find in the classic architecture of the city centres. On one side, factories had their revenge through alternative plans and investments that also abroad[54] rewarded their loss of productive meaning; but on the other speculation often lead to the demolition of industrial sites, either for the dimension of the lots or the possibility to build new urban areas.

The recognition of the value of industrial sites as cultural heritage came after political, academic and administrative alternations. Only in 2013 motions to reinforce the Cultural Heritage were launched, after the normative review of the Consolidated Law on Cultural Heritage presented by the Commission lead by professor Settis, and thanks to the reform of the Code of Cultural Heritage and Landscape in 2004, resulting from the proactive overture of Franceschini (1964) and Papalado (1968) Commissions[55]. The former– even if it did not explain thoroughly the concept of historical heritage – had the merit of adopting the definition of Cultural Heritage for *"anything constituting physical proof that has cultural value"*; moreover, it extended the principles of the Venice Charter to vernacular, modern and industrial architecture and cities, defining the scientific and normative basis for their safeguard and transmission to present and future generations[56]. Despite the concept of industrial heritage developed over time as a method for the historical, cultural and social comprehension of the society through its architectural and productive expressions, it did not guarantee its recognition as part of the world heritage. Some circumstances must occur, for this to happen: first of all, the society must express its will for the recognition of the inalienable identity-making value that the industrial sites represent for its past, and against the demolition of the site or loss of the values; secondly, State authorities must undertake the safeguard and preservation of the sites and ensure a change process towards them, and prevent the use stagnation, which represents itself a loss for the community.[57]

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[53] Covino, R. *Archeologia Industriale: usi impropri e potenzialità euristiche*. In Notiziario Semestrale AIPAI (II/3) December 2008, pp. 15 – 17.

[54] It is exemplifying the case of Catalonia, in Spain, where it still exists an extensive network of museums of production and industrial routes.[Author's note]

[55] The Franceschini Commission was named after its president and was set up by the Italian Parliament with the law n.310 dated 26th April 1964, on proposal by the Ministry of Public Education, the administrative and legal apparatus for the Cultural Heritage before the creation of the Ministry for Cultural Assets and Environments.
The Papalado Commission, presided over by professor Antonio Papalado, took office on 9th April 1964. It was created by the Ministry of Public Education, and it brought to the creation of legislative decrees "on safeguard and promotion of cultural heritage".

[56] Ferreira Franco, B. *Il patrimonio industriale della Sardegna: il Parco Geominerario come strumento per lo sviluppo del territorio*. PhD Thesis in Architecture. Aymerich, C. Sanna, A. University of Cagliari, A.A. 2011/2012.

[57] About it, see also:

*The industrial archaeology nowadays*

During the introduction of the TICCIH Conference in London in 2000, Marilyn Palmer and Peter Nevearson[58] proposed a reflection on the state of the art of the industrial architecture till then: although it had developed during the last decades, the development followed different but connected directions: on one side the proposals of reuse and protection of the heritage had focused on programs intended to preserve and study the industrial heritage in a sustainable way, involving thus the local or central Governments. On the other the elements involved in this discipline counted not only the material testimonies of the past 250 years but also those related to the social, cultural and economical factors involved in the industrialization processes. Moreover, while in many Countries the conservationist approach had kept coinciding exclusively with the field of interest of the industrial archaeology, in Great Britain in the early 1980s the initiative to create academic courses on this topic had progressively decayed, being however implemented in the following decade thanks to an academic acknowledgment. Many studies and researches focused in those years on the manufacturing buildings, promoted by several Royal Commissions and evolved into specific monographies and articles about the English industrial heritage. Although this consistent literature, the investigation of the physical features and of the function of the single industries or factories was still insufficient and it missed to explicate how the industrial heritage had affected the social and the urban dimensions carrying modifications of the way of life and of working in the communities. This implies therefore that it needs to add new techniques and new tools to frame these modifications, borrowing them from other disciplines such as the archaeology and the history, through the search of written documents, oral sources and graphic documents of the former industrial society in order to create a proper kit of tools. From the 1990s there was therefore a new deal of investigations and researchers that developed a new methodology based on the use of those techniques, passing from the study of the matters of the productivity and of the industrial evolution to the investigations of the social implies of that period, reflected in the constructive techniques and in the use of the spaces, in the changes of the landscape passing from rural to urban and in the structural configurations. This new approach is intimately linked to the British archaeological field that focuses on the archaeological object as the primary source of information along with the documentary and oral sources, becoming therefore *"the archaeology of the industrial period"*[59].

Outside Great Britain the issue of the industrial archaeology was the opposite: the archaeological method was in fact referred to the architectural or the aesthetical evaluation of

Vitale, A. Luci e ombre sulla gestione del patrimonio industriale dismesso. In *TECHNE. Journal of Technology for Architecture and Environment* (03/2012). Firenze: Firenze University Press, 2012, pp 97 – 101.

Bergeron, L. Industrial heritage tra archeologia industriale e processo di patrimonializzazione. In: Ronchetta, C. Trisciuoglio, M. *Progettare per il patrimonio industriale*. Torino: Celid, 2008, pp. 6-8.

[58] See Palmer, N., Nevearson, P. *Industrial Archaeology: Principles and Practice*. London: Routledge, 1998.

[59] Palmer, M. Understanding the Workplace: A Research Framework for Industrial Archaeology in Britain. *Industrial Archaeology Review*, 27:1, 2005, pp. 9-17. Op. cit. in Cerdà Pérez, M. *Arqueologîa industrial: teorîa y práctica*. Edited by Universitat de València. Valencia, 2011, p. 44.

the industrial object, without enhancing the stratifications that occurred in the building or the territorial analysis carried on through the historical cartography and the historical understatement of the social construction[60], which frequently ended to be a mere reductive geographical analysis.

In Italy in 1997 was founded the Italian Association for the Archaeological Industrial Heritage (AIPAI) and an Italian section of the TICCIH: the aims of the first associations were practically the recording, the catalogue and the inventory of the "goods of the industrial civilization", promoted through several Congresses of which we remember the one in Terni in 2000 "*Archeologia industriale: la conservazione della memoria*" (Industrial Archaeology: the conservation of the memory) focused on the legal and social management of the industrial heritage; the Congresses in Rome titled "*Una comparazione di esperienze e territorio*" (A comparison of experiences and territory) in 2003 and "*Il patrimonio industriale in Italia. Dall'oggetto al contesto, dalla conoscenza alla politica*" (The industrial heritage in Italy. From the object to the background, from the knowledge to the politics) in 2005. The Italian literature of 1990s is mainly dedicated to the study of the industrial heritage at a local or regional scale, mainly in regions like Emilia Romagna, Lombardia, Veneto and Piedmont thanks to the richness of their industrial production[61].

In the same way the other European Countries were the concepts of industrial archaeology and industrial heritage have become synonyms: they have thus developed programs and political actions aiming to save and valorise the industrial remains and presenting the results in a long and proficient series of congresses and publications, thanks also to the local and national associations.

*The objective of the industrial archaeology*

The theoretical distinction between the concepts of industrial archaeology and industrial heritage have conditioned the evolution of the first, which focused almost exclusively on the study and the conservation of the industrial monument, leaving the issue of the scientific methodology, able to generate a historical knowledge through the investigation and the interpretation of the material vestiges, almost unexplored. This led to a long series of researches focused on the industrial objects without paying the necessary attention to their location inside a certain landscape or territory, without applying the archaeological techniques due to the lack of a proper methodology and valorising only the most significant industrial remains, i.e. the "monuments", discarding those that are perceived as a source of information but lack of architectural or aesthetical values. Numerous publications have therefore concentrated on the most relevant industrial remains but have also forgotten of the ruins that, although featuring important evidences as testimonies of the industrial events, stand only as imprints of the past.

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[60] Cerdà Pérez, M. *Arqueologîa industrial: teorîa y práctica*. Edited by Universitat de València. Valencia, 2011, p. 46.

[61] Ibidem, p. 46.

The lacking of a proper trainee for those who investigate the themes of the industrial archaeology is therefore affecting the correct development of the discipline, due to a general unawareness of the archaeological methods and to the researchers' attitude to focus more on the history of the architecture or on the technical aspects of the construction or the economical history labelling the results under the general topic "industrial archaeology". In this sense the main aim of the industrial archaeology derives from the interests of the researchers, which is unacceptable in a discipline that claims to be rectified by norms and criteria: the main consequence of this behaviour is that the industrial archaeology keeps to be an uncertain field, whose objectives and interests are variable and undefined unless we accept that the industrial archaeology and the industrial heritage are part of a whole thing.

After this statement we may be able to define the main reason of the investigations on the industrial archaeology: it is the "*study of the material culture of the industrial – capitalist society, i.e. the compound of physical manifestations created by a human community in a certain time*"[62]. Andrea Carandini offered us a further definition of the material culture, that is "*a project of investigation consisting in a new way of reconstruct the history (intended in its whole dimension, as a rational narration of how the things have been really by the point of view of those who have produced them) starting initially from the most predominant materials in the working aspects*[63]". The investigation of the material culture could also be directed to the study of a proper industrial society through its real manifestations, its materials and their use: the application of the industrializing processes is therefore appreciable in the elements of the industrial reality, such as buildings, workshops, machineries, transport facilities, communications, agricultural improvements, dwellings and leisure facilities and so on, which represents the tangible expressions of the material culture as the result of the manpower, the social relations and the way of life of the studied communities. The research on the industrial heritage must therefore consider both the material expressions and the social and territorial contexts in which they were produced and expressed[64].

At the light of these considerations it is more appropriate to investigate not only the industrial "monuments" themselves but the whole amount of physical manifestations inside a certain society caused by certain historical factors: the material testimonies are therefore a mean to create historical knowledge to better explain the evolution of a human society and to comprehend the identity and the values of that community in confront to the present conditions, leading thus to the analysis of an industrial reality through its remains and expressions – and not to the opposite, i.e. the study of the industrial heritage of the industrial society.

The theoretical definition is however more complex than this: too often we forget that the investigative process should follow two phases, i.e. the question to define the problem from

[62] Cerdà Pérez, M. *Arqueologîa industrial: teorîa y práctica*. Edited by Universitat de València. Valencia, 2011, p. 50.

[63] Carandini, A. *Archeologia e cultura materiale. Lavori senza gloria nell'antichità classica*. Bari: De Donato, 1984, p. 250. Op. cit. in Cerdà Pérez, M. *Arqueologîa industrial: teorîa y práctica*. Edited by Universitat de València. Valencia, 2011, p. 50.

[64] Ibidem, p. 51.

which the investigation starts and the path to follow in order to obtain the needed information, which are obviously connected to each other. This mistake frequently led to a misunderstand between the theoretical aiming and the practical results pretending to be considered as industrial archaeology, although obtained through decontextualized works where the building (factories) or the machinery represent the final purpose for themselves and not a researching tool. The main consequence of this attitude is that the industrial archaeology stops to be the study of the expressions of the human actions, moved by social interactions and determined rational factors, connected to a certain landscape, affecting public and private lives, raw materials, communications and so on[65]. The main aim should therefore be the interpretation of these social, economical and technical relations giving in turn a picture of the whole "living system" interested by the industrial productions.

It is easy understandable that the theoretical definition of this discipline might often be confused with the economical, or the technological or the architectural history related to the industrial production, however we must not forget that it investigates on all of these aspects in order to identify the transformations occurred in the society due to the industrialization and its consequences: the means are clearly those of the above – mentioned disciplines and the more they are used the more the investigation would be completed and accurate, thanks to the multidisciplinary feature of the researching approaches; finally, the cognitive process obtained through these techniques would be reactivated in turn by the results in a sort of feedback relation. Even the chronological limits inside which the investigation should be inserted need to be specified, in order to avoid to confuse all the manifestations of the human production with an industrial significance: the industrialization must be intended as the results of the social and economical transformations that started in Great Britain in the 18th century and evolved in the capitalist system that featured the majority of the industrialized European Countries during the following century. The causes of this general evolution in the production and in the social assets must therefore be considered as the starting point of chronological input of the industrial archaeology referring, however, to the peculiar manifestations that interested each Country in a very specified manner: the industrializing process that evolved in Great Britain will be necessarily from the one in Spain or in France, even because the passage from the pre – industrial phase to the discharge of a specific technology to promote another one did not happen in the same moment and did not evolved in the same way. The Industrial Revolution and the Capitalist Industrialization started and developed with different scenarios and different speed and this is the main reason why the industrial archaeology must investigate the reasons of these differences inside the various social realities. This condition is the one that allows the industrial architecture to stand out as an autonomous discipline, distinguished from the archaeology itself thanks to the implications that all the factors involved in the industrializing process have determined in the involved field. The contributes borrowed by disciplines such as the technical architecture, the economical history and the history of technology must not let us equivoque the real individuality of this topic, amplified in the last decades through the development of proper researching

[65] Cerdà Pérez, M. *Arqueologîa industrial: teoría y práctica*. Edited by Universitat de València. Valencia, 2011, p. 53.

techniques and fields of interest[66].

[66] Ibidem, pp. 73 – 75.

### International authorities, Charters and Conventions

Even if we discussed industrial archaeology in the academic and scientific context so far, the institutional and normative contribution should not be underestimated, as it allowed – from the 1960s up to now – the introduction of preservative and promoting procedures of worldwide relevance about the industrial heritage. After the Venice Charter in 1964 – which extended and defined concepts such as historical monument, preservation and restoration[67] – many other declarations and Charters, both nationally and internationally, were compiled, culminating, in 1972, in the UNESCO Paris Convention concerning the Protection of the World Cultural and Natural Heritage – that represented the beginning of a more mature overture to the matter – in which the Convention on World Heritage – the mould of following Heritage Charters - was written.

This period marked the affirmation of the will to intervene for the collective promotion of such a valuable heritage through modern scientific methods, which allowed, through continual updates[68], the full introduction of buildings, objects and knowledge of the industrial age in the List of World Heritage: in fact, it includes not only monuments in the widest sense, but also sites and building conglomerations derived from man's sole or joined to nature's work of historical, aesthetic, ethnological or anthropological interest. This historic achievement of pooling and international participation direct to the cooperation and safeguard of the Universal Values of the Cultural Heritage was the first of various normative and conventional forms promulgated by UNESCO or by the member states. Especially the operative guidelines stand out, as they aim to guarantee the correct identification, protection and preservation of every member's heritage[69], in order to avoid the loss of knowledge or cultural and social identity the listed monuments carried. The guidelines, in fact, are essential for the understanding of the procedure of accreditation of the cultural heritage the member states need to follow in case they wish to register their properties either in the List of World Heritage or the List of World Heritage in Danger[70] and guarantee international support by the World Heritage Committee. Also in case of reuse and safeguard of cultural heritage proposals, UNESCO establishes as basic condition the

[67] The concept of monument includes both the architectural creation and the urban or environmental surroundings embodying evidence of a different civilization, of a substantial evolution or of an historical event. The preservation and restoration of the monuments aim to safeguard the work of art itself but also the historical proof. See: Venice Charter on Restoration, text agreed by the International Convention of Architects and Historical Monument Technicians, 1964, available in: http://www.brescianisrl.it/newsite/public/link/cartavenezia_1964.pdf

[68] In particular, see: Convention for the Safeguarding of the Intangible Cultural Heritage - Paris, 17 October 2003; Convention on the Protection of the Underwater Cultural Heritage - Paris, 2 November 2001; Convention on the Protection and Promotion of the Diversity of Cultural Expressions – Paris, 20 October 2005.

[69] The guidelines to which this dissertation refers are those promulgated in 1977 (later inspected and updated again in 1980), and in particular to its updates dated 2013 and 2015, available on: whc.unesco.org/en/guidelines/

[70] Clauses I.a and IV.b of the Operative Guidelines promulgated by the UNESCO World Heritage Committee in 2013: according to the Convention, the Committee can register a record in the List of the List of World Heritage in Danger if it belongs to the List of World Heritage and is endangered by a severe and actual threat, reported by a Member State in the Reactive Monitoring phase on the conditions of the record over time.

sustainability of interventions, in pursuance of contributing with the quality of life of the communities involved in the protection and conversion process. This requirement has to be guaranteed by member states for the conservation and safeguard of the Universal Value of Cultural Heritage.

Specifically, on the matter of industrial heritage, an actual step forward was made in 2003, when TICCIH promulgated the *Nizhny Tagil* Charter[71], affirming the fundamental importance of industrial buildings and structures in the social and cultural configuration of communities and countries and promoting the study of constructions of the industrial heritage sites, confirming the principles of the 1964 Venice Charter.

Industrial heritage holds the remains of industrial culture having historical, technological, social, architectonical or scientific value, either if they consist in buildings, machinery and working, mining or refining sites, or if they are linked to industry, such as housing, schools or social welfare; its meaning includes the production of documents, artefacts, structures, human and natural settlements, urban landscapes shaped for/by industrial processes, chronologically distributed from the Industrial Revolution to our days, definitely overcoming the limitation to the 19$^{th}$ Century industrial phenomena. The main goal of the Charter is to enhance this heritage, in the light of its uniqueness and peculiarity, of its historical role and the consequences of its effect on the development of communities and industrial sites; from the recognition of the cultural, identity-making, social and landscape value derives the importance of the identification, registration and protection of this heritage through the means proposed in the Charter, such as the inclusion in the World Heritage List or in the List of UNESCO World Heritage in Danger, the legal defence, the protection and preservation of the documents and the intangible heritage in specific facilities, economic development programs and regional or national planning tools considering the industrial heritage preservation.

Recently, another step forward has been made for the consideration of the industrial heritage as a common good in Europe, based on what UNESCO declared – that is, supporting and inviting the member states to cooperate for the safeguard and circulation of the value of their industrial heritage – and on the requirement of a systematic and congruous census of its extent and the various situations in which it appears. Between 2003 and 2008 the project *European Route for Industrial Heritage (ERIH Intereg II C)* was developed inside the European Union, aiming to create a masterplan for the conception of ideas and actions direct to the promotion of the European Industrial Heritage, and which is still operating in some countries of the EU (first of all, Spain, France and Germany), in which it keeps the fruition and divulgation of the identity-making and cultural values of the industrial plants, disregarding the building period and ideological boundaries of the national preservation and safeguard programs.

[71] TICCIH (The International Committee for the Conservation of the Industrial Heritage) The Nizhny Tagil Charter for the Industrial Heritage, 17$^{th}$ July 2003. The text of the Charter was written and subscribed by the representatives during the TICCIH Triennial Conference held in Moscow.

## The *Construction History*: from the construction of the knowledge to the research methodology

The *Construction History Society* is an association aimed at promoting and studying the history of construction, concentrating on the identification and protection of the information and archive sources that regard the history of construction, organizing and promoting events and periodicals on the matter.

Thus, the Construction History is the key element to understand and date structures: a peculiar technique used in a specific time may suggest the construction period of the building, and so it allows dating an edifice or understanding a shifting constructive sequence within the same construction. Since many buildings change over time, it is fundamental being able to understand the different constructive phases and their importance in the constructive chronology of the building itself.

It is undoubtedly necessary the full comprehension of social and economic circumstances that influenced the various constructive techniques in order to totally understand their history, and that is why the Construction Society includes also the history of the development of the associations, the contracts and trade companies, payment methods, working timetables, salaries, working conditions and worker's training. The Construction History – apart from the comprehension of the role and the conditions of workers in the building sites –investigates also how people in the past thought constructive technology itself: how did they calculate if a building would stand? How did they lay the foundations? So, it is inevitable a superimposition of fields such as history of engineering and of building workforce, including supervisors, designers, architects and engineers over time.

The Construction History covers all the periods, from the first sign of human activity to the recent past, from the cavemen's dwelling to nuclear plants. Of course, the techniques used to study different periods vary: the earliest buildings lack of written attestation, so the description, in general, depends entirely on the interpretation and archaeological surveys. Written attestations can be used for more recent sites, together with archaeological surveys. Later on, many detailed documents might have endured, recording how constructions were built through illustrations, models and pictures, and even oral testimonies of those who participated in the work can be registered and used in the study.

Often those who study the history of a building are also concerned with its preservation and restoration. However, the Construction History deals with the history of the development of construction industry, and thus concerns facts about the constructive history discovered during restorations or preservative actions. Therefore, since their purposes and results go beyond the historical field of interest, recoveries and conservative activities are not considered, unless the restoration of the building is not part itself of the development of the building. The Construction History is not unaware of the importance of recovery and preservation in the service life of buildings, yet in focuses on the study of building history and not on how a restoration should be done; nevertheless, it represents an essential gear of knowledge, given the recovery or maintenance of historical edifices.

The Construction History aims to collect facts on the past life of edifices, their building history and the techniques used in the construction phases over the various periods. The main questions it tries to answer are:

- How and why this edifice was built?
- Which techniques employed the contractors?
- What are the materials used?
- How much did they cost?
- What lessons can be learned through the history of this building?

Unluckily, often too little is known about the origin of the building, due to the loss of the blueprints and of the information on the building techniques and costs, so that recurrently the construction history of a building or of a site has to be completed through suppositions based on the conservation status, or through indirect information found in other sources, sometimes not included in the documentary or photographic heritage linked to the specific project; this happens, for example, while examining private or corporate mail, bookkeeping, daily allowances, general journals or corporate records in which information, facts or content on the matter might be found.

To fully understand the precise reason of academic interest towards the Construction History, it should be clarified what it really is: a technical approach to the conception of built world, architecture and civil engineering work, a difficult approach not unanimously accepted. The main problem in defining this discipline is now subject of discussion: after the first contributions by Summerson[72], for example, Dunkeld[73] analysed the matter and Louw[74] presented recently an essay in Madrid.

Some reasons lie behind the attention paid to the technical aspect: first, if a new discipline is emerging, it must have an easily recognizable identity, and the technical aspect represents the core of the Construction History. A more general approach would cause the Construction History to merge with other disciplines: history of architecture, archaeology, restoration of historical edifices, history of sociology and economy, etc. Truth is, many of these disciplines are important in the Construction History, but if the focus drifted towards one of these other fields, this new-born discipline would be undoubtedly subjugated by the corresponding prominent discipline. As said by Ricardo Aroca Hernández-Roz and Antonio de la Casas Gómez in the prologue of the Proceeding of the First National Congress on Construction History, organized in Madrid in 1996:

"*Construction History has its own filed and method. It requires the same recognition for history, technique and for the executive process. It is reasonable to think that this double request,*

[72] Summerson, J. What is the History of Construction? In: *Construction History,* vol. 1, 1985, pp. 1–2.

[73] Dunkeld, M. Approaches to Construction History. In: *Construction History*, vol. 3, 1987, pp. 3–15.

[74] Louw, H. Aesthetics, ethics and workmanship: The need for a cultural dimension to Construction History. In: Huerta, S. *Proceedings of the First International Congress on Construction History*. Madrid: Instituto Juan de Herrera, 2003, pp. 1335–44.

*difficult to satisfy, is what restricted until now the study of construction history."* It is not a new discipline, because "*architects and engineers in the second half of the 18th Century wrote their first works*" trying to make understandable "*the constructions taking into account the architectural conditioning, too.*"[75]

The surveys that lead to such approach require previously acquired knowledge, indeed, in this case technical knowledge. Without it, it is impossible to express pertinent questions on architectural knowledge. That is the main barrier for customary historians: they lack an adequate technical background to comprehend some kinds of queries. Some technical details might be understood, such as the shape of the stones in medieval architecture, but the main difficulties are in understanding the builder's point of view, that of the whole building process. Some important sections of classic treatises on architecture concern topics of high technical value (the production of cements, cutting the stones, plan of the incline, the building of wooden centrings, etc). But often architecture historians skip those sections, simply ignoring the technical treatises that made the history of construction in the last centuries, such as Fray Lorenzo de San Nicolás[76], Bélidor[77], Rondelet[78] etc.; and it gets worse when talking about stereotomy, carpentry, structural theory or building materials. Only in the last three or four decades did a systematic interest for such specific topics rise again, but still the references are wanting and fundamental bibliography is still lacking. Therefore, Construction History requires people interested in history with a technical education, historians ready to confront themselves with the complexity of technical themes or, in other words, people able to cover the gap between building technology and humanistic studies (arts, history, architecture, etc). Another one essential requirement concerns the specific methods of this new discipline.

The interest in building techniques from past periods can be traced back to Vitruvius, who used to quote Greek building treatises; surely, he was not undertaking an academic research project, but he did study the ancient Greek building tradition. The systematic analysis of the Roman ruins began in the Renaissance with the works by Brunelleschi, Donatello and others. Perhaps the main focus was on the terminology of the classical orders and the compositional laws, but Vasari wrote clearly on Brunelleschi's interest for Roman structures. It could be that the sight of the heavy masses of *opus caementicium* influenced to a certain extent the idea of what could be built and the exact proportions between the various load-bearing elements: The Pantheon was used as a model for Bramante's project for the Dome of St. Peters, while Leon Battista Alberti's description of wall building represents a vague memory of the Roman

[75] Aroca Hernandez – Ros, R., de las Casas – Gòmez, A. Pròlogo. In de lasCasas – Gòmez, A., Huerta – Fernandéz, S., RabasaDìaz, E. (eds.). Actas del Primer Congreso Nacional de Historia de la construcciòn, Madrid, 19 – 21 settembre 1996. Torrejon de Ardoz (Madrid): EFCA S. A. Parque Industrial Las Monjas, 1996, p. XI.

[76] San Nicolás, Fray Lorenzo de. *Arte y Uso de Architectura*. *Primera parte*. Madrid: 1639. Op. cit. in Huerta, S. Construction History in Spain. In *Construction History: Research Perspectives in Europe*. Fucecchio (Florence): Kim Williams Books, 2004, pp. 43-59.

[77] Belidor, B.F. *La science des ingénieurs dans la conduite des travaux de fortification et architecture civile*. Paris: 1729. Op. cit. in: ibid.

[78] Rondelet, J. *Traité théorique et pratique de l'art de bâtir*. Paris: chez l'auteur, 1802–10. Op. cit. in: ibid.

construction of bricks or stones embedded in concrete, and Roman bridges were the model for builders in the following epochs.

At the beginning of the 19th Century the majestic treatise by Rondelet included many monographic studies on some of the most important buildings from the past: The Pantheon in Rome, Basilica of St Vitale in Ravenna, the Cathedral in Florence, etc. The first systematic studies were conducted in the context of analysis and interpretation of the gothic architecture: first Robert Willis in the United Kingdom and Viollet-le-Duc in France, later on Ungewitter[79] in Germany, but these studies were so focused on the gothic architecture, that there was no possibility to include them in a new discipline.

Augustine Choisy has been the first who tried to define a new approach. In his introduction to *Art de bâtir chez les Romains*[80] in 1873 he explicitly the method and objectives to pursue, explaining in the introduction that:

"*ancient buildings have been described several times under the architectural point of view, but the details of their building are still vaguely known*."

After the first volume, he published *L'art de bâtir chez les Byzantins* in 1883 and *L'art de bâtir chez les Egyptiennes* in 1904, while in the monumental *Histoire de l'architecture* in 1899 and *Vitruve*, published posthumously in 1909, he wrote about the whole matter of architecture, stressing the importance of the technical elements. Choisy can be considered the father of Construction History, as he wittingly introduced this approach in a clear way, contributing to its elevation (Choisy's analysis of Roman and Byzantine edifices, even if with some historical errors, were never outdone in the description of technical problems and processes used).[81]

Other authors followed the technical-rational approach used by Willis, Viollet-le-Duc and Choisy. In Germany, for example, the architect Josef Durm[82] wrote superb essays on the construction art in ancient Greece, Rome and in the Renaissence; although it occupied only part of the work, he gave great importance to the technical aspect and included plenty of analytic drawings of the architectural elements of the buildings. Mohrmann[83] reviewed Ungewitter's manual and published a new edition in 1890, where the systematic use of structural analysis was introduced for the first time to comprehend the mechanics in gothic cathedrals and link those results to their edification and architectural composition. Many other construction manuals included a historic section with descriptions of the buildings and the past procedures, according to Rondelet's model, and including the new analysis by Choisy, Durm,

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[79] Ungewitter, G. *Lehrbuch der gotischen Konstruktionen*. Leipzig: T. O. Weigel, 1859–1864. Op. cit. in: ibid.

[80] Choisy, A. *L'art de batir chez les Romains*. Parigi: Ducher et C.ie, 1873. Op. cit. in: ibid.

[81] Huerta, S. Construction History in Spain. In *Construction History: Research Perspectives in Europe*. Fucecchio (Florence): Kim Williams Books, 2004, pp. 43-59.

[82] Durm, J. *Die Baukunst der Griechen*. Leipzig: Diehl, 1881. Op. cit. in: ibid.

Durm, J. *Die Baukunst der Etrusker und Römer*. Darmstadt: Diehl, 1885. Op. cit. in: ibid.

Durm, J. Die *Baukunst der Renaissance in Italien*. Stuttgart: Bergsträsser, 1903. Op. cit. in: ibid.

[83] Mohrmann, K. *Lehrbuch der gotischen Konstruktionen*. 3rd ed. Leipzig: T.O. WeigelNachfolger, 1890.

etc. Some examples are Breymann[84], Gottgerteu[85] and Esselborn[86], while monographies on the architectural currents stressed – like in Egle's[87] works – the constructive descriptions.

Another common thread for the Construction History can be found in the general histories of technology, in which there were always chapters about construction and civil engineering. The interest for the history of engineering began in the mid-19th Century[88], but the foundation of Construction History as an independent discipline dated to the beginning of the 20th Century: building was considered part of technology and it was only partially regarded by the academics. Neubrger, for example, wrote about it in some chapters of the *Die Technik desAltertums*[89] in 1919, and some other chapters treat of the construction in the *History of Technology*[90], edited in 1954-1958.

The advent of Modern Architecture decreased mercilessly the interest for the Construction History in the first part of 20th Century: it was not only a style twist, but a complete change in the building process. The old tradition of wooden and concrete construction, vaults etc., that dominated for millennia, came suddenly to an end, and the academics and theorists stopped studying this kind of buildings. Undoubtedly there have been a certain degree of inertia in abandoning this current: some scholars kept on teaching the traditional constructive methods, some architects kept on projecting with traditional architectural styles, some books[91] were published on the matter – with little favour. This kind of works was considered obsolete and was simply ignored even by the 1900s-1940's bibliography, as the content revision of architecture journals and alike denote. Only in the 1950s an interest for the Construction History was renewed, especially thanks to the archaeologists: the major works by Blake and Lugli[92]

[84] Breymann, G.A. *Allgemeine Baukonstruktionslehre mit besonderer Beziehung auf das Hochbauwesen*. Suttgart, 1856 1863. Op. cit. in: ibid.

[85] Gottgetreu, R. *Lehrbuch der Hochbaukosntruktionen. Vol. 1: Stein-Konstruktionen*. Berlin: Ernst & Sohn, 1880–88. Op. cit. in: ibid.

[86] Esselborn, K. *Lehrbuch des Hochbaues*. Leipzig. Engelmann, 1908. Op. cit. in: ibid.

[87] Egle, J. von, Praktische Baustil und Bauformenlehre aus geschichtlicher Grundlage. Stuttgart: Wittwer, 1905. Op. cit. in Huerta, S. Construction History in Spain. In *Construction History: Research Perspectives in Europe*. Fucecchio (Florence): Kim Williams Books, 2004, pp. 43-59.

[88] Stummvoll, J. von. Technikgeschichte und Schrifftum. Kurze Einführung in die Probleme der Geschichte der Technik und bibliographische Dokumentation der Fachliteratur. Wien: Österreichisches Institut für Bibliothekforschung, 1975. Op. cit. in Huerta, S. Construction History in Spain. In *Construction History: Research Perspectives in Europe*. Fucecchio (Florence): Kim Williams Books, 2004, pp. 43-59

[89] Neuburger, A. Die Technik des Altertums. Leipzig : R. Voigtländer, 1919. Op. cit. in Huerta, S. Construction History in Spain. In *Construction History: Research Perspectives in Europe*. Fucecchio (Florence): Kim Williams Books, 2004, pp. 43-59.

[90] Singer, C. Holymard, E. J. Hall, A. R. (eds). *A History of Technology*. New York, Oxford: Oxford University Press, 1954–1958.

[91] Hess, F. *Konstruktion und Form im Bauen*. Stuttgart: Julius Hoffmann, 1943.
See also: Thunnisen, H.J.W. *Gewelven, hum construtie en toepassing in de historische en heiden dadgse Bauwkunst*. Amsterdam: Ahrend, 1950.

[92] Blake, M. E. *Ancient Roman Construction in Italy from the Prehistoric Period to Augustus*. Washington: Carnegie Institution, 1947.

represented the turning point after which began a spread of specific studies on the Construction History, even if at an early stage.

The Construction History was recognized an independent discipline in the 1980s, a period in which publications, books, meetings and symposia, in addition to events organized by associations – often of international interest – spread. In 1985 the *Construction History Society* – which publishes also the *Construction History Journal* and the written recordings of conventions organized every year on the matter – was founded in the United Kingdom. A certain interest was clear in the USA, where the *Building Technology and Civil Engineering Interest Group* was formed within *the Society of the History of Technology*, with the publication, until the 1990s, of a newsletter entitled *The Flying Buttress*.

In any case those were all isolated actions and, even if the amount of publications grew exponentially, the effect of a work within a common disciplinary field was never achieved: the articles were published in journals and conventions about architecture, engineering, medieval history, Asian studies, archaeology etc. The Construction History did not acquire the status of discipline internationally recognized, yet, and even the bibliographic research of a typical word of Construction History is still difficult and fragmentary. Riccardo Gulli, in an essay published in 2004, explained this difficulty in the comprehension of the interdisciplinarity and yet unity in the branch of Construction History by saying:

*"about the considerations on the scientific and practical value of this type of research, the most direct reference is generally the field of restoration, reuse and structural renovation. Those are disciplinary differentiations that circumscribe professional competences, but at the same time, they are formed by the fundamental need to establish a steady relation with historic disciplines, in every-one of their different and various forms, that not always and not just belong to the traditional field of action of the historian. In fact, the complexity and the transversality of construction knowledge – mediating between scientific and artistic elements, between science and building art – lead to surmounting the artificially placed barriers and bravely enter an unexplored territory where science, technique and architecture – mutually legitimized – are interlaced."*[93]

## The Construction History in Italy

The *raisond'être* of the *Construction History* is best represented by its heterogeneity, in its main goal to know the common traits of knowledge – contextualizing them in their field – whose origins were afterwards fragmented during the interpretation caused by the disciplinary specialization. [94]

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Lugli, G. *La tecnica edilizia romana con particolare riguardo a Roma e Lazio*. Roma: Scienze e Lettere ed., 1957.

[93] Gulli, R. Margin Notes on Construction History in Italy. In: *Construction History: Research Perspectives in Europe. Fucecchio* (Firenze): Kim Williams Books, 2004, p. 24.

[94] Gulli, R. Margin Notes on Construction History in Italy. In: *Construction History: Research Perspectives in Europe. Fucecchio* (Firenze): Kim Williams Books, 2004, pp. 23-41.

In Italy, the situation of Construction History harks back to the issue of the meanings and to the results achieved by Sergio Poretti and his research team from Engineering Faculty at University of Rome Tor Vergata. Before him, Eugenio Battisti, in a Convention in 1998, indicated History of Technology as a key for the future historic research, directing a long period of research on the links between architectural codes, technological innovation in architecture and the development of Italian engineering between the two World Wars. The struggle for finding the correspondence between the advanced technical education and the architectural autarkic production is perfectly represented in the works by Poretti and his team, even if they encountered many hindrances given especially by the reluctance of historic reinterpretations of the fascist period. The fundamental point that supported and legitimized this research is best summarized by Poretti:

*"about modern and contemporary architecture, a wide historic-analytic synthesis preceded the re-enactment of events and the study of the works. And even now, after persisting and even repetitive investigations on the most sophisticated cultural developments, the simple material history remained completely unexplored. Italian history was not an exception when, after being ignored for a long time, attracted historians, but almost only on the vicissitudes and controversial facts that characterized the relation between architectural culture and fascist politics, to such an extent that the specific characteristic of the copious heritage erected between the two World Wars are little known, instead of being deeply studied, as every preservative or reuse intervention unequivocally demonstrates. The development of a new phase in the historicization of contemporary architecture is waited – and awaited –, in which, as it happened for periods historically better known, the historic investigation – even maintaining an overview on the situation –would take the form of a continuous, collective, multiple storage that gradually increase itself as much as with the contributions of numerous specialized competences. In this perspective are to be included the studies of scholars of engineering faculties that studied in the field of technical architecture for many years. These studies have a precise goal: recreate the evolution of constructive methods, not through conceptual models, but through the developments adopted in the fascist era linked to the peculiar architectural characteristics of the buildings."*[95]

From this research route emerged the results partially published in *Modo di Costruire* with the editorial by Libera, De Renzi, Ridolfi and Samonà (Poretti, 1990[96]) on the history of design and architecture of the buildings of the Post Service, becoming in that way one of the main arenas for authors, specialized research, conference acts and essays on the glorious period of the Modern Construction in Italy. Gulli quoted, in particular, *Studi sull'edilizia in Italia tra Ottocento e Novecento (Studies on construction industry between 19th and 20th Century)*[97] and *La*

[95] Poretti, S. La costruzione moderna in Italia: Indagine sui caratteri originari e sul degrado di alcuni edifici. Il Modo di Costruire. Roma: Edilstampa, 2001.

[96] Poretti, S. Progetti e Costruzione dei Palazzi delle Poste a Roma 1933-1935. Il Modo di Costruire. Roma: Edilstampa,1990.

[97] Vittorini, R. Capomolla, R. (a cura di). Studi sull'edilizia in Italia tra Ottocento e Novecento. Roma: Edilstampa, 1999.

*costruzione moderna in Italia: Indagine sui caratteri originari e sul degrado di alcuni edifici (Modern construction in Italy: Survey on the original characteristics and the decay of some buildings)*[98] that collected constructive models illustrative of that architectural period, reinterpreted through the study of the relation between form and structure, autarkic codes and technological devices, using descriptions of the constructive details in the various cases, that otherwise would have hardly ever emerged and restored for academic communities.

Numerous institutions and Universities were involved in this research route, interesting mainly the fields of Technical Architecture and Building Techniques, especially: Marche Polytechnic University, University of Bari, University of Cagliari, University of Florence, University of Naples Federico II, University of Rome La Sapienza, University of Palermo, University of Pisa, University of Turin, University of Trento, University of Trieste and University of Udine. The most stimulating results on Construction History in Italy concern the restoration of the modern heritage, in which it was feasible interlacing fruitful collaborations with international institutions such as Docomomo, coming to a broader acceptance of the multidisciplinary and participatory purposes, as affirmed in the introduction to the Act of the First National Convention, organized in Rome in 1998:

"*instead of genuine interest from the historians, de facto the study of the development of the modern constructive technique endures being episodic and fragmentary, and even now it encounters difficulties in placing itself within the far-from-malleable field of academic research. Restoration of the modern heritage is not a new field of research, but rather a new topic that must be absorbed by the various pre-existing fields.*"[99]

After these studies were published and the study of modern heritage was confirmed of academic interest, some research programs, developed by different university bodies, were submitted: the research team guided by Pier Giovanni Bardelli from the Engineering Department of the University of Turin examined the most important architectural events in Piedmont[100]with the same guidelines used for the research in Tor Vergata. The relation between architectural codes and technological devices is the main object of Anna Maria Zorgno's studies, focused frequently on the buildings of the late 19th-early 20th Century and that deal also with the development of steel and reinforced concrete technologies.[101]

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98 Poretti, S. et al. La costruzione moderna in Italia: Indagine sui caratteri originari e sul degrado di alcuni edifici. Roma: Edilstampa, 2001.

99 Poretti, S. Introduzione. In Architettura Moderna in Italia, Documentazione e Conservazione. Proceedings of the First Conference DOCOMOMO Italia. Il Modo di Costruire. City: Edilstampa, 1999. Op. cit. in: Gulli, R. Margin Notes on Construction History in Italy. In: Construction History: Research Perspectives in Europe. Fucecchio (Firenze): Kim Williams Books, 2004, pp. 23-41.

100 Garda E., Bardelli, P. G. Filippi, E. Picco, G. Ricordo e intenzione. Forma e criteri di selezione per l'architettura moderna in Piemonte. In: Proceedings of the Conference *Image, use and heritage. The reception of architecture of the Modern Movement* Parigi, 16-19 settembre 2002.

101 It is suggested the read of the following essays:

Similarly, significant for the development of structural engineering were the studies by Vittorio Nascè, from University of Turin, who made use of the fundamental contribution of the historic mould meant as basic constituent of technical knowledge.[102]Also in the academic circle of Turin, the works by Luciano Re[103]are included within the themes of restoration, preservation of concrete historical buildings and the traditional building techniques of Piedmont, for example his research on stone and concrete bridges built in the 19th Century, on the suspension road bridges, on the bridges in Savoy parks, on the restoration and the techniques used in to intervene on artefacts and in the historical extensions of Piedmont in the 19th Century.

Moreover, Giovanni Carbonara from University of Rome La Sapienza wrote a detailed study on historical constructive technologies as a tool for preliminary investigations for architectural restorations.[104] Even if the field is circumscribed in the areas of Rome, Lazio, Umbria and Abruzzo, Carbonara's research exemplified the contribution of notions produced from the history of construction and analysis of constructive technologies on the study of historical buildings.

Even if it may sometimes be difficult identify the specific topics of the Construction History, it is possible to acknowledge that the archive research, the detailed inventory of the constructing models described in every element and the accurate consideration of the building normative history are elements of the theoretical analysis of the limits in which the researcher must work and of the further cognitive results. In that way, the value of historic research – such as that of Sergio Poretti and Maristella Casciato for Docomomo –, along with the examination of specific constructive processes (either mechanical or technological), is based on the need of an "intrusion" in the field of historians by those who have a purely technical-scientific culture in

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Zorgno, A. M. Tecnologie costruttive e cultura del progetto in Europa e in Italia nell'Ottocento. In: *Atti del Quarto Seminario di Storia della Scienza e della Tecnica: Tecnica e Tecnologia nell'Architettura dell'Ottocento*. Venezia: Istituto Veneto di Scienze, Lettere e Arti, Biblioteca Luzzatiana, 1994.

Zorgno, A. M. *Materiali, tecniche, progetto. La cultura del progetto nel Piemonte del secondo Ottocento. Ricerche di Tecnologia dell'Architettura*. Milano: Franco Angeli, 1995.

Zorgno, A. M. Barelli M. L., Garda, E. *Ridisegnare il costruito. Materiali, tecniche, progetti*. Torino: Levrotto Bella, 1995.

[102] Nascè, V. (eds). *Contributi alla storia della costruzione metallica*. Firenze: Alinea, 1982. Op.cit. in Gulli, R. Margin Notes on Construction History in Italy. In: *Construction History: Research Perspectives in Europe*. Fucecchio (Firenze): Kim Williams Books, 2004, pp. 23-41.

[103] It is suggested the read of the following essays:

Re, L. (eds.). Sospesi a dei fili. *I ponti pensili dell'Ottocento valsesiano*. Torino: Lindau., 1993. Op.cit. in Gulli, R. Margin Notes on Construction History in Italy. In: *Construction History: Research Perspectives in Europe*. Fucecchio (Firenze): Kim Williams Books, 2004, pp. 23-41.

Re, L. *I ponti piemontesi. Progetti e cantieri*. Torino: Celid, 1999. Op. cit. in: ibid.

[104] The theme concerned mainly the technical construction of medieval walls, the fortifications on Sacco river, the "a tufello" wall building technique around Rome, preservation and construction of vaults in Salento between the 16th and the 18thCentury, the late medieval fortifications, etc. See: Gulli, R. Margin Notes on Construction History in Italy. In: *Construction History: Research Perspectives in Europe*. Fucecchio (Firenze): Kim Williams Books, 2004, pp. 23-41.

order to study a given architectural or productive phenomenon, which is an often-criticized condition for its unappropriacy. [105]

The research routes coming from the sphere of technical architecture and structural analysis, even if more pertinent to Construction History than to historical research, gave an important multisectoral contribution on national extent about specific characterizations of building procedures, traditional architectural cultures and their typological, material and technological characteristics. Some examples were given during the convention "*Tradizioni del costruire nel territorio nazionale. Continuità ed evoluzioni delle tecniche edilizie per la salvaguardia ambientale del contesto insediativo minore*" (Building traditions on the National territory. Continuity and evolution of building techniques for the safeguard of the environment in small settlement contexts)[106] organized in Bologna in 2001, during which results of research conducted by eleven institutes coordinated by Adolfo Cesare Dell'Acqua were published. The main result was undoubtedly the applicability of traditional techniques and materials on restoration activities and on new edifices built in places where the ideal morphological, technological and environmental characteristics endured. In this sense the research in the field of technical architecture conducted by Luigi Zordan in L'Aquila[107] is highlighted, as he identified the peculiar characteristics of the historic centres in Abruzzo through the interpretation of the most representative and of the rules of the traditional architectural techniques, the definition of the problems and the issues related to the restoration, the decomposition and recomposition of the building in its context and, finally, the procedure needed in pre – Modern contexts lacking of anti-seismic regulation.

In the same theme framework, but concerning a different architectural reality and context, was arranged the research by Antonello Sanna, from Engineering Faculty of the University of Cagliari. He directed his research towards an information system for the local variations of the building process which – through an analytic process and starting from historic documentary research – used the direct information collected through investigation means during the architectural and engineering survey of edifices, and tried to introduce a parameter for the classification of the typological variants, using technology as basis for the definition of the restoration guidelines.

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[105] Gulli, R. Margin Notes on Construction History in Italy. In: *Construction History: Research Perspectives in Europe*. Fucecchio (Firenze): Kim Williams Books, 2004, pg. 32.

[106] Gulli, R. Margin Notes on Construction History in Italy. In: *Construction History: Research Perspectives in Europe*. Fucecchio (Firenze): Kim Williams Books, 2004, pg. 34.

[107] Zordan L., et al. *Le tradizioni del costruire della casa in pietra: materiali, tecniche, modelli e sperimentazioni*. L'Aquila: Dipartimento di Architettura ed Urbanistica, Università dell'Aquila. Aquila: GTE, 2002. Op. cit. in Gulli, R. Margin Notes on Construction History in Italy. In: *Construction History: Research Perspectives in Europe*. Fucecchio (Firenze): Kim Williams Books, 2004, pp. 23-41.

## Research Methododology

The research method starts from the considerations reported so far: first of all, the approach to the matter is based on a historical-technical survey of buildings, through a study of architectural stratifications and the origin of its architectonic and structural aspects. Thus, the main questions concern the knowledge of the planning, architectural and structural origins of the artefact: the issues of human work and technical abilities adopted in the building cannot be underestimated; neither can a more ancient building be preferred to a more recent or the other way around. Hence, for the process of comprehension, every measure must be adopted, in order to collect all the information that could explain the purposes of the construction, the workforce and the abilities involved, the reasons lying behind the preference of an architectural system over the others, the choice of the structural components used, the cause of the current aspect and the condition that shaped it.

Clearly, the method used for these investigations must deal with the multidisciplinary heterogeneity mentioned above, which allows examining the available sources even when they are not treatises or derived from direct surveys and are constituted, instead, by archives, essays, epistolary and historic sources. This approach aims, thus, to regard to the case study avoiding the pure historical reconstruction, an easy mistake when treating of a work only through one and only point of view or only one source.

It is reasonable to affirm that the research method employed in the specific case study of the dissertation is conformed to the research method of the Construction History, from which it adopts the analytic study of the bibliographic, archival and historical sources to answer the questions on the architectural artefact it demands.

A step forward must be taken, anyway, to overcome an obstacle that is the academic conception of the Construction History on the general matter: in its definition and because of its nature implicitly oriented on the architectural history, the Construction History does not consider any possibility of recovery, reuse or conversion of its subjects of study. It is caused by the fact that, even if Construction History acknowledges the importance and the possibility to draw information for the architectural studies by restorations, its systematic interest is focused on architectural, technical and structural issues, not considering recoveries, functional proposals or returning to contemporary through reuse. After the identification of this approach to the architectural heritage taken into account, the methodology should be completed with preservative or recovery interventions, characterized through the classification – according to the type and preservative condition – of the architectural elements, or through the study of an edifice in the building area of Monteponi.

In both cases, even if the process of knowledge occurs in the same executive procedure as in the Construction History, the dissertation aims to overcome the exclusively analytic phase of architectural history and find possible revisions for the safeguard, the recovery and the promotion of the case study, in the light of the meditation on the role and goal of the Industrial Archaeology on its heritage. This last methodology is based on the use of direct research techniques directed to non-invasive diagnosis of a building – exemplifying of the mining architecture of Sardinia in 19th Century – to report its decay level and to propose preservative and recovery actions, directed to reuse.

### Objectives and original contributions

The research carried out so far already authoritatively recognized the site of Monteponi, in Sardinia, as an example – of national interest – of mining archaeology between the 19th and the early 20th Century, in the "mature" phase of industrialization. The recognition – validated by UNESCO, too – was based, until now, on one side on the most specifically "environmental" aspects, and on the other on the economic and manufacturing value of Monteponi in the great mining experience of modern Sardinia. Still, unlike "traditional" archaeological sites, the archaeological-mining heritage remained on the edge of this re-discovery:

- It is still unclear its Construction History and its place in the wider international landscape of Neoclassical and Eclectic constructions on which the architecture of the "machine age" was founded, until the development of the Modern Movement;
- The decay of this heritage advances and recovery plans to stop it are episodic and inadequate; also, the recoveries made up to now seem not to consider the peculiarities, the structural characteristics and the performance-related aspects of the artefacts.

The fundamental importance of the matter is there for all to see:

- The archaeological-mining heritage is considered a primary source under the social-cultural point of view, both in cultural perspective and as a feature of the development of Sardinia. It is mentioned in International Conventions, national Institutions such the Geological Mining Park, regional legislative apparatuses, investment plans and projects for the environmental reclamation of the sites and for the promotion with cultural and economic aim.
- The Sardinian case is potentially a reference in the national and international panorama, since it keeps almost untouched one of the most relevant heritage belonging to the modern European mining epopee in the Mediterranean area.
- Thus, the dissertation on Monteponi develops a researching plan, composed by an in-depth historic research direct to the interaction between the study of architectural and cultural features and the technologic aspects of construction and making it functional, in order to organize preserving and requalification programs based on the investigation on the field.

For this purpose, **the thesis aims to**:

- Collocate Monteponi in the international panorama of the Construction History;
- inventory the architectural and constructive components of a series of buildings, representative of the site of Monteponi, and contextualize them in the coeval European architectonic and building culture;

- Select a building, within the site of Monteponi – with reference to the intervention programs of the "Sulcis plan" – which will be the subject of a detailed field research, through an extensive architectural survey, total or on exemplary parts, to represent its consistency and decay;
- Define the composite elements that contribute to fine-tune the recovery possibility, under the cultural, architectural-technological and social-economic points of view.

**The original contributions of the research and methodology** are inferable through the intentions:

- The implementation of the methods of the Construction History to contexts poorly investigated previously, and of advanced techniques for field research, for the reconstruction of the architectural stratification of the program of mining archaeology;
- The contextualization within the European scene of the architectural cultures, of the constructive techniques and of the prospect of recovery of the case study, in a functional program that assimilates the return to the community as a permanent workshop for the mining heritage recovery.

# PART 2

# INTERNATIONAL CASE STUDIES

## The European Mining Heritage: characterization and development

The second part of the thesis focuses on the presentation of several of the most important examples of restoration and rehabilitation of former industrial compounds in Europe. The aims of this section are mainly the construction of the knowledge of the European background of the $19^{th}$ and the $20^{th}$ century in which is also set the most important industrialization of Sardinian mining heritage. This is the epoch when great foreign Companies started the exploitations of the mineral basins, carrying on technological and building advancements that feature both the Sardinian and the European industrial compounds. The comparison of analogies and differences is therefore indispensable to trace the origins of the formal and linguistic evolutions of Monteponi's heritage. Secondly, although the majority of the European examples are dismissed in their former activities, they still feature a whole amount of cultural and identity values and meanings that have been successfully preserved and valorised through a contemporary campaign of reuse and restoration in order to relaunch the architectural and cultural scenarios that could approach the mining palimpsest in Monteponi.

The choice of these cases is thus linked to the affinity to the case study of Monteponi, since they are all examples of the evolution of mining activities from the pre – industrial era throughout the $19^{th}$ and $20^{th}$ centuries and they run along with the most important expansions in Monteponi's industrial history.

The methodology and the aims of this work – which have been presented in the first part as an investigation on the constructive features and on the technical conception of the industrial heritage as a mean to identify the influence of the modern constructive principles on the development of these compounds – are intended in this part to show the technical, economical, social and cultural aspects of the settlements of the international examples, in virtue both of their productive past and of the rehabilitation and reuse of their facilities thanks to the actions promoted by local and international actors.

The international cases are therefore a field of analysis of the architectural and technological heritage, which has been valorised and preserved by the programs of reuse and restoration elaborated by Universities, International Organs, public administrations, local actions etc. in order to avoid the loss of the identity and the historical values that these industrial monuments represent for the local communities and the productive world. The investigation is based on the study of the historical backgrounds of these cases – linking in particular to the cultural, economical and enterprising factors that led to their assets – and on the typological plus constructive analysis of their compounds in order to set a canvas for a further confront with the main case study. We are indeed in front of industrial realities, although different in their territorial configurations, that feature similar innovations: in the typology of their elements, such as mining castles, shafts, workers' facilities, cableways, ramps, directorial buildings and so on; in the technological aspects regarding the construction and the use of materials and the assembling, i.e. brick masonry, iron, steel and cast iron elements, wooden and metallic roofs and so on; in the formal language, influenced both by the $19^{th}$ century architectural principles and by the stylistic approaches that mix local traditions and international contributes. Finally, at the light of this investigation, the Construction History methodology shows here many characteristics of the industrial settlements that can be further put in relation to Monteponi's features in order to discover possible affinities in the architectural development and in the functional assessment of these realities, which could be consequently translated into proposals for their valorisation.

The international cases have not been chosen simply due to their geographical collocation, which might involve the Mediterranean and Mittleuropean areas, but to the wideness and completeness of their architectural palimpsests that offer suitable meeting point with the main case study of this thesis. Moreover, we find similitude in the technical and formal approaches of these industrial realities mainly thanks to the influences of the European culture on the designers' and managers' education and to the affinities among the European mining companies that started a massive industrialization and deep exploitations both in those Countries and in Sardinia during the 19th and the 20th centuries: we are therefore facing two parallel paths, which contain on one side the starting and the development of modern exploitations in Sardinia and on the other the settlement of mines in the most industrialized Countries of that era.

These cases show therefore a variety of elements that concur together to the formulation of their peculiar heritage and are subjected to different practices of rehabilitation and restoration of the facilities, both in a territorial and in a local scale, programs of safeguard of the historical and social values related to the settlement of urban communities and to the damages that affect the structures.

Firstly we present the industrial mining heritage located in Tuscany, precisely the project of the Archaeomining Park of the Metalliferous Hills in Grosseto through the researches promoted by the Universities of Florence and Siena with the contributions by Massimo Preite, Gabriella Macciocco and Letizia Franchina among the others.

In this case we find a territorial masterplan that involves numerous sites belonging to the mining past of the region, featuring different structures and facilities, peculiar constructive elements and materials from different epochs: the procedures of rehabilitation and safeguard consist in a first survey of the whole Maremman territory, with the recognition of the most important industrial centres of the area; furthermore we find a characterization of the main features and buildings that constitute these sites, starting from the *ex – Ilva* compound in Follonica, followed by the Gavorrano's mines and mining towns and finally the Massa Marittima's mine of Niccioleta.
All of these elements are showed through the history of their settlement, of the main buildings and the characteristics of the whole compounds or only several parts: it is very interesting in that sense the contribute of Gavorrano's mining heritage, which presents the greatest variety of mining facilities and structures that underwent programs of reconversion and social – cultural reuse, which will be explained in the final part of this dissertation.

The second example shows the Almadén's and Puertollano's mining heritage that insists on an extended territory, which had been exploited since the Romans for its deposits of quicksilver. This region is located in Castilla – La Mancha and presents numerous facilities, buildings and routes related to the extraction of the mercury and to the development of urban areas along with the implementation and addition of mining activities. After an initial characterization of Almadén's and Puertollano's mining heritage from a historical and typological point of view, the analysis focuses on the technological features of the mines, particularly on the technical buildings that were installed in Almadén and Puertollano as long as on the extractive necessities and on how the implementation proceeded. The main elements of this heritage consist of a great variety of shafts, mining fences, urban edifications, turbines, power stations and so on and in virtue of them we may find different restoring and safeguard plans, promoted by National and local administrators, by the UNESCO Committee and by the Spanish Heritage and Culture Organizations. In this chapter there is also a description of the methodology at the base of the reconversion plans and programs, with the specification of the completed projects and the aims of the interventions, at the light of several agreements such as the *El Bierzo* Chart, the National Plan for the Industrial Heritage, the Convention for the Almadén Mining Park and so on. Furthermore there is a part dedicated to the description and to the consistency of the buildings that form the Almadén's mining compound, which show similitude with those in Monteponi and offer a picture of the urban life and the technical facilities in a mine of the 19th century. There are specific references to the sanitary and mining facilities and to the history of the technology of the main tools involved in the mine, i.e. the ovens and their technical evolution, which represent one of the most peculiar elements of the whole compound.

The last case is the Nord – Pas de Calais and Wallonie mining basin that features a great number of facilities and structures included in the UNESCO World Heritage List and rehabilitated thanks to important restoring plans since the 2000s. The history of this basin is linked to the long exploitation of coal deposits that run from the Ruhr region to the North Sea, crossing the area included by the Belgian Wallonie and the French Nord – Pas de Calais: we are in front of a wide and long territory containing numerous typologies of mining centres, exploiting cores, mining towns, shafts, transport facilities and so on that have sensibly modified and transformed the natural landscape creating an homogeneous productive field, with a proper history and environmental asset which distinguish it from the other coal basins in Europe.

During its three – centuries long evolution this region has passed through irreversible transformations from a pre – industrial phase in the 18th century to a post – industrial era in the 1900s. The main elements of this heritage are therefore linked to the exploitation and extraction of coal with consequent environmental phenomena, i.e. the big hills of mining slag and scoria, transporting innovations, new urban settlements located near the mines and evolved into real mining towns and finally technological elements such as shafts, mines and castles. The whole built and natural heritage conforms this complex industrial landscape, which distinguishes itself from the other sites due to the poor differentiation in the productive field and to the homogeneity of the urban configuration, derived from the mining Companies' attitude to build their own mining centres and towns near to the exploiting cores. All the elements featuring this complex heritage are therefore explicated and enhanced in the UNESCO World Heritage List and in the characterization plans developed by the Local actors jointly with the International Organs for the protection and valorisation of the industrial heritage and its cultural values.

This last case is presented through an initial identification of the peculiarities of the built and the natural landscapes that are deeply connected to the historical and technical evolution of the mining basin, following by the description of the urban, architectural and technical typologies that characterize the mining heritage, such as the mining towns and their different physiognomies, the Directorate Buildings (*les Grands Bureaux*), the transporting facilities such as railway stations and mining paths, the shafts.

# ITALY: TUSCANY

## The Technological and Archaeological Park of Grosseto's metalliferous hills

### Introduction

The founding of *Technology and Archaeological Park of Grosseto metalliferous hills* has been dated back to May 2002, by an Environment Minister Decree[1].The design and project of the Park – within a 2005-2006 masterplan which was carried out by the University of Siena and Florence jointly to the affected local entities – focused on the management of the sites as well as on initiatives of evaluation involving the Municipalities of the Consortium of the Park and on the choice of a branched operative administration, aiming at exploiting the working skills of its staff on the whole territory of the Park, coming from all the public administrations (Ministry of the Environment and Cultural Heritage, Tuscany Region, the Province of Grosseto and its numerous municipalities).

The Park pursuit is to asset measures of development and opportunities of safeguard and evaluation of the territory regarding present-day grounds of the archaeological-industrial heritage, of the cultural and historical identity appraisals, permanently set out on Tuscan area, engraved in the collective memory. The Masterplan strategy crosses the integrated evaluation of the resources of territory – in the cultural, archaeological, historical, and industrial connotation – acting as a safeguard of the main elements, accomplishing with the local communities, the management of archaeological-industrial heritage according to an implication of its recovery – reuse[2]. Both the masterplan and the Park at the time of their drafting aimed at intervening not only in the single handcrafts or limited territorial basin, but in a broader areal extent, marked by a compulsive centuries-old mineral and metallurgical analysis, ranging from the places of extraction, processing, fusion and storage of materials, urban areas, warehousing and facilities services, accumulation centres, scums, etc enjoying a territory and environmental system convenient to their functioning.

The project formulation, the strategies and the initiatives for promoting, safeguarding and evaluating the cultural heritage, respectful to the practices already carried out in the European asset, envisage in particular a sort of maintenance and rediscovering system, which shall be not only on a single - centred site but on a wider cultural and landscape itineraries, whose diversified choice is protruded on the variegated threshold of deepening and extension of the interventions and the projects in a broader scale such as the *Grand Hornu*, the *Bois du Cazier* and the *Bois du Luc*, while the European cultural itineraries landscaping oriented such as the *Zeche Zollverein* and of *Zollern*, the Northern Pas de Calais – Wallonie mineral basin, of the *Blaenavon Industrial Landscape* and of the *Cornwall and West Devon Mining Landscape*[3].

[1] Ministerial Decree 28/02/2002 of the Ministry of Environment pursuant the law 388/2000. See: Preite, M. (Ed). *Masterplan. La valorizzazione del paesaggio minerario*. Florence: Tipografia editrice Polistampa, 2009, p. 197.
[2] Ibidem, pp. 9 – 11.
[3] Ibidem, pp. 15 – 18.

## The modern mineral heritage

A vast repertoire of the past mining production in Grosseto's territory constitutes the field of the masterplan interventions about those projects of recovery and protection of the historical working places and the cultural identity. Many facilities, once ceased their production, suffer because of the difficulty in finding new destinations of use compatible with the forms or the original functions: the mining castles, furnaces and treatment installations whilst offering a unique variety of forms and contents, are not easily adaptable to new forms of reuse without requiring a significant change. The processing of the masterplan has then been confronted with this condition to trace all the available testimonies and documentation to know the plant engineering systems, the projects of the production plants and the architectural and technological characteristics to be able to study changes of use compatible to projects that are most suitable for the mining and civil constructions. The classification of the heritage has divided the artefacts in: "pits of extraction" that constitute the mineral extraction core and rise as symbols of the past and of the memory of mining places; " plants for treatment of mineral" which have most suffered the dismantling phases, demolition and abandonment at the end of mining activities and that now have also proved to be the archaeological ruins[4] ; "geothermal energy" that, thanks to their vertical configuration represent a strong visual sign in landscape and finally "residential" that obviously includes residential construction of mining centres built directly by the companies industrial mining - present in the Tuscan territory.

[4] Maciocco G. Il patrimonio minerario moderno. In Preite, M. (Ed.). *Masterplan. La valorizzazione del paesaggio minerario*. Florence: Tipografia editrice Polistampa, 2009 p.83.

## Gavorrano's mining heritage.

In this Municipality the industrial heritage is mainly linked to the mining building managed by the Montecatini Group.[5] [6] This latter succeeded in the mining management in 1910 and in 1965 it also obtained the management of the Ravi Marchi mine.

The first limonite coating in Gavorrano neighbourhood dated back to 1840 by Succi Company, which ignored the much more important presence of a pyrite deposit in the site depth.[7] This deposit was recognized only in 1898 by Francesco Alberti and the discovery made Gavorrano one of the most important national pyrite extraction basin: the *Guido Praga* of Rome was the first firm to conduct the extraction for passing some years later the conduction to Italian Pyrite Union, which however lasted up 1910 as the mine switched to the Montecatini Group, as it became the most influent shareholder over the years.[8] The Company had already possessed the Fenice Capanne deposit since 1899 and it hoarded into this way a further extractive source with the Gavarrano pyrites: another extraction bank was added in 1909 in Grottone area nearby Ravi and in 1930 it was up to Rigoloccio with two shafts realized in 1925; the excavations were kept on at Valmaggiore in 1952.

The *Montecatini* Group also purchased in 1965 the Ravi Marchi mine[9] [10], afterwards added to the Ravi Montecatini, rigorously managing the interventions aiming at deeply operating in Roma Shaft, which compensated both the plants and mechanized transports of Ravi and Rigoloccio mines. A cable from Ravi Montecatini to Gavorrano was already installed in 1930 to link the Roma Shaft with the Rigoloccio excavations and the worked mineral was sent via cableway to Scarlino Scalo to be exported via Portiglioni roadsteads by sea or by train. This impressive network of cableways, extended for 45 km, was abandoned since 1959 following the abandonment of the segment by Ravi Montecatini to Roma shaft; in 1968 the same fate touched at Scarlino Scalo and by the following year road transport for all the connections were introduced [11].

Today the survived structures offer a complete overview on the generative, urban and industrial building plant related to the Gavarrano mining industry, which particularly consists of:

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[5] Preite, M. Le miniere in Maremma. In Preite, M. (Ed.). *Paesaggi industriali del Novecento. Siderurgia e miniere nella Maremma toscana*. Florence: Edizioni Polistampa, 2006, pp. 99 – 101.

[6] Preite, M. Le miniere in Maremma. In Preite, M. (Ed.). Paesaggi industriali del Novecento. *Siderurgia e miniere nella Maremma toscana*. Florence: Edizioni Polistampa, 2006, pp. 99 – 101.

[7] Preite, M. Le miniere in Maremma. In Preite, M. (Ed.).*Paesaggi industriali del Novecento. Siderurgia e miniere nella Maremma toscana*. Florence: Edizioni Polistampa, 2006, p. 140.

[8] Ibidem, p. 140.

[9] Ibidem, p. 141.

[10]Maciocco, G. I Patrimonio Minerario Moderno. In Preite, M. (Ed). *Masterplan. La valorizzazione del paesaggio minerario*. Florence: Tipografia editrice Polistampa, 2009, p. 84.

[11] Preite, M. Le miniere in Maremma. In Preite, M. (Ed.). *Paesaggi industriali del Novecento. Siderurgia e miniere nella Maremma toscana*. Florence: Edizioni Polistampa, 2006, p.142.

- Shafts and mining castles

*Rigoloccio*

This section is grafted around onto the shaft 2, realized in 1927 for mining, and then used as a ventilation channel. The conditions of conservation of mining buildings are unfortunately alarming given the state of advanced oxidation of the metal structures of the winch room and of the alarming deteriorating conditions of the materials by which the mill trunks for labourers were executed, demonstrating the low quality of the products used and the shrinkage allowance provided on the patterns[12] .
Before 2006 the great landfill for inert materials was covered by a layer of grass loam and protected by a system of control of the surface waters in order to preserve the memory of the mining activity that relates to it; however, it was not possible to save the ancient loading hoppers, now demolished.

Figure 1. Shaft n.2 of Rigoloccio. Source: Preite, M. Paesaggi industriali del Novecento, 2006.

*Valsecchi*

Valsecchi Section is another of the localities of pyrite extraction whose building heritage suffers from a serious abandonment and degradation: the linear settlement begins with the power station, the winch and the shaft mining and closes with the building aspirator. The pit, whose depth is 410 meters and 3 meters in diameter, is paired with a castle wooden mining

[12] Ibidem, p.144.

dating back to 1955, which stands out in quality of rare preserved specimen in the original[13][14].

*Impero Drilling Shaft*

This is a shaft for the ascent and the descent of the miners, dug from 1936 and raised up to 240 m of height at the end of the Fifties. The access tunnel, 4 m wide and long 300, is coated in reinforced concrete and leads to the room of the winch. The latter is still present and moves through a machine with cylindrical drums the cage for the movement of the miners.

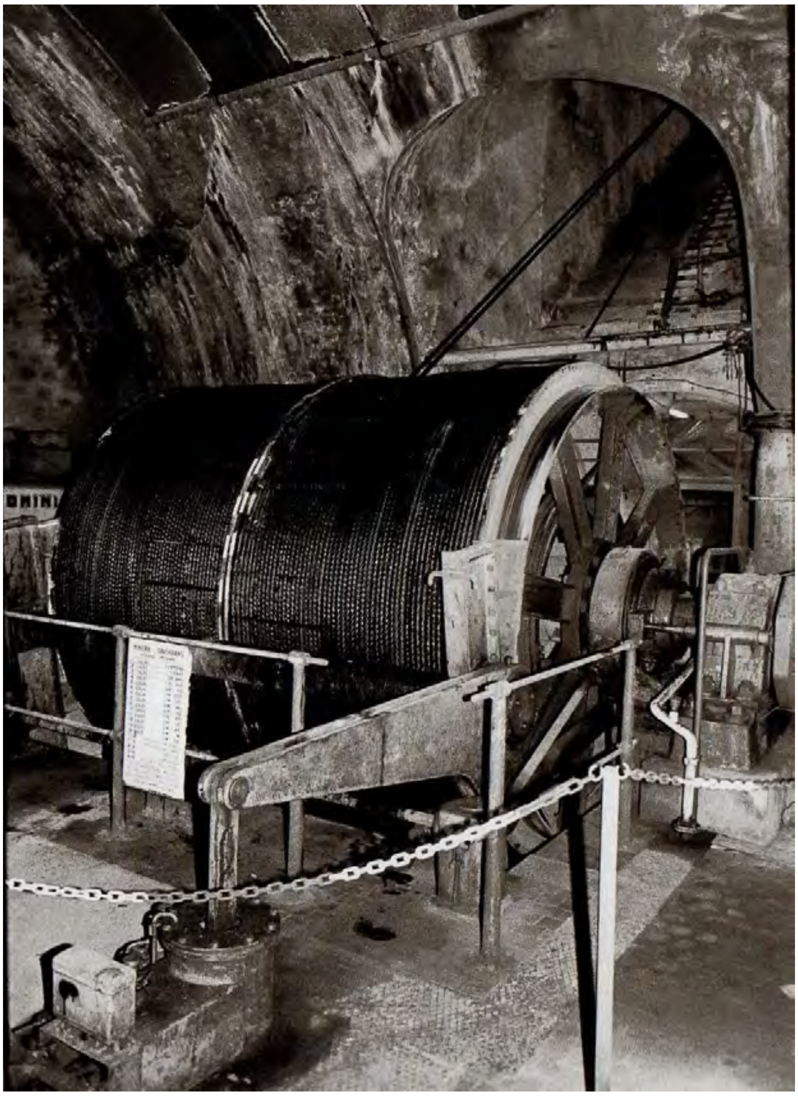

Figure 2. *Impero* Shaft windlass hall. Source: Preite, M. Paesaggi industriali del Novecento, 2006.

[13] Ibidem, p. 145.

[14] Maciocco, G. I monumenti della tecnologia. In Preite, M. (Ed.). *Paesaggi industriali del Novecento. Siderurgia e miniere nella Maremma toscana*. Florence: Edizioni Polistampa, 2006, p. 187.

*Santa Barbara* shaft of Casteani mine.

Built by the end of Nineteenth century for lignite extraction purposes, it has a mixed towered structure for the extraction, which was composed by a wooden headframe rested on a stoned plinth. The base is survived and it lies in Ribolla vicinity.[15]

*Valsecchi shaft*

The castle is the unique original wooden structure which survived in discrete conditions and it is mainly constituted by a vertical framework surmounted by four pillars for the cage sustenance and by four downwards divaricated struts reinforced by Saint Andrew's crosses. Both the tower and struts are tied together by plaques and iron bolts. The use of flatten ropes is detectable thanks to the still existing pegs at the top of the structure. [16] [17].

*Roma shaft*

It is the main shaft in Gavorrano mining site. The structure project was directed by Demag Society. [18] [19] The castle represents a leading retailer among the extractive structures of the Park, due to its 35 metres of height. It is constituted by an entirely iron framework for the winding extraction and by two strong thrust bearing rafters, realized by moulded, nailed and bolted together C profiled that lean over the concrete plinth. These are tip folded at the upper extremity to form a bracket which sustains the summit crest.[20] [21]
The little headframe and Roma shaft in its totality constitute the point of scenic perspective of Gavorrano site: along a central axis in which the main buildings are set up, as the carpentry, the emergency room and workshop, we find the binomial presence of Roma shaft and the panoramic belvedere that looks toward Gavorrano .
The winch room is housed in a two-storey building made of reinforced concrete with a flat cover and fixtures in iron, which contained a winch to cylindrical drums from 50 Hp replaced in the Sixties by more powerful *Koepe* pulleys to attain greater depth[22]. There are also power generators, control panels and crane that testify together with the electrical power plant

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[15] Maciocco, G. Le Infrastrutture. In Preite, M. (Ed.). *Paesaggi industriali del Novecento. Siderurgia e miniere nella Maremma toscana*. Florence: Edizioni Polistampa, 2006, p. 183.

[16] Preite, M. (Ed.). *Masterplan. La valorizzazione del paesaggio minerario*. Florence: Tipografia editrice Polistampa, 2009, p. 84.

[17] Maciocco, G. Le Infrastrutture. In Preite, M. (Ed.). P*aesaggi industriali del Novecento. Siderurgia e miniere nella Maremma toscana*. Florence: Edizioni Polistampa , 2006, pag. 187.

[18] Preite, M. (Ed.). *Masterplan. La valorizzazione del paesaggio minerario*. Florence: Polistampa, Publishing Printing 2009, p. 84.

[19] Maciocco, G. Le Infrastrutture. In Preite, M. (Ed.). *Paesaggi industriali del Novecento. Siderurgia e miniere nella Maremma toscana*. Florence: Edizioni Polistampa, 2006, pag. 183.

[20] Maciocco, G. I monumenti della tecnologia. In Preite, M. (Ed.). *Paesaggi industriali del Novecento. Siderurgia e miniere nella Maremma toscana*. Florence: Edizioni Polistampa, 2006, pag. 193.

[21] Preite, M. Le miniere in Maremma. In Preite, M. (Ed.). P*aesaggi industriali del Novecento. Siderurgia e miniere nella Maremma toscana*. Florence: Edizioni Polistampa, 2006, pp. 145 – 151.

[22] Ibidem, p.146.

variety and the search for modern systems for the control and management of mining works in the middle of the Twentieth Century.

Figure 3. Roma Shaft sightseeing after the closure. Source: Preite, M. *Paesaggi industriali del Novecento*, 2006.

The compressor room is inserted in a large building with a single plane whose openings are divided into those on the ground floor made on stone base and those of the upper level. The

structure shall pay in a state of serious degradation, accentuated by the damage of the roof covering and the closing of the openings.
The ancient cableway, used to transport the mineral and driven by an electric motor, retains the hoppers in reinforced concrete and the base, while the metallic components are irreparably damaged by carelessness and by time[23].
Even the crushing plants that dealt with both the fillings and the slug are strongly unreadable: the first, in 1949, was built on three descendants levels and connected to the second system using tapes for the transport of the shattered.
The washery was recasted several times throughout the Twentieth century: built in 1910, to the initial structure two sections were added between 1932 and 1935 to increase its capacity and for the treatment of fine materials. After the completion of Roma shaft the washery assumed a clearer and diversified configuration thanks to new articulation in distinct levels, made with regular spans and covers a flap[24].

*Vignaccio I* shaft from Ravi Marchi mine: the metallic tower, realized with different pairs of 11 m high metallic profiles and by struts, leans over bricked plinths.[25]

*Vignaccio* II shaft from Ravi Marchi mine: it belongs to the same typology, but in this structure reticular girders were employed[26].

*Valmaggiore* shaft: dating back to 1931, it was used for minerals movement and of workers as well as a ventilation shaft. The headgear that surmounts the shaft is constituted by full bolted and studded metal sections and from struts diverging downwards[27]. The corner pillars are connected between them through Saint Andrew crosses; the top turret containing the winch is covered with double flapped corrugated metal strips. The shaft opening was sealed with a reinforced-concrete slab[28].

*Radini shaft* (Ravi Marchi mine): it was realized in 1911 to be exploited until1965.This specimen testifies the passage from the castle walls to the metal ones, thanks to the presence

[23]Ibidem, p. 139.
[24]Ibidem, pp.149 – 150.
[25]Maciocco G. I monumenti della tecnologia. In Preite, M. (Ed.). *Paesaggi industriali del Novecento. Siderurgia e miniere nella Maremma toscana*. Florence: Edizioni Polistampa, 2009, pag. 85.
[43] Maciocco G. Il Patrimonio Minerario Moderno. In Preite M. (Ed). Masterplan. *La valorizzazione del paesaggio minerario*. Florence: Tipografia editrice Polistampa, 2009, p. 85.

[27] Ibidem, p. 85.
[28] Maciocco G. I monumenti della tecnologia. In Preite, M. (Ed.). *Paesaggi industriali del Novecento. Siderurgia e miniere nella Maremma toscana*. Florence: Edizioni Polistampa, 2006, p. 188.

of metal trellis linked to the iron patch and arranged on masonry plinth[29]. The cutting machines' power was provided by an electric winch by 50 HP of power[30].

- Mineral processing implants

The crushing plant of Gavorrano mine remained in service until 1951 when it was replaced by the new San Giovanni washery and after having undergone various modifications. In origin it was constituted by terraced bastions in reinforced concrete, covered by sheets and opened by a series of arches framed by bricks that recall the floor courses of the main front, to house the machinery.[31] The plant is still existing.

Among the various mineral treatment sites there are:

San Giovanni basins: it contains the 1951 washery, where there were the sieves and the sieves and a landfill where were accumulated the sterile of sieving.

Ravi Marchi old washery and new washery: the former, dating back to 1918 - 1920, hosts the jaw crushers for crushing the minerals while the second, built in 1955, was constituted by a terraced masonry structure to which was added in 1958 a flotation plant for the washery sludge. Today only the *dorr*[32] (a typical rectangular basin, used for the storm water) survives.

- Workers' villages

In Gavorrano territory the mining sites preside over three workers villagers: Filare, along the route which connects the country to the mine, that includes the recreational club as well as the workers' houses, a canteen and some laboratories that develop around the valley in which the quarry pops up[33]. Ravi's village springs around 1910 near *Vignaccio* shaft and it stands near the industrial buildings, i.e. the winze, the *Radini* shaft, the compressor places and the power station. The clue blockage departing from the winze lined the services for the workers, the laboratories and the sleeping quarters for who lodged into the mine. Among the most important and better-preserved facilities, there are the Directorate's residence and the laboratories, neatly separated from the labourers' buildings.
The Bagno di Gavorrano village was realized in the Thirties of Nineteenth century and it included various workers'houses and the former *Casa del Fascio*.[34]

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[29]Ibidem, p. 184.

[30]Preite M. (Ed). *Masterplan. La valorizzazione del paesaggio minerario.* Florence: Edizioni Polistampa, 2009, p. 84.

[31] Maciocco G. Le Infrastrutture. In Preite, M. (Ed.). *Paesaggi industriali del Novecento. Siderurgia e miniere nella Maremma toscana*. Florence: Edizioni Polistampa, 2006, pp. 197 – 198.

[32] Ibidem, pp. 198 – 199.

[33] Maciocco, G. Il Patrimonio Minerario Moderno. In Preite, M. (Ed). Masterplan. La valorizzazione del paesaggio minerario. Florence: Tipografia editrice Polistampa, 2009, p. 86.

[34] Maciocco, G. Il Patrimonio Minerario Moderno. In Preite, M. (Ed). Masterplan. La valorizzazione del paesaggio minerario. Florence: Tipografia editrice Polistampa, 2009, pp. 197-198.

Ravi Montecatini Mine

After the research of possible pyriferous deposits near Ravi village, started in 1908 by Montecatini group decision, it began an intensive exploitation of Gavorrano's mining area. The abundance of the deposits however entered already a crisis in the Fifties and the Company chose to invest its resources on the area of Valmaggiore, within walking distance from the village. This area was already being exploited in the Thirties and is characterized by quite a few buildings: the dressing room and the showers for the local workmen, lined in a flapped structure with a central body and two lateral and metal framed equipped ribbon windows; the compressor room made of metal carpentry, which is now in a state of total devastation to the vegetable invasion and for the progressive reduction of the roofs; the winch room, dated 1940 and contained in a masonry building with a central tower and a saddle roof, is highly degraded and now has lost structural components and important finishes[35].

Ravi Marchi mine

The history of Ravi Marchi mine is deeply linked to that of the homonymous Society to whom the permit of this site was given, wedged within the vast area of the Montecatini concessions; for its insulation it was awarded with the nickname of *Isole Marchi*. The limited extension of the batch has not however prevented to concentrate a large variety of structures linked to the extraction and processing of iron sulphide, activity durations for approximately 50 years: there are in fact the sector of Vignaccio, containing the washeries, and extraction plants; the mining village, directional centre of mine; landfills; the galleries for explosives. The *Radini* and *Ortino* sectors left no traces except in the mining castle and its winch in the first site, since the 1920s onwards the Company concentrated on Vignacci establishments[36].
The most relevant mining structures are: the cableways that connected the mine to the Gavorrano railway station, realized in 1914 and dismantled in 1959, in favour of the vehicular transports; the old washery for pyrite treatment, realized in 1918-1920, divided in the crushing department and the effective washery, that was doubled in 1925; the new washery, built in 1955, developed on 5 levels containing a flotation plant of which the circular structures of dorr and the inclined plane, moved by two winches (one at the top and one downstream), survive.
The Ravi Marchi passed to Montecatini Company in 1965 and the plants soon fell into disuse, supplanted by the gallery that linked the mine with the Roma Pit mine of Gavorrano, where the sieve operations, crushing and processing of minerals were carried out.

[35] Fantini, D. La miniera di Ravi Marchi. In Preite, M. (Ed.). *Paesaggi industriali del Novecento. Siderurgia e miniere nella Maremma toscana*. Florence: Edizioni Polistampa, 2006, pp. 163 – 164.
[36] Ibidem, pag. 166.

### Massa Marittima: the Niccioleta mine

The exploitation of the mining basin of Niccioleta, ended in 1992, began in 1842 by the Florentine *Società Metallotecnica* and continued between 1896 and 1898 with the *Société Belge Anonyme pour la Recherche et l'Exploitation des Minérais* for the search of ferriferous minerals, interrupted in 1907[37]. The Montecatini group took the management of the Niccioleta site by the purpose of extracting copper in the place of iron, acquiring the mining rights in 1913 and reopening two dismissed shafts: *Serpieri* Shaft in *Stregaio* and *Montomoli* area in the so called *Galleria dei Morti*. In 1924 – 1925 the Montecatini group realized another shaft, the *Corvo*.

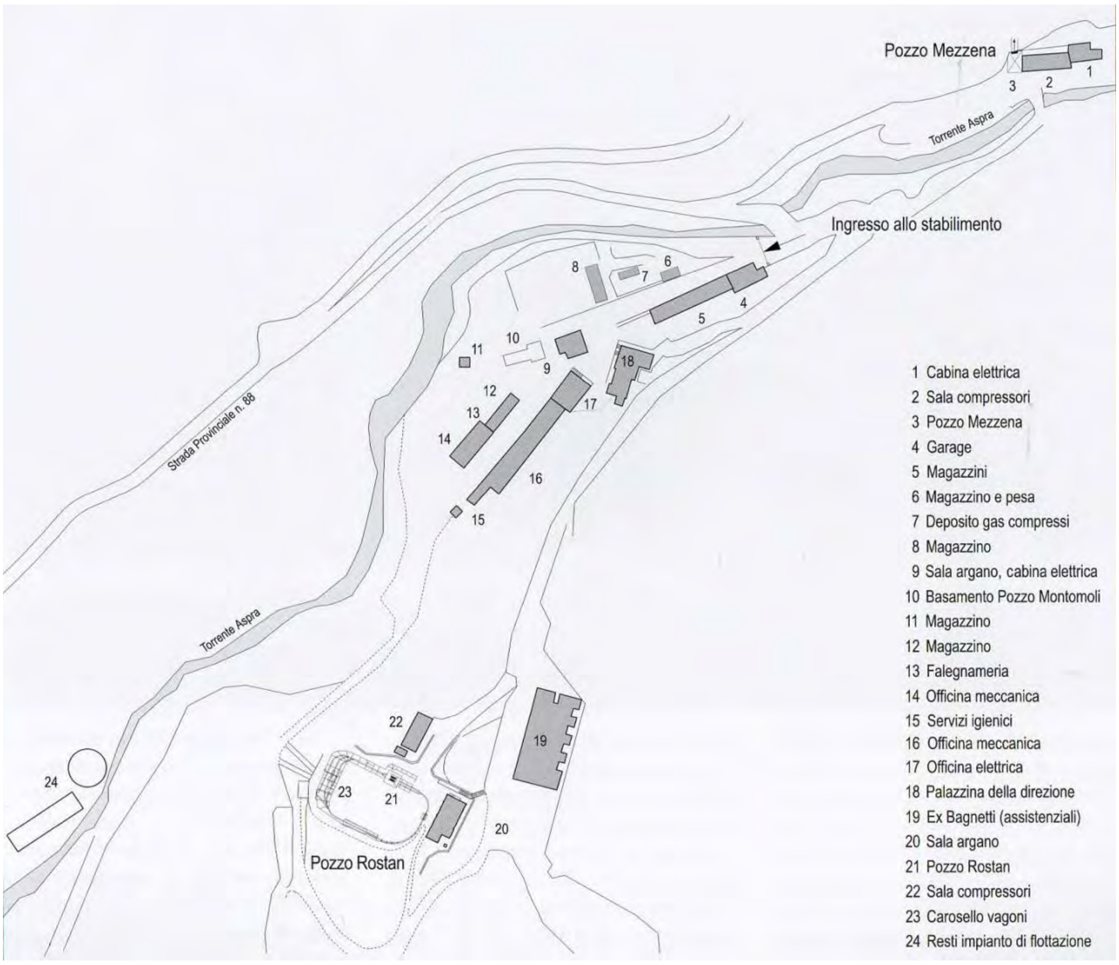


Figure 4. General Planimetry of Niccioleta. Source: Preite, *Paesaggi industriali del Novecento*, 2006.

[37] Preite, M. Le miniere di pirite. In Preite, M. (Ed.). *Paesaggi industriali del Novecento. Siderurgia e miniere nella Maremma toscana*. Florence: Edizioni Polistampa, 2006, pp. 153 – 154.


Figure 20. Internal of pit Montomoli. Source: Preite, *Paesaggi industriali del Novecento*, 2006.

Figure 21. Corvo Pit at present. Source: Preite, *Paesaggi industriali del Novecento*, 2006.

The fate of this mine, resulting at first negative in searches, came to a turning point in 1927 with the discovery of a great pyrite shoal that gave the beginning of the modern development of Niccioleta, thanks to the realization of the washery and the yard of crushing in 1930 near *Pozzo Montomoli*. The initial transport of the minerals on wagons up to *Ghirlanda* railway station was replaced in 1931 by cableway linking Niccioleta Boccheggiano to the core of *Pian dei Mucini* and to Scarlino Scalo, where continuing via train, finally reached Portiglioni to be boarded on ships. In 1935 two new shafts were added, the *Fontegrilli* and *Mezzena:* the latter became the main centre of extraction of the mine, thanks to its strategic position with respect to the underground.


Figure 5. Mezzena pit on duty. Source: www.lombardiabeniculturali.it

Given the increase in production and the volumes of mineral to treat, between 1933 and 1936 the Montecatini realized the village for workers and technicians, where the typical functional and social separation in workers'towns of the Fascist era were set: along the main road there were the collective services such as the school, the outled and the *dopolavoro*; in the north area there were the Director's villa, parted from the rest, and residences for employees. The southern part of the village, instead, is set around a rectangular square accessible only from the middle of the sides and varied in its forms and typologies: multistorey buildings, terraced houses and corner buildings[38].

Figure 6. The after -work edifice in the mining village of Niccioleta. Source: Preite, *Paesaggi industriali del Novecento*, 2006.

At the end of the war, the Company proceeded to the reconstruction of the yards damaged by bombings, namely the washery, *Montomoli* shaft and the galleries. Moreover it hastened to the construction of new facilities: the firsts were the floatation and the New Washery in 1952, followed by the metallic headframes which replaced those almost destroyed of *Montomoli* and *Corvo;* in 1960 the Company realized the new *Rostan* shaft that replaced *Montomoli* and became a central node in the organization of the work in the Mine: the *Rostan* was in fact responsible for the movement of large materials such as machinery, and minerals, while the *Mezzena* introduced miners and the materials of small dimensions in the underground; both were endowed also with ventilated galleries outfitting the yards, together with *Montomoli, Fontegrilli, Corvo* and *Tosi*, built in 1959.
Starting from the Sixties, the mine was characterised by three productive centres: *Mezzana,* with the compressor room and the power station, the gallery and the shaft; *Rostan* where the extraction and crushing of the minerals to be sent to the flotation-decantation took place and that includes the crane and the compressor room; *Montomoli* including the auxiliary services and laboratories, as warehouses, workshops, carpentry and power station. The Directorate, connected to *Rostan* by a staircase, the extraction shafts and ventilation were added to these three cores. At the end of the decade the treatment plants of the minerals became superfluous since the Company had become producer of sulphuric acid and they could send directly the

[38] Ibidem, pp. 155 – 157.

rough minerals to *Casone* chemical plant[39]. The transport, initially entrusted to the cableway, was supplanted in 1968 by trucks, loaded in correspondence of the silos located under a overturning system, specially created following the transformation of the washery and flotation plant in carousels for the sorting of the laoded wagons of mineral. These, once emptied, came at the shaft mouth through the carousel and fell in the gallery for the next collection. Currently, the "*Décauville braking systems of wagons, the reverse and the lifters chain that reported in share the wagons from where they slipped to reach again the cage which was supposed to lead them back to gallery are carefully retained".* (Preite, 2006)[40].
Since 1971 the minerals had been sending to a crushing plant that minced pyrite and then they were transported on belts up to the pit basement to be sorted and finally loaded on wagons.

Figure 7. The carousel of wagons at Rostan shaft. Source: Preite, *Paesaggi industriali del Novecento*, 2006.

[39] Ibidem, pag. 161.
[40] Ibidem, p. 161 – 162.

The mining castles

In Niccioleta site we find a typology of headframes where the frames of the cages are independent from the ones dedicated to reject the traction created by ropes in tension in the winch, represented by the struts, by carrying elements, by thrust bearing etc. may be encountered. To the former category *Tosi* Pit and *Rostan* Pit may belong[41] [42]. The first is characterized by a 24m high tower and by metal solid profiles, on which the stair leading to the millstones is placed and by two unshielded struts linked to each other. The latter is even 30 m high and it contains a chassis of slip of the nests obtained from reticular I-beams holding two struts welded by plates to the main frame. After the closure of the mine, the shaft mouth was closed with two slabs in reinforced concrete and the stair was partially demolished to prevent access to the headframes[43][44].

Figure 8. On the left Tosi shaft, on the right Rostan shaft. Source: Preite, *Paesaggi industriali del Novecento*, 2006.

[41] Maciocco, G. I monumenti della tecnologia. In Preite, M. (Ed.). *Paesaggi industriali del Novecento. Siderurgia e miniere nella Maremma toscana*. Florence: Edizioni Polistampa, 2006, pp. 192 – 193.

[42] Maciocco, G. Il Patrimonio Minerario Moderno. In Preite, M. (Ed.). *Masterplan. La valorizzazione del paesaggio minerario*. Florence: Tipografia editrice Polistampa, 2009, pag. 88.

[43] Ibidem, pag. 88.

[44] Maciocco, G. I monumenti della tecnologia. In Preite, M. (Ed.). *Paesaggi industriali del Novecento. Siderurgia e miniere nella Maremma toscana*. Florence: Edizioni Polistampa, 2006, pag. 192.

# SPAIN: CIUDAD REAL

## The Mining Heritage in Castilla - La Mancha

### Introduction

Throughout the last fifteen years in Spain an incremental process toward the National Heritage in general occurred and in particular toward cultural, architectural and historic manifestations of the industrial and mining production. The changes undoubtedly affected a variety of socio-economic transformation that led Spain to high levels of scientific and cultural production[1], like many other European realities. The interest toward the industrial heritage has been as much academic as scientific and gave a value that exceeds the "headpiece" linked to historical and artistic circumstance; it collects cultural, ethnological testimonies and identities of the variegated Spanish territorial conformation. The industrial heritage is then invested in a social and cultural role that must revitalise and bolster the "places" in which it is constituted, responding both to a conceptual reuse that prevents the loss or dismemberment, and collective for returning to the communities of affiliation.

In Castilla-La Mancha's areas this ideological and methodological adjustment aiming at the protection and recovery of the architectural, technological and urban waste of mining and industrial production spans to the territorial scale, investing more productive sites and bringing together testimonies on tangible and intangible assets, such as the identification of the population's customs and life conditions that "*we accept today as an important element of the cultural heritage to which material and social value is worthy to be recognized*, *not precluding any artistic interest*, *whose conservation, protection and study are essential for the understanding of the industrial contemporary society.*"(Benito del Pozo, 1998: 171)[2]

The first initiatives and the first studies on industrial heritage date back to the end of the Sixties and the beginning of the Seventies[3] on the initiative of bodies such as the Council of Europe, which promoted events including the European Inventory of Cultural Protection (EICP) to inventory and summarize the status of goods in the inventories manner on the historical-artistic heritage, monuments of military architecture and urban – rural sites. This activity was added after the specific cataloguing, as in the case of the inventory of Historical - Industrial Heritage in Asturias in 1987 that became a good example for other Spanish regions.

In the meantime, a long and fruitful season of conferences and seminars contributed to spread the interest for industrial heritage and for the issues of recovery and reuse, as in the case of the days for the protection and rehabilitation of industrial heritage in Bilbao in 1982, the Spanish Days of industrial heritage and Public Works in Seville in 1990 and the Seventh International

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[1] Cañizares Ruiz, M. C. Patrimonio minero-industrial en Castilla – La Mancha: el área Almadén – Puertollano. *Investigaciones Geográficas*, n. 31, 2003, p. 88.

[2] Ibidem, p. 88.

[3] Ibidem, pp. 89-89.

Congress for the conservation of the Industrial Heritage held in Madrid in 1992, upon the request of the International Committee for the Protection of Industrial Heritage.[4]

The first pioneer initiatives in the recovery field of Spanish industrial heritage must be sought in the museum context as well as for the Historical Mining Museum D. Felipe de Borbòn foundation in Madrid or the Historical Mining Museum de La Uniòn in Murcia and that of science and technique of Catalunya in Terrassa, located in a wool factory at the beginnings of the Twentieth century, to which the Paper Museum of Capellades, Museum of Cork in Pallafrugell and the Museum of leather and water in Igualada followed. Equally important, the Museum of Baracaldo Art, the Museum of Arts and Sciences in Valencia and the Science Museum of Valladolid, a project result for a factory conversion for the flour production by Rafael Moneo. For the Castilla La Mancha region the Science Museum in the old town of Cuenca is worthy to be mentioned[5].

In the mining field, with the exception of the Sixteenth century ancient *Ferrerìa de la Mirandola* restoration and conversion in Legazpi, the Basque Country in 1952, we must wait but the beginning of the Nineties for the first restorative promulgator initiatives and of the mining assets: the Park - Museum of Rio Tinto in Huelva in 1992 reuses in fact the copper mine, while the Mine and Industry Museum of Asturias in coal valley of *El Entrego* in Oviedo in 1994 focuses on the ruins of San Vincente mine and it rises above the land of landfill derived from coal mining.

The common objective of these measures is the conservation of the cultural and historical heritage that the mining valleys guard and, at the same time, seek new alternative uses that skimp or at least would slow down the economic collapse[6].

## Mine industry and heritage in Castilla - La Mancha

The affirmation of the industry in Spain and in its most developed areas has suffered over the years a passage from pre-industrial phase of handicraft production to the establishment of true and own industrial plants that, after the intense growth of the secondary sector in the period between the Nineteenth and the middle of the Twentieth century, has finally concluded its parable in descending phase consequent to the oil crisis of the Seventies.

In Castilla - La Mancha the pre-industrial stage is located temporally in the Eighteenth century with the predominance of productive activities linked intimately to the intervention on the Royal factory state and it cared for the most part the transformation processes of natural products (wool) and mining (metals). The mining activity, historically established in Spain since the pre-

[4] Cañizares Ruiz, M.C. *Territorio y patrimonio minero-industrial en Castilla – La Mancha*. Cuenca: Ediciones de la Universidad de Castilla - La Mancha, 2005, p.35.

[5] Ibidem, p. 35.

[6] García García, G. La adaptación de la Mina Alfredo (Riotinto) para visitas. *Ingeopres(Actualidad Técnica de Ingeniería Civil, Minería, Geología y Medio Ambiente)*, n. 58, Madrid, 1998, pp. 56-60.
Op. cit. in: Cañizares Ruiz, M. C. Industrial and mining heritage in Castilla - La Mancha: the Almadén – Puertollano area. *Investigaciones Geográficas*, n. 31, 2003, p. 90.
Op. cit. in: Cañizares Ruiz, M. C. T*erritorio y patrimonio minero-industrial en Castilla – La Mancha*. Cuenca: Ediciones de la Universidad de Castilla – La Mancha, 2005, p. 36.

Roman era, gained strength as the industrial sector in the Nineteenth century in the major production sites as Almadén for mercury, Hiendelaencina for silver, Hellìn for sulphur deposits and Puertollano for coal ones; prosperity of these sites became such to be awarded the "subsector of the *most important industrial activity in the region*,"[7]as well as the conversion to petrochemicals and thermoelectric power production in Puertollano and Ciudad Real areas, which remains one of the heavy industrialization rare events in this Spanish region.

The serialise of industrial production – identifiable in the categories of production on a medium scale in the small or the tertiary sector like textiles, furniture craftsman, shoe making and processing of raw materials such as leather and wood up to the food sector – has not favoured over the years a rapid growth and an expansion of the industry in the territory and it has caused a slow insertion of firms in the new emerging spaces, ideal to respond to industrial change that has characterized this region throughout the Eighties.

The types associated with industrial production end up reflecting the productive characterization of which buildings, equipment, machinery and at the same time lifestyles, technical knowledge and the plant that constitute the remains intangible assets[8] of the Spanish industrialisation, still survive.

From the comparison of production places typologies, the various groups that are classified according the raw materials used and related with the relative supply systems have been detached: energy (windmills, hydraulic mills, factories of electricity), the mines (structures and constructions), agro-food industry (shops, crushers), metal processing sites and mechanical industries (foundries, metallurgical centres), construction (brick factories and calcine) etc. In the totality of these sets we can find the complex of territorial productive culture, which in Castilla La Mancha's area should focus out in the intentions of those who work for the enhancement of this cultural heritage to promote precisely those spaces where the industrial production has stopped caused the decline or the backwardness for economic and political reasons[9]. It is just in that Spanish geographic asset that we recognize a deep stratum of mineral heritage drenched into a cultural thickness, in which the identity values of local communities and the high scientific consideration in respect with the high technological and architectonic quality of its material goods are conflated to form the true industrial mineral heritage of the region.

### The industrial mining heritage in the area Almadén - Puertollano

The territory taken into consideration for the analysis of the characteristics of the mining-industrial assets is in the south-western area of Ciudad Real province, in the heart of Castilla-La Mancha. There are three major regions: the *Comarca de Almadén*, i.e. the valley where the compounds of Almadén and Almadénejos stand; the *Alcudia– Sierra Madrona Valley* rich of

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[7] Panadero, M., Pillet, F. Castilla – La Mancha. In García, J. M., Sotelo, J. A. (Eds.) *La España de las Autonomías*. Madrid: Síntesis, , p. 319. Op. Cit. In: Cañizares Ruiz, M. C. Industrial and mining heritage in Castilla - La Mancha: the Almadén – Puertollano area. *Investigaciones Geográficas*, n. 31, 2003, p. 90.

[8] Cañizares Ruiz, M. C. *Patrimonio minero-industrial en Castilla – La Mancha*: el área Almadén – Puertollano. *Investigaciones Geográficas* n° 31, 2003, pp. 90-91.

[9] Ibidem, p. 91

testimonies of the industrial mining past; finally, the area of Puertollano that represents the only urban settlement of this area.


Figure 1. Indication of the mining area in Ciudad Real Province. Created by the author.

*Short characterization of mining and industrial activities*

The mining history of the region begins in pre-Roman times in which we assisted to an implementation of the first cinnabar extraction, after the Roman occupation. The ore was extracted in fact in Roman mines to exploit vermilion for dyeing and later employed for the extraction of silver and lead in *Valle de Alcudia*, particularly in *Diògenes* and *San Quentin*[10]mines.

After the collapse of mining activities during the Visigoth occupation, with the arrival of the Arab conquerors there was a strong recovery of the extraction and processing of cinnabar in Almadén, especially for medicinal preparations and for the alchemical beliefs attributed to mercury. After the *Reconquista* in the mid-Thirteenth century the Almadén mine was acquired by the Order *de Calatrava* that rented it to private until the mid-Sixteenth century, when it was sold to the Spanish Crown.

Cinnabar became an increasingly important resource, even in the centuries of the Modern Age in conjunction with anthropogenic factors such as wars, urban development, population growth and intensification of textile pigmentation. Starting from 1555, moreover, the exports of mercury in the New World, obtained from the fusion of cinnabar, are intensified due to the increase of requests, due to the exhaustion of the metal in the Peruvian mine of Huancavélica[11]; over the

[10] Ibidem, p. 93.
[11] Ibidem, p. 93.

same period the mines were leased to German bankers Függer to deal with loans granted to Charles I.

Except for Almadén and its cinnabar field, from the Seventeenth to Nineteenth century almost all mining complexes entered a phase of decline, which only stopped thanks to the legislative intervention[12], which opened the doors to foreign investments, thus benefiting the mining companies and bringing innovations in mining techniques such as railways. The last three decades of the Nineteenth century were marked by the reactivation of the silver-lead mines, the exploration of new mining deposits in *Horcajo* in the Valley of Alcudia and Sierra Madrona and finally the discovery of coal deposits in the mining area of Puertollano in 1873. In this area in fact the French and Belgian firms did take off the economy linked to the exploitation of the basins, reaching high levels of production during the First World War thanks to coal and bituminous slate.

In Puertollano's area this evolution developed in an even more obvious manner, especially referring to the mining heritage: in *Nuestra Senora de Gracia* foundries (1882) and *La Paz* (1886) was in fact worked the greatest amount of galena in the whole province[13] [14] and the origin of industrialization may be traced there, along with the slate bituminous treatment sites to produce industrial oils that the Mining - Metals of Peñarroya Company had implanted in 1917. After the war, this process further increased by its role as economic and social evolution of this production centre after the creation by the National Institute of Industry of the *Empresa National Calvo Sotelo* to bring the distillation of bituminous slates on a larger scale during the autarchy[15] [16] [17]. Later these activities were addressed towards the petrochemical industry, preserving the coal mines active.

## The heritage: analysis and typology

Ciudad Real jurisdictional area is certainly marked by the presence of age-old mining activity that has changed the landscape, the urban settlements, the productive and social history over the centuries. The built landscape is then identified with the presence of rural and urban components, defined by inhabited centres built at the mine opening and their ancillary services, and by industrial components, for the most part consisting of abandoned sites, headframes, treatment and smelting plants.

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[12] See Mineral Law of 1825 and General Mining Act of 1869.

[13] Cañizares Ruiz, M. C. Patrimonio minero-industrial en Castilla - La Mancha: el área Almadén - Puertollano. *Investigaciones Geográficas,* n° 31, 2003, p.94.

[14] Cañizares Ruiz, M. C. *Territorio y patrimonio minero-industrial* en *Castilla - La Mancha* Cuenca: Ediciones de la Universidad de Castilla - La Mancha, 2005, p. 66.

[15] Cañizares Ruiz, M. C. Patrimonio minero-industrial en Castilla -La Mancha: el área Almadén – Puertollano. *Investigaciones Geográficas*, n. 31, 2003, p. 94.

[16] Cañizares Ruiz, M. C. T*erritorio y patrimonio minero-industrial en Castilla – La Mancha*. Cuenca: Ediciones de la Universidad de Castilla – La Mancha, 2005, p. 42.

[17] Cañizares Ruiz, M. C. Algunas iniciativas de turismo minero en Castilla – La Mancha. *Cuadernos Geográficos*, 34 (2004-1), p. 138.

The interactions of these components then finished creating the social and cultural relations between the production world tied to the mines and the way of life and work of the people living around the mining sites, adapting according to more or less stable equilibrium to the environmental diversity and mineral resources, which have ensured their survival over the centuries.

*Almadén District*

The patrimonial inheritance that the age-old exploitation of cinnabar deposits left on this territory is linked not only to the transformation processes and mercury processing but also to the criteria by which the mining sites have gradually configured depending on its useful life, the availability of raw materials and technological and plant transformations on the territory. The reflections of these processes are still perceptible in the built remains, those of the Bourbon period, in the urban context located around the mines and in transporting and connecting systems, such as the *Ruta de Azogue* marking the ore transport route from the Almadén in Seville. For these reasons, the mining industry heritage kept in Almadén and Almadénejos sites is a prime example of how mining technology has permeated over the centuries this territory and its urbanization phenomena.

The conservation of these elements, bounded to the extractive – industrial systems, is therefore aimed at the preservation and prominence as testimonies of the historical and technical value they play in their urban and territorial system of belonging. The typical case of cinnabar baking ovens is extremely exhaustive in respect of cultural and technological comprehension of the evolution that over the centuries has transformed the mining sites: first *de aludeles* or *Bustamante* ovens were named after Juan Alonso de Bustamante and were inserted into the cinnabar processing circuit in 1646; then the reverb ovens or *Hornos de Buitrones* and *xabecas* ovens from the Arabic system. The layering of these ovens makes an idea of an ongoing willingness on the part of keepers and mining leaders to increase the productive standards through the improvement and the study of new technologies, which are combined to interventions of urban and social planning, connections between the mining sites and exportation ports and cultural-technical exchange on a local and extra-continental level. The *Bustamante* ovens, designed by Lope Saavedra Barca in 1643, in fact, were used in the mines of Huancavelica in Peru and remained in use in Almadén mines up to early Twentieth century, in addition to the Idrija ovens in 1806, and replaced in 1887 with Livermoor ovens and with Spirek in 1902.

The *Bustamante* ovens were running between 1720 and 1928 and they were continually subject of studies, comparisons and implementations that are however based on their manufacturing quality, thanks to the vaulted structures entirely made of bricks and earthenware jars channels. The latter collected mercury fumes developed by the combustion of cinnabar through wood fires placed inside. Much of the ovens have been lost, but a pair in good condition has been preserved within the mining area of Mayasa Company, the company that owns the Almadén and Arrayanes Mines. Five pairs of *de aludeles* ovens survive in a state of semi abandonment in Almadénejos, in correspondence with the Mine of *Nueva Concepción*. Altogether, the remnants of the ovens are a valuable testimony of cinnabar metallurgy in the Almadèn region and its transportation to the suburbs of the State, demonstrating the technical and cultural value that covers them. The *de aludeles* ovens were therefore declared Heritage of Cultural Interest in 1992 and the Spanish Historical Heritage Institute took charge of their recovery through a project cost amounted to € 250,000[18].

Along with a part of the characterization and typology of the mining heritage, other elements of value within the production circuits, namely *Bariteles* cannot go unnoticed. They are circular buildings which housed the *Baritel*, a capstan driven by horses which had the task of draining the wells and load and unload the ore mined in them. These machines consisted of a vertical shaft to which they connected through one or more horizontal planks whose ends horses were hitched at. The horses then turned around the central shaft by raising or lowering the collection and drainage equipments. The *Bariteles* derived from the lathes of hand-extraction and they were used until the mid-Eighteenth century, when metallic castles and steam extraction machines were introduced.

The still visible and best preserved *Bariteles* are those of *San Andrés* Pit, in the first level of *Mina del Castillo* and of *San Carlos Pit* in *Nueva Concepcion* in Almadénejos mine, dating from the end of 1700 and recognized as Heritage Cultural Asset since 1958. This *Baritel* is located outdoors and features a circular plant of 17 meters in diameter and a sixteen-sided polygonal portion, closed by a hemispherical – conical vault covered by ceramic tiles covering the 16 pitches. The structure is made of bricks with ordinary equipment and brick layers[19].

Figure 2. *Baritel* of the *Pozo San Carlos* in the *Nueva Concepciòn* mine in Almadénejos. Source: http://solienses.blogspot.it/2016/05/una-vez-mas-en-Almadén.html

[18] Ilustre Colegio Oficial de Geólogos, *Tierra y tecnología – Revista de Información Geológica*, n. 29 (1° semestre), 2006, p. 9.

[19] Cañizares Ruiz, M. C. Patrimonio minero - industrial en Castilla - La Mancha: el área Almadén - Puertollano. *Investigaciones Geográficas*, n. 31, 2003, p. 95.

After the Eighteenth century metallic castles were introduced and gradually replaced the wooden *Bariteles*: among the best known and best preserved is the *San Aquilino Pit* in Almadén mining site, the only one of this type in *the Cerco of San Teodoro* to keep intact the engine room and part of the original plant.[20].


Figure 3. Metallic Castle of *San Aquilino Pit*. Source: Parque Minero de Almadén.

## The mines fences: the *Cercos*

The *Cercos* constitute the wall perimeter of the extraction site, including the deposits and production/extraction facilities. To date, even partially remains the *Cerco of San Teodoro,* which hosts the eponymous shaft and was the fence where there were general services and the main functions of the mine; within it there are the *San Teodoro* shaft, the metal and the engine room of *San Aquilino* shaft, the laboratories and compressor room, as well as the current visitors centre, made with the creation of the Mining Park[21]. Other well preserved *Cerco* is the *Cerco de Buitrones* or *de la Distilaciòn,* which contains the storage rooms for the mercury, the pair of *Bustamante hornos* and the *Puerta de Carlos IV*, dating back to 1786, that allowed the entry and the exit from the mine. The *Cerco de la Mina del Pozo* is almost totally collapsed[22] [23].

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[20] Cañizares Ruiz, M. C. Algunas iniciativas de turismo minero en Castilla – La Mancha. *Cuadernos Geográficos*, 34 (2004-1), p. 135.

[21] Rubio, R. F. (Ed.). *Rehabilitación de Espacios Mineros. Experiencia española*. Proceedings of the Congreso Nacional del Medio Ambiente - Cumbre del Desarrollo Sostenible, Madrid 1-5 diciembre 2008, p. 36.

Available in: http://www.concretonline.com/pdf/08mineria/art_tec/MIN_final.pdf

[22] Cañizares Ruiz, M.C. Patrimonio minero-industrial en Castilla - La Mancha: el área Almadén- Puertollano. *Investigaciones Geográficas*, n. 31, 2003, p. 95.

In Almadénejos the *Cerco de Buitrones* preserves much of the original walls of the period 1757 - 1757 and some ovens remains.

## Urban edification

The urban system that has developed around the mining enclosure includes residential buildings and ancillary services related to the mining sector. Among them in the first place there is the *Casa Academia de Minas*, of 1777, which was the first training school for mining engineers throughout Spain and later converted into school for master builders. The building has a brick equipment and a Neo-Classical façade on two floors, which gives a typical noble aura of the Eighteenth-century Palace.

Within the urban factory there is also the *Real Hospital de Mineros de San Rafael,* founded in 1752 by the Superintendent Francisco Javier de Villegas in the wake of the Enlightenment health movement ideals directed to care workers' health[24]. Built between 1765 and 1775, it is an L-shaped building with patios and garden and other dependencies inside. Its main façade stands out for its central portal in brickwork, on which sober Doric pilasters and a representative balcony stand. The portal ends with a small bell tower with a niche where is a Rococo icon of the Archangel St. Raphael. The front walls at the sides of the portal are made of limestone and masonry, covered with cement and lime plaster.

Finally, the *Galeria de Forzados*, built in 1754 to house the condemned to forced labour in mines, connected one of the mine galleries with the prison.[25].

## Shafts

*San Teodoro* shaft is one of the earliest realized at the half of the Eighteenth century to extract the cinnabar in *Castillo* mine, discovered in 1698 by the Superintendent Miguel de Unda: the peculiarity of this well is the installation of a winch[26] in place of mules that worked in the underground of *San Andrés* pit, and the first steam machine used in Spain for the dewatering of the subsoil waters.

The original aspect of *San Teodoro* Pit has been modified several times, making it now completely unrecognizable from the Eighteenth-century configuration: the first modification dates back to the *Consejo de Castilla*, which is the main nerve centre of the Spanish monarchy government power during the Modern Age from the Sixteenth to the Nineteenth century. The Council became in fact the owner of the mine and endowed it with numerous infrastructures such as metal runners and extraction electrically powered machinery. The second modification

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[23] Carrasco Milara J. *El Parque Minero de Almadén* In Acts of the 6th International Meeting on the Actuality in the Museography, Bilbao 17th- 20thJune 2010- España, pp. 93-95.

[24] Peris Sánchez, D. *Paisajes Industriales de Castilla-La Mancha*. Madrid: Bubok Publishing S.L., 2013, pp. 244 – 246.

[25] Ibidem, p. 246

[26] Illustre Colegio Oficial de Géologos, *Tierra y tecnologia- Revista de Información Geológica,* n° 29 (1st semester), 2006, p.11.

dates to 1962 when the shaft reached its current configuration and the depth of 500 meters for 19 levels of extraction[27].

Figure 4. *San Teodoro pit* before the modification in 1962. Source: mti-minas-castillalamancha.blogspot.it

The most ancient and the best preserved in Almadén mine is the *Pozo San Aquilino*, whose first traces amounted from 1543[28] which related of a vertical shaft, best known as *La Grùa* of 30 arms depth. Its depth later arose up to 14 levels and a steam engine for mining purposes was installed, further replaced by an electric machine with guarded steel coils and cables, still visible in the room of the equipments located at the foot of *San Aquilino* shaft.

[27] Ibidem, p.11.

[28] Ibidem, p. 11.


Figure 5. *Cerco de San Teodoro*: *San Aquilino pit* and engine room, in close-up the extracted mineral .
Source: Parque Minero de Almadén.

The technical buildings associated with the extraction sites in Almadén include the laboratories and a compressor room, made in 1924 at the urging of the Board of Directors that pressed for the provision of more modern treatment facilities since 1918. The electrification of the mine, which got underway in those same years, brought the total mechanization of water dewatering processes while the slag heap was used to fill the gaps created by the exploration galleries. In the laboratories we may still observe the machines that were in operation at the time of closure of the mine: given the need to provide autonomously to the technical support and materials to the whole mine, there were carpentries, casting and forging workshops, welding, joints, mechanical and electrical workshops[29].

Currently, the former compressor room houses the Mining Interpretation Centre, where the machinery for the production of compressed air, blown inside tunnels for mechanical drills operation, is quartered. The Centre, located near *San Teodoro* shaft and the mining workshops, houses the Mining Park reception and it also contains a projection room, a cafeteria, bathrooms and storage rooms.

[29] Ilustre Colegio Oficial de Geólogos, *Tierra y tecnologia- Revista de Información Geológica,* n°29 (1[st]semester), 2006 p. 11.

Figure 6. The Mining Interpretation Centre and *San Teodoro* shaft. Source: Parque Minero de Almadén.

### *La Valle de Alcudia and Sierra Madrona*

In the area of Alcudia and Sierra Madrona, bounded by the *Comarca de Almadén* and Puertollano from the north, there are many mining complexes: *La Romana – Veredillas* includes for instance several mines as *La Romana* and *La Emperatriz,* whose masonry-built mining castles still survive.[30].

*San Quintin* mining site has almost destroyed, the mining village linked to it has completely disappeared and the only traces of its mining past linked to the extraction of silver are represented by the remains of a washery. Its most important and distinctive element is the in-view brick and stone masonry headframe, equipped with a winch pulleys housed in the upper part and an engine room of large dimensions that dates to the period of greatest growth and tenor of the mine, between 1887 and 1934 under the ownership of *Sociedad Minero - Metalúrgica de Peñarroya* (SMMP).

From *Diogenes* mine the castle of access to the well number 5 has survived to nowadays, and it is currently housed in the patio of the *Escuela Politecnica* of Almadén: it is characterized by a four-storey tower in bolted metal profiles that support the fifth and last floor on which the mounting platform of the toothed wheels and metallic cables for extraction accommodate. The other buildings that make up the complex are part of the old mining village and represent an excellent example of the French style urban mining, with the ruins of washing plants and laboratories[31].

[30] Cañazares Ruiz, M.C. Patrimonio minero-industrial en Castilla - La Mancha: el área Almadén – Puertollano. *Investigaciones Geográficas,* n°31, 2003, p. 96.

[31] Ibidem, p. 98.

Figure 7. *Diògenes mine* headframe in the patio of the *Institute of Technology* in Almadén.
Source: http://mapio.network/pic/p-50310676/

Between 1888 and 1910 the most fruitful period for the mining complex of *Horcajo*[32] [33] arises, controlled by French and Belgium societies that set a great centre of exploitation of lead and argentiferous galenite deposits. Notwithstanding the size of the site, to date only few survivors and in state of ruin remain, since that the population who live in the old mining village tends to practice farming more than mining and therefore the structures which guaranteed essential elements such as hospital, drugstore, school and social cooperative got progressively abandoned. Among the remains of mining activity a square-planned shaft stands on a thick bricked platform, which is reinforced by counterforts placed at the angles and surmounted by two ogival arches at the opposite sides conferring agility to the structure. Two round-arches at the sides are flanked and jointed by a rectangular compartment. In the upper part we can find

[32] Peris Sánchez, D. *Paisajes Industriales de Castilla - La Mancha.* Madrid: Bubok Publishing S.L., 2013, pp. 205-230.

[33] Cañazares Ruiz, M.C. Patrimonio minero-industrial en Castilla – La Mancha: el área Almadén - Puertollano. *Investigaciones Geográficas,* n° 31, 2003, p. 98.

what remains of the old structure bearing the pulleys, as well as the recovery shaft of the extracted material (*amaine*) with a metallic platform and the guarding balustrade. In the middle of the village a survivor shaft stands on, consisting in a building in load bearing masonry crossed by round-arches and other remains of buildings related to mining[34]. Other brick-in isolated shafts contour the Alcudia Hill, too, such as the *Pozo Minero, Los Dolores* at Almodóvar del Campo, *Pozo* remains of the *Las Simonas* at Hinojosas de Calatrava and *La Gitana y El Encinarejo* at Mestanza.

*Puertollano area*

Puertollano mineral basin stands to testify the richness of the industrial past of the region, thanks to the well preserved industrial architectonic heritage and dating for a greater part to a period between 1870 and 1950; the coal extraction took place from 1873 to 1970s, followed on in the open pit mines with the purpose of feeding the two thermal power station in the neighbourhood; then the multi-layer bitumen shale intersecting through the coal strata which were exploited from 1917 to 1966 for obtaining the industrial oils during the autarchy[35]. With difference respect to other basins, Puertollano was object of mineral diggings for the coal extraction in subterranean pits spread along the valley: unfortunately, the remains of these extractive sites are deemed to be abandoned or demolished, including the dismantling of part of machineries, even those emerging from the open pit mining extensions near the ancient sites. The first renewal and recovery plan of mineral goods dated back to 1992 with the creation of the *Parque of the Pozo Norte* and of the *Museo de la Minerìa al Aire Libre*, which offer selected deemed areas to the urban expansion and the spare time realized above the mineral valley. The Park is placed on the Mining area of the *Pozo Norte*, belonging to the *Sociedad Minero Metalúrgica de Peñarroya*, and it preserves numerous elements of historic and technical asset such as the shaft of the *Pozo Norte* of 1928 in the ogival part of the area. This construction in fact results the main attraction of the Park, thanks to its 30 metres of height and the conservative good quality: it is formed by eleven benched bodies in the upper part and it is surmounted by a pavilion roof. The steel supporting structure is assigned to four great pillars reinforced by crossed tie rods. The machine room, which contained the most advanced engines of that epoch, was destroyed in 1978 together with the hoppers in reinforced concrete and consequently the toothed well was the one survivor left visible, which was formed by a pair of feed spools by an electric engine for the wires rolling[36].

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34 Cañazares Ruiz, M.C. Patrimonio minero-industrial en Castilla – La Mancha: el área Almadén-Puertollano. *Investigaciones Geográficas,* n° 31, 2003, p. 98.

35 Cañizares Ruiz, M. C. Algunas iniciativas de Turismo minero en Castilla - La Mancha. *Cuadernos Geográficos*, 34 (2004-1), p. 137.

36 Cañizares Ruiz, M. C. Patrimonio minero-industrial en Castilla – La Mancha: el área Almadén-Puertollano. *Investigaciones Geográficas,* n° 31, 2003, p.99.

Figure 8. Metallic shaft of the *Pozo Norte* in Puertollano. Source: www.puertollano.es

Figura 9. Museo de la Mineria in Puertollano. Source: Joaquín Bautista García su Panoramio.

Among the other plants of considerable assets there are some machineries used to extract coal and bituminous roofing slate, as the steam machine *050* manufactured in Belgium in 1907: this is an apparatus consisting of five pistons coupled to a total weight of 90 tons, which earned it the name of *La Gorda*, meaning the fleshy. Still, the machine 4000 – 015 and the prime mover of the gallery, both with a diesel engine, replaced the animal traction in the movement of the mine wagons in 1940[37].

*Heritage and safeguard measures*

Reclamation projects of Almadén mining assets relate to the machine room of the *Pozo Norte* and the creation of a new exhibition hall for the putting in exhibition of machinery and toothed wheels. The *Pozo La Cruz* was converted into the centre for the mine interpretation and it is possible to observe again the original structure composed of a parallelepiped shaft in masonry, located above a platform and to which a structure is borne with barrel vaulted ceiling that stayed the machinery.

Further restoration projects involve the *San Juliàn* and *San Felipe* pits: the former was constituted by four bodies carrying on which the toothed wheels covered by a roof with two slopes were placed, which today unfortunately got lost; the room of the machines is made of plastered bricks

[37] Cañizares Ruiz, M. C. Algunas iniciativas de turismo minero en Castilla – La Mancha. *Cuadernos Geográficos*, 34 (2004-1), pp. 138-139.

and a pitched roof and poured into a state of ruin, while the machines that it hosted are lost. In this complex a washery and a chimney of a melting furnace (no longer existing) still survive[38].

Figure 10. Puertollano: *Pozo San Juliàn*. Source: Minas de Sierra Morena. Los Colores de la Tierra. 2013. Autor: JCC.

The second pit, the *San Felipe*, is highlighted by a five-body metallic cradle shaft, with cement plastered bricks and two pitched roofed machine room. The coils and the cables of the no longer existing cages still survive.

[38] Cañizares Ruiz, M. C.Industrial and mining heritage in Castilla - La Mancha: the Almadén – Puertollano area. *Investigaciones Geográficas*, n. 31, 2003, pp. 99-100.

Figure 11. Puertollano: *Pozo San Felipe*. Source: Minas de Sierra Morena. Los Colores de la Tierra. 2013. Autor: JCC.

Outside the mining valley there are other structures linked to the mining extraction, such as: the shaft of the *Pozo Santa Maria*, belonging to the mining *Asdrùbal* complex with an incorporated mining village. The pit, built in 1910, is realized with five bodies, a benched pavilion roof, a frame of four pillars and beams bearing the central structure. A metallic ladder allows to reach the last level where there are the gear units.

*Pozo Elorza* shaft emerges in the north part and is constituted by seven buildings with a central structure surmounted by four pillars and parallel beams. The upper benched building, containing two parallel gear units, is hedged by a metallic vault. What remains today of the ancient machine room is just a hydraulic device and an ashery into a rectangular building laid to the shaft, above a concreted uncharged by a round-arched structure.
The treatment site and silage of mineral, realized in masonry, is still intact and it has a vault from which vehicles loading the mineral from the hoppers entered. In addition to this, there are also a water deposit and a cylindrical hopper joined to the rotating mechanism of the wagons for the mineral transport.[39]

[39] Ibidem, p.100.

Figure 12. Puertollano: *Pozo Elorza* nel 2012. Source: www.verpueblos.com

What still survives of the shaft of the *Pozo Arguelles* is just a winch located in one of the extraction buildings, whose foundations still remain.

*Don Rodrigo* pit, indeed, is countersigned for having wooden framed beams and bricked counterforts linked each other through closed round arches closed by bricklayers; a little bricked cistern used in the past as a magazine still survives, too. *Valdepeñas* pit shows off also as a bricked structure similar that of the metallic shafts, with a central zone open for the passage of the cages and bricked round arches. Still remaining in Puertollano, some elements placed in the so called complex of *Apartadero Calatrava* are worthy to be mentioned as a valuable part of the mineral heritage: these structures are linked to the mining life and still preserve some features that faithfully reproduce the original style. Today just the buildings and the machineries that the *Sociedad Minero – Metalúrgica de Peñarroya* (S. M. M. P.) had installed near the mine, where the distillation processes of the bitumen shales and the production of electric energy took place, still survive.

## The *Apartadero Calatrava*

The *Apartadero Calatrava* today represents the only industrial area of the first thirty years of the Twentieth century presenting a certain grade of integrity: the greater part of the installations located in the Puertollano territory amounts to the beginning of the century and, although it was object of a sort of a continuous process of integration and improvement by the owners, forms a historic and architectonic compendium which make it a unique specimen of the mining industrial past of this Autonomous Community[40].

The complex was conceived in the origin to accommodate the under station in which the coal, extracted in the carboniferous hills, was stored and then charged and transported for the redistribution. The *Sociedad Minero – Metalúrgica de Peñarroya*, owner of the greater part of the mining railways, controlled almost all the railway transports, despite the presence of other companies with their own railway installations already present in Puertollano. Here the road[41] from *Asdrùbal* mine joined together with the railway coming from Madrid towards Badajoz, up to the electric train coming from Conquista and all the series of little train lines that linked the neighbouring mines with pathways and different directions.

Actually, beside the traces left which give back life to this railway framework, the buildings and the machineries belonging to the S.M.M.P productive establishments, close to the carboniferous *Conca,* are still preserved. The most important ones, beside of being objects of study aiming at their evaluation and recovery, are:[42]:

- *The thermoelectric power station.* Dating back to 1917, this is the most important building among the preserved ones. It is considered the most ancient of Spain[43] and it may be considered as an example of the renewal and industrial development carried out by this Mining Society. For its construction some waste materials resulting from the demolition of a coal gasification building, bought by the Spanish Electric Company, were used[44]. The highest levels of production were reached starting from 1926, when a turbo-alternator of a great capacity was installed.

  The building is characterized by a central body and two towers housing the refrigerating plant: the first consists of a two-floor, red bricked and glazed edifice surmounted by double-pitched roof. The great glazed panels, which allowed the natural light to enter, are perfectly suitable to the principles of industrial architectonic functionalism. The towers

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[40] Cañizares Ruiz, M. C. La infravaloración del patrimonio industrial urbano. El "apartadero Calatrava" en Puertollano (Ciudad Real). In Pumares Fernández, P., de los Angeles Asensio Hita, M., Fernández Gutiérrez, F. (Eds.). *Turismo y transformaciones urbanas en el siglo XXI*. Almerìa: Universidad de Almerìa, 2002, p. 498.

[41] Herce, J. A. et al. *Apuntes sobre Arquitectura Industrial y Ferroviaria en Castilla – La Mancha 1850-1936*. Guadalajara: Colegio Oficial de Arquitectos de Castilla – La Mancha, 1998, p. 265.

Op. Cit. In: Cañizares Ruiz, M. C. La infravaloración del patrimonio industrial urbano, El "apartadero Calatrava" en Puertollano (Ciudad Real). In Pumares Fernández, P., de los Angeles Asensio Hita, M., Fernández Gutiérrez, F. (Eds.). *Turismo y transformaciones urbanas en el siglo XXI*. Almerìa: Universidad de Almerìa, 2002, p. 498.

[42] Cfr. Cañizares Ruiz, M. C. La infravaloración del patrimonio industrial urbano (Ciudad Real). In Pumares Fernández, P., de los Angeles Asensio Hita, M., Fernández Gutiérrez, F. (Eds.). *Turismo y transformaciones urbanas en el siglo XXI*. Almerìa: Universidad de Almerìa, 2002.

Cfr. Cañizares Ruiz, M. C. Algunas iniciativas de Turismo minero en Castilla - La Mancha. *Cuadernos Geográficos*, 34 (2004-1).

Cfr. Cañizares Ruiz, M. C. Patrimonio minero-industrial en Castilla - La Mancha. *Investigaciones Geográficas*, n. 31, 2003.

[43] Cañizares Ruiz, M. C. La infravaloración del patrimonio industrial urbano. El "apartadero Calatrava" en Puertollano (Ciudad Real). In Pumares Fernández, P., de los Angeles Asensio Hita, M., Fernández Gutiérrez, F. (Eds.). *Turismo y transformaciones urbanas en el siglo XXI*. Almerìa: Universidad de Almerìa, 2002, p. 498.

[44] Ibidem, p. 499.

were built starting from the reinforced concrete cylinders surmounting reinforced concrete pillars displayed in a circular perimeter.

Its overall state of preservation featured an advanced state of degrade, with important deficits in the coverings and in the glazed portals, and even the machineries have been taken out and stolen during years.

In 1995 a municipal report explained the worrying probability that within few years the building would be collapsed due to the negligence of the owners of the epoch, in danger of losing one of the most important thermoelectric power station of the Nation[45]. Fortunately the eventuality of its collapse has been averted by the municipal intervention in 2010, with the promotion of a competition for the recovery and the interventions of the restoration of the edifice. Since 2011, after a reconversion project, the Thermoelectric Power Station has become the Congress Centre and the Exhibition Centre of Puertollano city, with a project of the Architectural Office of Toledo A.I.A., in collaboration with *Sacyr* Society for the realization of the predicted actions[46].

The ancient building of the processors, the electric power substations, has been converted into an event place and coffee service, while the upper level has become a commercial space. An *ex novo* building, annexed to the north part of the Central, has been deemed to the neuralgic and management centre of the complex and as a main entrance during the working days. The original spiral staircase leading to the first level has been integrally preserved such as the metal bridge which crossed over the inner space of the main building.

The refrigerating tower represents one of the key elements of the recovery project, being the second most ancient Spanish tower with a spectacular reinforced concrete ceiling rose, which has been cleaned up and cleared out by debris.

In summary, the restoration has provided: 380000 units of restored bricks; 47000 kg of reinforcing steel in the structure of the cover; 65000 kg of plaster for the refrigeration tower; 400 $m^2$ of carbon fibre; 65000 $m^3$ of ground movement; 5000 $m^3$ of materials demolished in the interior in the main buildings as pallets of machinery, forge, reinforced concrete etc.; 3000 $m^2$ of coverage; 1500 $m^2$ of metal works[47].

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[45] Ibidem, p. 499.

[46] "The ancient thermoelectric power station of Calatrava will be converted into the Congress Palace of Puertollano." In CONEXO, 4 September 2008.
Available in: http://www.nexotur.com/noticia/9050/CONEXO/La-antigua-central-electrica-de-Calatrava-sera-transformada-en-el-Palacio-de-Congresos-de-Puertollano.html

[47] Ayuntamiento de Puertollano (Eds.). The first phase of the future pavilion of Conference and Exhibition has come to an end. In *Puertollano. Revista de Informaciòn Municipal*, n. 101, April – June 2010, pp. 16 – 17.

Figure 13. The Thermoelectric power station before the restoration. Source: Javer Callejas on Google Earth.

Figure 14. Interior of the Thermoelectric Central in 2008. Source: Javer Callejas on Google Earth.


Figure 15. Overview of the interior during works: the metallic bridge present in the roof has been preserved. Source: https://minasdepueblonuevodelterrible.jimdo.com

Figure 16. The external during the works of the company *Sacyr*. Source: https://minasdepueblonuevodelterrible.jimdo.com

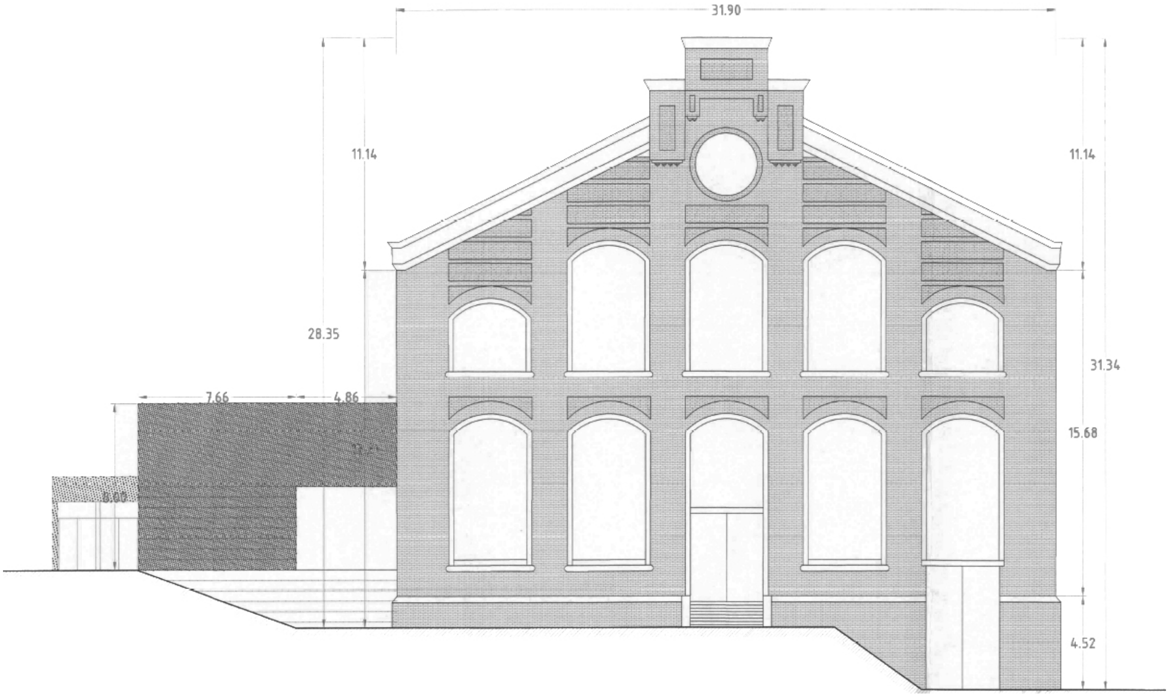


Figure 17. Section of the west side of the new Congress Centre: on the left the building added to the central nave.
Source: Ayuntamiento de Puertollano.

Figure 18. The Thermoelectric central station after the recovery works in 2011.
Source: Ayuntamiento de Puertollano.

- *The Bitumen Shales Distillery*. It embodies S. M. M. P. economic ambitions to exploit the bituminous slates through a complex process of distillation to obtain hydrocarbons. The plant was built in 1917, as an experimental project, in the vicinity of the Thermoelectric Power Plant: it consisted of a circuit board, the main one of the distillation followed by the condensation of the vapours of oils, by the recovery of the essences and greases and other complementary installations such as the distillation of oils, the laboratory of essences, that of the ammonium sulphate and paraffins etc. The buildings were built with bricked walls and double pitched roofs, however the progressive abandonment has caused an accelerated degradation: the large bricked chimneys of the oven are currently preserved while the original machines were sold by the Mining Company as old scraps and are therefore lost[48][49].

- *The Central Laboratory*. This large size complex was made in 1919 near the railway with the purpose of repairing the machineries that belonged to the S. M. M. P. and for these activities a foundry and forges were included. It represents an interesting case since it was equipped with every type of machinery and employed many workers.
  The supporting structure is in brick masonry and suffers from an important state of deterioration affecting both the coverage and the walls; the original machinery has instead been dismantled and sold as old scraps.[50]
- The *Laboratory of the machinery repair of the Railroad of the Mines*. This building is in vicinity of the Thermoelectric Power Plant where the steam engines that ran in the valley could access. It is constituted by double pitched coverage culminating with a beam structure and grooved plates, two large bricked pillars and a leaned body with great large window and an independent door. Through two large metal portals the machinery accessed inside, while a smallest counterdoor allowed the passage of personnel. A recessed compartment in the centre of the laboratory ensured the space necessary for the works of machinery repairing; the moulds for the creation and repairing of worn or deteriorated parts were placed in a room adjoining the main local. The level of degradation of the building is like the preceding examples of industrial buildings of the *Apartadero Calatrava*.

In addition to these elements of greater importance, within the mining heritage of the industrial area of Puertollano there are other properties worthy of mention: the material heritage, which includes tools and machinery of the mining life, was partly recovered and preserved thanks to

[48] Cañizares Ruiz, M. C. La infravaloración del patrimonio industrial urbano. El "apartadero Calatrava" en Puertollano (Ciudad Real). In Pumares Fernández, P., de los Angeles Asensio Hita, M., Fernández Gutiérrez, F. (Eds.). *Turismo y transformaciones urbanas en el siglo XXI*. Almerìa: Universidad de Almerìa, 2002, p. 499.

[49] Cañizares Ruiz, M. C. Patrimonio minero – industrial en Castilla – La Mancha: the Almadén – Puertollano area. *Investigaciones Geográficas*, n. 31, 2003, p. 100.

[50] Cañizares Ruiz, M. C. La infravaloración del patrimonio industrial urbano. El "apartadero Calatrava" en Puertollano (Ciudad Real). In Pumares Fernández, P., de los Angeles Asensio Hita, M., Fernández Gutiérrez, F. (Eds.). *Turismo y transformaciones urbanas en el siglo XXI*. Almerìa: Universidad de Almerìa, 2002, p. 499.

the interest of the Company *Cerconsa* and *Encasur* S. A. and today the saved machineries are hosted in their seats.

To conclude, starting from the Nineties there were several initiatives directed to make the industrial mining heritage acknowledged and awarded: the most important, always linked to the mining buildings in Puertollano, have created real symbols for revitalising or "restore" the image of the town. Among these we must remember[51]:

- The *Municipal Museum,* realized in an ancient consistory house in 1923, that has hosted since 1996 the tools and the mining equipment, the materials employed in the mines of the valley exposed in two permanent exhibition galleries, as well as wagons and lanterns and a genuine cartographic collection of the geological characteristics of the coalfield.

- The *Pozo Norte Park,* made in 1992, is considered as the first *museum of the mine in the open air* and it is settled in vicinity of the shaft that the *Peñarroya* society used to extract the bituminous slates. In addition to the mining castle, the extraction and transport machineries and mining tools such as wagons and carbide lamps are also well preserved. It represents an excellent case of musealization outside the building of the museum, because it enables spreading a knowledge obtained in the same cultural background of industrial goods. In 2000 it has been expanded with the *"Mining Interpretation Centre"* with the installation of a "Mine – Image" reproducing a 500 m deep underground gallery, which serves as a model in natural scale whose expenses are entirely covered by the Hunosa S. A. and by the municipal administration[52].

- *Pozo Santa Maria* shaft was recovered in 1999 by the *Encasur* S. A., owner of the production sites *Asdrùbal* mine, in collaboration with the Town Hall in Puertollano. The recovery also provided the extraction of the shaft from the building in which it was incorporated (in a state of ruin) to be transferred into one of the roundabouts access to the city and it was in fact converted into one of the main symbols of the mining past in Puertollano, together with the Pozo *Norte* shaft. Their architectural value, in virtue of their emblematic role as elements of the industrial iron architecture and their probable provenience from the School of Gustav Eiffel[53], springs out even more the importance of the preservation and evaluation of these items, which are the best expression of an identity value and common sharing.

[51] Ibidem, pp. 500 – 502.

[52] Cañizares Ruiz, M. C. Algunas iniciativas de Turismo minero en Castilla - La Mancha. *Cuadernos Geográficos*, 34 (2004-1), pp. 138 – 140.

[53] Cañizares Ruiz, M. C. La infravaloración del patrimonio industrial urbano. El "apartadero Calatrava" en Puertollano (Ciudad Real). In Pumares Fernández, P., de los Angeles Asensio Hita, M., Fernández Gutiérrez, F. (Eds.). *Turismo y transformaciones urbanas en el siglo XXI*. Almerìa: Universidad de Almerìa, 2002, p. 501.

Figure 19. Puertollano: *Pozo Santa Maria* oggi. Source: Tinico Jones - Flickr Hive Mind

## Methodology for the valorisation of the industrial mining heritage of Castilla – La Mancha

The first initiatives on conservation and restoration of the mining heritage started during the Eighties: some individuals and small groups in fact kept interested in the conservation of some significant elements of the metalliferous mines in the region, as in the case of shaft n. 3 of the mine of *Horcajo* (Ciudad Real), which was translated in the patio of the Almadén School of Mining Industrial Engineering in 1978 after the definitive closure of this mine by the end of the Seventies. This action constituted the embryo of other projects of valorisation of the mining heritage in this region. Since then, various projects were approved at regional level, divided into three groups[54]: those in the executive phase or development, those only at a study phase and the category that collects still devoiced cases of recovery projects, but which are subject of interest[55].

| | |
|---|---|
| Group A<br>Realised or under construction | · *Cueva* – Iron mine (realised)<br>· *Pozo Norte* of Puertollano open pit Museuem– Ciudad Real (realised)<br>· Gold mine interpretation Centre in Buenasbondas – Toledo (realised)<br>· *Lapis Specularis* Roman mine in Cuenca province. *La Mora Encantada*mine of Torrejoncillo del Rey – Cuenca<br>· Cultural project of the mining silver complex of *Hiendelaencina* – Guadalajara |
| Group B<br>Under planning initiatives | · Saline complex of *Las Salinas de Imòn* e di *La Olmeda de Jadraque* (Guadalajara)<br>· *Campo de Calcitrava* cultural park. *Cerro Gordo*volcano at Granàtula de Calatrava (Ciudad Real) |
| Group C<br>Appealing areas without project | · Mining landscape of Valle di Alcudia<br>· Cultural park at Sierra Madrona at Setiles (Guadalajara)<br>· Granite exploitation in Ventas with Peña Aguilera (Toledo) |

[54] Mansilla Plaza, L. *Methodology for the mining industrial heritage of Castilla - La Mancha evaluation for the mining industry heritage evaluation of Castilla - La Mancha,* Doctoral Thesis, Montes Tubio, F.P. Almarcha Núñez - Herrador, M.E. University of Cordoba. Cordoba: Cordoba University Editing Service, 2013, p. 173

[55] Ibidem, p. 174.


Figure 20. Map of the evaluation project in Castilla – La Mancha. Source: Mansilla Plaza, L. 2013, p. 175.

### *Pozo Norte* di Puertollano open pit mining museum (Ciudad Real)

One of the most attractive areas for the mining industrial heritage of Castilla - La Mancha is the valley of *Ojailen* river in Puertollano (Ciudad Real). Its remains – originated by the exploitations of coal minerals, bitumen shales and industrial oil residual of shales distillery – contour the industrial mining landscape and confer it a highest heritage level since that along with the mining works we find all the installations related to the industrial development already present in the area.

The interest for the recovery of this important heritage must be conducted to the 1990s with the recovery of some tools and materials for the creation of a mining section in the Municipal Museum and the starting of the municipal project "*Puertollano the green*" in 1992, with the main purpose of widening the green area of certain urban zones among which the *Pozo Norte* detaches. The economic contribution of the Municipal Council to the planning was translated into a reconversion project of the area, entitled *Pozo Norte Open Pit Mining Museum*.

A qualitative leap in the whole process was achieved with the inclusion of the mining area of Puertollano in the National Plan of the Industrial Heritage of 2000, through an initial study motivated by the great patrimonial value of this area of Castilla - La Mancha. The municipal interest for the enhancement of its mining heritage propelled a new project of expansion and improvement of the existing one, ushering in the open-air museum of Pozo Norte and the relocation of the items owned by the Municipal Museum, with the objective of the environmental regeneration of the area and a more popular touristic installation. This new project, known as the Mining Museum of Puertollano, was financed with FEDER funds starting from an operational program for the local period 2000 - 2006, the conversion plan of depressed mining regions

(1998 - 2005) dependent on the Ministry of Industry and Energy (piano MINER) and by the Municipality of Puertollano, with an estimated cost up to 2.1 million euro[56]. The new space is structured for the museum building, that includes: the visit on the upper floors with the permanent exhibition of highly didactic purpose, dedicated to the evolution of the mining region from Prehistory up to our days; the coal mining world; miners' life etc. In the area located in the undergrounds level different methods of mining exploration applied in the Puertollano mines can be regenerated through 500 metres long mine made in an underground tunnel. After the creation of the Council of Tourism in 2004, the town of Puertollano gave a greater protective pulse at its mining heritage from which new ideas to work in other areas of the city sprang up as in the *Apartadero Calatrava*, to convert it into an Exhibition Centre and a palace of congresses and exhibitions, with the objective of increasing social events, commercial activities and free time in the city.

### Recovery of Almadén Mines: normative proceedings and Heritage Charts

The recovery and reconversion planning for Almadén mines is the event in the last years that may best fit to *Nizhny Tagil* and *El Bierzo Charts* philosophy[57]. In addition to these two Charts, the recovery project is passed through the previous regulative steps translated into the promulgation of plans and programs aimed at obtaining both the recognition of Almadén heritage as universal and the legal and administrative status of a Mining Park.

The beginning of Almadén enhancing process can be temporally placed following the arrest of the mining sector of the valley, on the thrust of the authority's willingness involved to avoid the loss of the mining assets. Thus, it descended a collaboration between the various actors at the academic (University of Castilla - La Mancha), local (Ayuntamiento de Almadén) and national (Institute for Cultural Heritage etc.) levels, involved to invest in design strategies by the purpose of disseminating and exploiting Almadén mining heritage and create at the same time a reference model for future interventions.

The first legislative instrument that fits in this context is the *El Bierzo* Chart, formulated in a specific manner for the Mining heritage, which synthesizes the will and the strategies proposed by part of the institutional bodies of Spain for the preservation and dissemination of their heritage. While in a synthetic manner, the Chart marks the key points to be observed in interventions of recovery and maintenance of assets, in particular about the dissemination of the intrinsic values that are the subject of study.

*El Bierzo Chart* (2007)

This document represents both a synthesis of reflections on cultural values linked to the mining in the industrial age and at the same time of the methodological proposals and their storage in

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[56] Mansilla Plaza, L., *Methodología para la valorazicación del patrimonio minero industrial de Castilla - La Mancha*, Doctoral Thesis, Montes Tubio, F. P., Almarcha Núñez – Herrador, M. E. Univeristy of Cordoba. Cordoba: Cordoba University Editing Service, 2013, pp.179 -193.

[57] Culture Minister, Spanish Cultural Heritage Institute *Carta de El Bierzo para la Conservaciòn del Patrimonio Industrial Minero*. Madrid: Gráficas XXXXXX, March 2009.

view of their revitalizing to the public. The document has been processed by the technicians of the Institute of the Cultural Heritage of Spain and by the Direction of Fine Arts and Cultural Property and it was presented during the technical days of Ponferrada in October 2007 with subsequent approval by the Council of the Historic Heritage in 2008. The conditions under which the Chart has been developed adhere from one hand to the sectorial development pursued by the National Plan of Industrial Heritage and on the other hand they act as an operational instrument prepared in conjunction between the various administrative authorities involved in the Cultural Management.

In the introduction of the document values that award the identity and cultural character to the goods protected by the Charter have been exposed, from which methodological and operative choices for their protection as a response to the need of "arbitrated protocols of intervention on the part of the bodies involved" derive:

- Historical Value

- Material, movable and immovable property value

- Value of technological processes

- Environmental values

- Anthropological and ethnological values

- Aesthetic values

These protocols provide different indispensable steps to create a sort of "assembly" of prevention and of the knowledge of the assets values of Spanish mining heritage.

*1. Inventory*

It is necessary to undertake an inventory of the industrial mining heritage as the first requirement to be able to plan both the security and the promotion, where the elements and the compounds subject to protection and monitoring must be identified. In order to carry out this inventory, it should be approached with methodological skills starting from multidisciplinary independent criteria, preparing in advance a methodology, a language and easily recognizable decodifying criteria. There must be also an evaluation between the different disciplines and actors involved in such a way that the objectivity and coherence, the durability and the accessibility of information collected are guaranteed.

In the inventory activities associated with any mining complex must be considered as a minimum the following steps:

- Study of historical and archaeological complex. Geographical delimitation of the compound.
- Location of each of the elements that comprises the mining complex, including the moveable property as well as the documentary heritage coming from the archives.

- The legislative scheme of works that compose the mining complex.

- State of conservation and analysis of pathologies.

- Study of Anthropology and Ethnography.

*2. Selection*

Once we have established the general overview of the items, we must select those of particular relevance and apply the protection degree according to each case, depending on the rules and laws at the municipal level, autonomous, state and international. The criteria for the application will be:

- The historic authenticity.

- The most representative type.

- Absolute and relative antiquity in terms of typology or technique.

- State of preservation.

- The integrity of the cultural identity and symbolic specifications.

- The historical significance.

- The report of the properties and of the installations with the community of which they are part.

-The possibility of managing the mining complex on behalf of the Community to which they belong, guaranteeing a minimum level of sustainability.

*3. Legal protection.*

The legal protection of moveable property and buildings which constitute the mining heritage is imperative for its conservation: it will be carried out mainly through figures intended for this purpose in the legislation relating to the cultural and historical heritage, environmental protection and regulations for the urban zoning. It is thus necessary that the local authorities provide for the preservation of their industrial mining heritage in the phases of the urban planning, especially in those cases where it presents a marked coexistence and proximity to the current urban settlement with that of the mining assets. For their part the public administrations must protect the most important elements of this Heritage through the possibilities offered by the Declaration of Good of Cultural Interest (BIC) or equivalent protective measures.

*4. Intervention*

The intervention must be conceived as the result of a previous process of investigation undertaken through instruments such as the Masterplan, preliminary studies or viability studies. These apparatuses in fact allow to approach the actuations in respect of the mining assets with adequate guarantees based on a solid investigating work and on a strategic base that has been

planned in an appropriate manner at all the levels (technical, managerial, usability etc.). In the project of intervention must be regarded even the combination of tasks associated with the improvement of the most interesting part of the complex, as well as the impact of the same on the environmental system and the landscape.
This means that within the allowed limits to safeguard the identity, the integrity and the authenticity of cultural goods each choice must be evaluated as best as possible to ensure that the mining complex is used in a manner consistent with the promotion and improvement of its heritage status, for the purposes of safeguarding of a greater social viability and sustainability of the project.
The access to the inside of the mine, motivated by the observation of the mineralized levels according to natural processes or for the desire of life experience, must be in all cases made after the stabilization of security measures that also include the limits imposed by the preservation of the asset. Security will be guaranteed if the combination of the rules that the concern it will be included or incorporated into legislative regulations within the area.

*5. Dissemination*

Among the key principles of preservation activity of the Mining Industrial Heritage the probability of its improving is worthy to be evaluated. If a mine is public opened, for example, the maintaining of its decaying nature shall attract people interest to enter.

For these reasons the educational and communicative program which simplify the conceptual learning of the plants assets and the mining complex as a whole is essential, also thanks to the adoption of a model that the involved Administration thinks most suitable: mining museums, mining musealization, cultural parks of the heritage and so on. Exhibitions, editing, conferences also need to involve the public on the relevance of its own nature and to explain the consistency of the mining heritage; these activities must be considered of fundamental importance by public authorities.

*6. Preventive conservation and its maintenance*

Preservation and restoration works of the mining elements must be planned considering their natural geomorphologic peculiarities, such as continuous floods, difficulty in environmental monitoring and so on. The preventive, conservative and maintenance works are essential for the effective working of the mining installation.

## Almadén and Arrayanes S.A Directive Plan. (MAYASA)

The second event which marked the path of arrival to the actual Almadén consecration to Mining Park dates back to 2002[58], with the drafting of a National Plan of industrial heritage, thanks to the collaboration between MAYASA and the Directorate General of Fine Arts and Cultural Property (IPHE) through the Institute of the Spanish historic patrimony, then Institute of the Cultural Heritage of Spain (EICP). The National Plan included, among its recommendations for the completeness of the rehabilitation project, the implementation of a further legislative program and management of mining site, which culminated in the Master Plan as the basis of work for the interventions of implementations. The cost of the latter program was € 220,000 and for its drafting was instituted a competition by invitation for thirteen teams of work, selected by IPHE always in 2002.

The objectives of the plan were:

· be a tool for drawing, planning and controlling the actions aimed at transforming the Almadén mine in a public, cultural and educational space with a touristic vocation, in order to retrieve, preserve and enhance the historical value of the industrial heritage and technology.

· The future Mining Park of Almadén must allow to explicit the technological evolution of the mercury extraction in the mine and the extraordinary richness of the deposit, the global value of exploitation and its important role in the development of Spain and America.

· Allow the Mineral Park to become the driver of touristic development of the valley and reach a compatibility between the conservation of the mining industrial heritage and the tourist sustainability.

The competition was won by the Quality System Company and in April 2003 work was begun. The drafting of the methodological Master Plan was based on the following steps:

1. *Inventory and investigation.*

   The main objectives are the realization of an inventory of the industrial heritage goods of the mining society and an evaluation of their preserving state, which – after a completed historic, architectonic[59], geologic and mineral investigative activity [60] – may include the oral witnesses of the workers, technicians, retired and other local actors, allowing to obtain four basilar

[58] Mansilla Plaza, L. El Parque Minero de Almadén. *Her&mus*. *Patrimonio cultural en Castilla – La Mancha: entre la diversidad y la innovación*,volume III, n. 1, january – february 2011, p. 18.

[59] The architectonic study needed to analyse the value of the places and the building aiming to find new and possible interventions. The architectonic inventory analyses the complex of the patrimonial estates and industrial goods, according to their value and their use to their future employment. Mansilla Plaza, L. 2013, p. 234.

[60] The geologic and mineral study allowed to realize an exhaustive fact-finding on the possibilities to adapt the mineral space to touristic use, including the analysis of specific legislation, of environmental impact and on security either inside and outside of the mine. In this case the cataloguing card of the material culture, revealing the existing lacunas and the possible solutions. Mansilla Plaza, L. 2013, p. 234.

documents[61] for the realization of the subsequent phases and the Mineral Park starting activity.

2. *Museographical and museological study.*

These works constituted a milestone for the analysis of the installations to be converted for expositive use, to draw a comprehensible and directed visit relating to the object of valorization. The museological plan included a route guidance above the main exhibition containers, which also proposed different museographic developments, montages and museum resources.

3. *Interventions programs.*

The core of this step was a realization of an analysis on the actuative paths to be realized into the buildings, mining settlements and other liable spaces suitable of a new redeployment, including the terms and the costs of each intervention.

4. *Study of the viability, financing and economic management.*

The completed works had as objective to analyse the different alternatives for the recovery and the start of the entire project, including also a communication plan and dissemination for the first years of development of the project.

The objectives of the Directive Project, in conclusion, aimed to maintain the highest possible degree of authenticity of the restoration works of the galleries and the mining equipment, through multidisciplinary contribution of personalities involved in its drafting, such as experts in metallurgy, mining engineering, architecture, history, museology, archival and biblioeconomy. The goal is then the preservation of the patrimonial complex with a respectful and compatible restoration program, faithful as best as possible to the original characters of exceptional value. This latter aspect raises finally the bases for the Declaration as a World Heritage, by virtue of the singular and unique values that the restoration has maintained and highlighted.

The following table finally indicates how the methodology used in the case of Almadén mines would follow perfectly the models presented in the National Plan of Industrial Heritage (2000), making it one of the most important cases of application of national directives throughout Spain.[62]

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[61] The obtained documents were:

1. The inventory, the cataloguing and the quantitative and qualitative analysis of the patrimonial elements of the mining complex.
2. The documentary fonts.
3. The historical memory of the complex and its elements.
4. The Heritage Asset Declaration (BIC). Mansilla Plaza, L. 2013, p. 234.

[62] Mansilla Plaza, L., 2013, p. 235.

<table>
<tr><th colspan="3">Comparison of the National Plan of the Industrial Heritage Methodology and MAYASA Directive Plan</th></tr>
<tr><th colspan="2">National Plan Methodology P. I. 2000</th><th>MAYASA Directive Plan Methodology</th></tr>
<tr><td colspan="2">Inventory</td><td>Inventory, cataloguing, quantitative and qualitative analysis of the patrimonial elements of the mineral complex.</td></tr>
<tr><td colspan="2">Legal Protection</td><td>Just a few isolated elements survived under BIC status: de aludeles ovens, Carlo IV Door and the Baritel of San Carlo.</td></tr>
<tr><td rowspan="5">Directive Plan Actuation</td><td>Descriptive Memory</td><td>Memory, documentary fonts and the documentation of BIC declaration.</td></tr>
<tr><td>Historical Analysis</td><td>Historical memory of the complex and its elements.</td></tr>
<tr><td>Legal study</td><td>Study of the good property.</td></tr>
<tr><td>Proposals for re-use</td><td>Museological and museographical study correlated by proposals of use and related interventions.</td></tr>
<tr><td>Management and dissemination plan</td><td>Viability, financing and economic management focus.</td></tr>
</table>

Source: Mansilla Plaza, L. 2013, p. 235.

### Previous initiatives

Only since the Eighties of the Twentieth century the concern for the recovery and conservation of the mining assets of Almadén began awakening in the consciences of the regional and local administrations, alarmed by the concrete possibility that years of neglect and carelessness after the closing of the activities threat to wipe out their mining goods. The first event in this direction occurs in 1984 with the formation of the Geological Mining Group of the School of mining engineering and industrial of Almadén, the first throughout the region to focus on the protection of the geological and mining heritage. This initiative was followed five years later by the foundation of the historical mining museum *Francisco Pablo Holgado*[63], which was the first symbol of the collective interest for the cultural heritage of Almadén. The museum occupies three exhibition areas of more than 800 $m^2$: the first is the patio of the school, dedicated to large elements of industrial archaeology including the shaft n.3 of the mine of Diògenes; the second corresponds to the area of the tunnels of the Royal Prison of the convicts of the Eighteenth century; the third is divided into two sections, Palaeontology - Mineralogy and the history of the valley of Almadén. The entire complex is concluded with the Centre of

[63] Mansilla Plaza, L., 2013, p. 226.

Interpretation of the Royal Prison and with the historical library of the School of the Eighteenth century[64].

After this museum institution in 1989, there were numerous projects of heritage that were followed systematically and continuously for all the Ninety years. Among the most significant we shall recall[65]:

- The "Strategic Planning of ecotourism in Alcudia Valley" project, called *Futures* program, drawn up by the Provincial Deputation of Ciudad Real in the years 1994 - 1995 to inventory all the elements of the ethnographic heritage of the valley of Almadén, among which those of the mining and industrial stand.

- The creation in 1995 of the private society called *Almadén Vallley Touristic Society*, for promoting touristic visits in search for the cultural and environmental richness of the city.

- The Manifest for the rehabilitation of the historical mining heritage in Alamdén Valley, carried out by the Spanish Society for the Defence of the Geological and Mining Heritage (SEDPGYM) in 1996[66].

- The "European Mining and Industrial Route of Ciudad Real" set in the valleys (*comarcas*) of Almadén, Almodòvar del Campo and Puertollano in 1997, carried out by the University of Castilla – La Mancha and funded by the Council for the Culture and Education. Among the objectives of the route, the possibility for the area to obtain the *statu*s of World Heritage Site.

- The creation in 1998 of the Association for the Defence of the Almadén Historical Heritage with the aim of stimulating the local government and mining enterprises to recover and to enhance the cultural heritage of Almadén.

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64 Mansilla Plaza, L. El Parque Minero de Almadén. *Her&mus*. P*atrimonio cultural en Castilla – La Mancha: entre la diversidad y la innovación*,volume III, n. 1, January– February 2011, pp. 14 – 15.

65 Mansilla Plaza, L. *Metodología para la valoración del patrimonio minero industrial de Castilla - La Mancha,* Doctoral Thesis, Montes Tubio, F. P., Almarcha Núñez – Herrador, M. E., University of Cordoba: Editing Services of Cordoba University, 2013, pp. 225 – 230.

66 In the Manifest text it can be read: "*The mining and related to the mining mine settings of this valley belong to the World Mining Heritage, as many of them are the unique living specimen left*. [...] *Into this heritage that constitutes a real Mining Park we underline single buildings and settlements:*

The mines :*Vieja* in Almadén, *Nueva Concepciòn* and Almadenejos;

- The Mining Academy of the 18th century;
- The miners Hospital of the 18th century;
- The hexagonal and unique in the world *Plaza de Toros*, 18th century;
- The Baritel of San Carlos (18th century);
- Aludeles or Bustamante ovens (18th century);
- The forced workers galleryi (18th century) and the Real Prison archaeological rests;
- S. Aquilino, S. Teodoro, S. Joaquìn Castles and the Diògenes Mine."

Cfr. Annexed n. 15 Mansilla Plaza, L., 2013, pp. 430 – 431.

- The creation of the Foundation Almadén *Francisco Javier de Villegas* in 1999 by MAYASA S.A. in 1999 to administer the historical heritage through the collaboration of public and private entities. In 2000 it was technically and financially supported by the Council of the Protectors of the Foundation, made up of experts in the technical - mining field, the General Directorate of Archives and representatives of the Spanish American Countries.

Since 2002, we may highlight the following activities:

- Defense Campaign for the Old Mine of Almadén and its inclusion as part of the Master Plan for the Mineral Park of Almadén in 2002, promoted by the School of Mining and Industrial Engineering and the Almadén Official College of Technical Mining Engineers of Ciudad Real.

- Establishment of a technical table for Almadén in 2002 in which the administrations at all levels, trade unions, businesses and the School of Mining and Industrial Engineering of Almadén developed a five-year plan for Almadén's and the homonymous Valley development (PIDAC) with five strategic axes; one of the objectives was the promotion of infrastructures and the recovery of the historical heritage[67].

- Project *Mercury Route* in 2010: studying the possibility of recovery and development as a touristic route of the former path on which mercury was carried from Almadén to Seville, with attention to the current situation of routes to identify the potential for tourism.

- *Waldo Ferrer* Museum of the *Colegio de Hijos Obreros*: inaugurated in January 2008, the museum shows the beginnings of this college since the Twentieth century, when it was created to contrast the miners' children illiteracy until its most recent developments.

- *Mina de la Luz* guided tours in 2010: it is a municipal project that shows above the street level in Almadén the routes of mining tunnels and excavations that lie beneath the city (in fact the name Almadén means "the mine "in Arabic.)

- Dramatized *Night Trails* in 2010: during the month of August, several local associations of Almadén tell the story of the city and its mines exploiting the historical and emblematic places of the mining area[68].

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[67] Mansilla Plaza, L. *Methodología para la valoración del patrimonio minero industrial de Castilla - La Mancha* Doctoral Thesis, Montes Tubio, F. P., Almarcha Núñez – Herrador, M. E. University of Cordoba: Cordoba: Editing Services of Cordoba University, 2013, p. 230.

[68] Ibid, p. 231.

# FRANCE: NORD PAS - DE - CALAIS

## Mining heritage in the Nord – Pas De Calais Mining Basin

### Introduction

The events affecting the mining heritage of the French Region of Nord – Pas de Calais and its extension beyond the Belgian border in the Wallonia area, are intimately linked to the territorial, landscape, urban and architectural characterization of its infrastructure and satellite towns gravitating around them: the properties that contradistinguish these sites from the historical and environmental point of view constitute a mining region in its own right within the coalfield that extends from north-western Germany to the UK, identified by virtue of the homogeneity of the productive factories, mining and settlement systems of the industrial past of this macro - region.

The mining area is in fact a territorial example in which the manufacturing sector has made substantial and irreversible changes in the residential, economic, social and infrastructure modules and it simultaneously went through a three centuries long evolutionary phase where has passed from the Eighteenth century pre - industrial phase to the Twentieth century post-industrial one[1]. The main features of this area are therefore intimately linked to its mining of coal deposits, resulting in environmental (*terrils)*, transporting (the stations and railway networks), urban (the workers' city and community services) and technological (mining equipment, *fosses* and mining castles) phenomena which together concur to the creation of the Nord - Pas de Calais – Wallonie industrial setting.

The coal basin is distinguished from the others for two main reasons: first, its mono characterization – due to a weak industrial production differentiation, except for the areas of Valenciennes/Denain and Douai – demonstrates the predominance of mining on other productive activities. This is mainly since the coal, once extracted and transformed, was not retained within but moved elsewhere for final processing, isolating the extractive sector from other industrial activities within the confines of the coal region. Secondly, the consequences of this industrial monothematism reflect the condition of the mining landscapes – very different, although pooled by the same mining extractive vocation – both in the urban physiognomies of the workers' cities and in the Nineteenth and Twentieth century social frameworks, deeply linked to the Mining Companies vicissitude and root near the extraction sites[2].

According to the homogeneity of production, land use, urban migration and social and technological components this coal mining region has taken the exceptional value of witnessing the industrial and landscape evolution – from the conception of workers' towns to the local

[1] Association Bassin Minier Uni, Mission Bassin Minier, Centre Historique Minier de Lewarde, Ministère de la Culture et de la Communication et al. (Eds.). *Synthèse du dossier d'inscription*. Comines: Qualit'Imprim, [sd], pp. 5-12.

[2] Ibidem, p. 10.

connections and the exploitation of the subsoil – which led to the proposal and the inclusion of the Nord-Pas de Calais Mining Basin in the UNESCO World Heritage List in 2012[3].

## The UNESCO acknowledgment

The Nord – Pas de Calais mining area was recorded on June 30th 2012 in the list of UNESCO World Heritage with the title of living evolving cultural landscape: in fact, it is a remarkable case of transformation of a historical, mainly rural, landscape for more than three centuries of mono-industrial coal mining and it perfectly illustrates the change initiated by the industrialization both from technical, social, cultural, landscape and environmental point of view.

Before the start of mining, the landscapes of the mining basin were characterized by vast rural and agricultural areas, organized on a relatively dense urban system but of modest size. The industrial rise of almost three centuries around the subsoil deposits has changed intensely the physical characteristics of the territory, generating a set of physical elements useful to the development of activities. Thus, numerous technical elements shore the landscape: shafts, castles, transport infrastructure and so on. The industrial growth of coal mining has also enriched the urban landscape and the pre-existing urban centres and it has dotted the urban landscape and workers' cities with services and community functions. However, the irruption of mining activities in the regional scenario has not erased the signs of production, creating a coherent and homogeneous territory where the overlap and the cohabitation of old and new urban, agricultural and industrial functions are the expression of the different periods of the history of the territory.

### *The perimeter of the properties enrolled in the UNESCO World Heritage*[4]

The UNESCO nomination requires the definition and delimitation of the perimeter of the properties proposed for inclusion. This exercise has imposed the selection of many goods, on the basis of criteria to be met, thus allowing to argue and demonstrate the Outstanding Universal Value of the selected elements.

To date the included perimeter inscribes a quarter of the still existing mining heritage, including 353 mining objects, and the rest is representative of the typological and chronological diversity of heritage. The spread of mining for more than three centuries and intense competition that the various private mining companions used to practice each other are at the origin of a particularly

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[3] Apourceau-Poly, C., Bertram, C., Mission Bassin Minier Nord - Pas de Calais (Eds.). *Plan Local d'Urbanisme et patrimoine minier inscrit sur la Liste du patrimoine mondial de l'UNESCO*. Comines: Qualit'Imprim, 2015, pp. 10-11.

[4] All elements of the mining assets were not included within the perimeter of the assets listed in the UNESCO World Heritage List. Nevertheless, this selection doesn't scratch the local interest that certain elements may represent for municipalities. If it is essential to protect the heritage inscribed on the List, it can be as important for municipalities to preserve and enhance the other elements of their mining heritage. See: Apourceau-Poly, C., Bertram, C., Mission Bassin Minier Nord - Pas de Calais (Eds.). *Plan Local d'Urbanisme et patrimoine minier inscrit sur la Liste du patrimoine mondial de l'UNESCO*. Comines: Qualit'Imprim, 2015, p. 12.

intense emulation that is readable today in the Nord – Pas de Calais Mining Basin's architectural and landscape richness: the mining heritage, both from technical and social point of view, deserves sufficient importance to realize about a 120 km remarkable chain of extraction units which constitute at the same time some signals for past working memory of the region, but also manmade interventions[5].

The inscribed perimeter, including 87 municipalities extended over 4,000 hectares of land, includes among others:

- 17 remains of shafts
- 21 castles
- 51 *terrils*
- 54 km of *cavaliers*, or mine railway routes
- 3 stations
- 124 mining towns
- 38 schools and school groups
- 26 religious buildings
- 22 health facilities
- 7 different collective structures (halls for parties, trade houses, sports facilities)
- 3 Great Offices of mining companies.

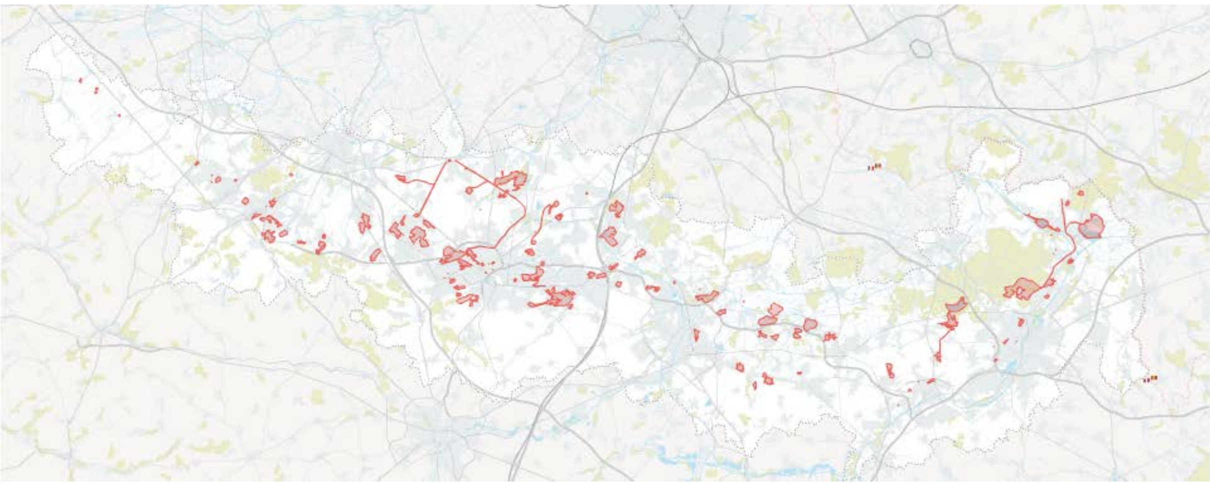

Figure 1. Perimeter of assets recorded in the WHL. Source: www.atlas-patrimoines-bassin-minier.org

## The buffer zone[6]

Beyond the inscribed perimeter, a buffer zone was also defined in accordance with the requirements of the World Heritage Centre: it embraces the objects and collections resulting from the mining heritage (but not only), which although not answering to the claims of Universal

[5] Association Bassin Minier Uni, Mission Bassin Minier, Centre Historique Minier de Lewarde, Ministère de la Culture et de la Communication et al. (Eds.). *Synthèse du dossier d'inscription*. Comines: Quality 'Imprim, [sd], pp. 62-63.

[6] Association Bassin Minier Uni, Mission Bassin Minier, Centre Historique Minier de Lewarde, Ministère de la Culture et de la Communication et al. (Eds.). *Synthèse du dossier d'inscription*. Comines: Quality 'Imprim, [sd], pp. 63-64.

Value Outstanding participate to the whole historical and landscape interpretation of the mining basin. It thus strengthens the landscaping coherence around the inscribed goods and it offers glimpses of views on the same. The whole inscribed perimeter and its buffer zone concerned in total 124 Municipalities[7].

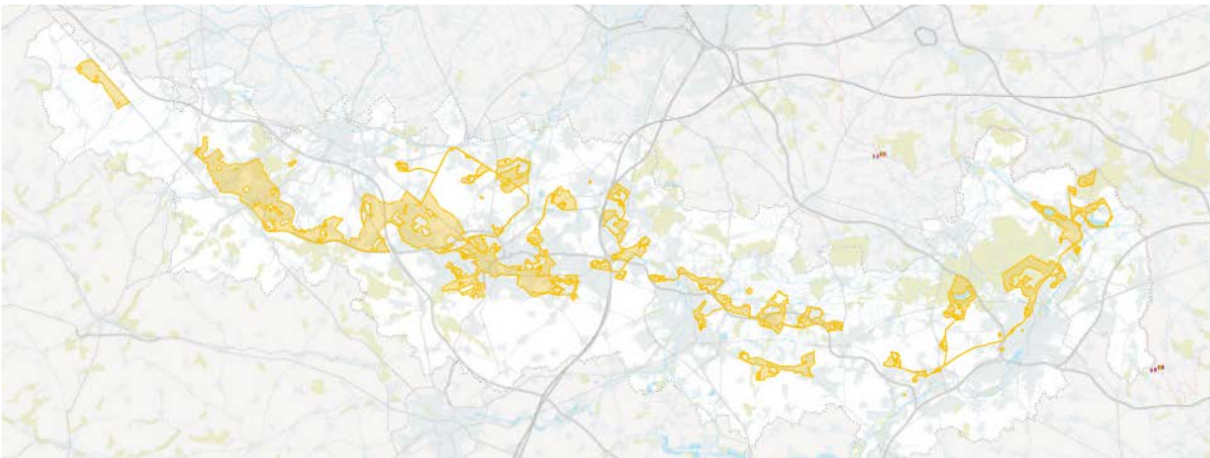

Figure 2. Perimeters of the buffer zone. Source:www.atlas-patrimoines-bassin-minier.org

### The elements of the Mining Heritage

The obtaining of the UNESCO certification offers to the mining area an undeniable possibility through the recognition of consistency, which is clearly reflected by its landscape, urban and architectural characteristics. The enhancement of the elements of the mining heritage is an essential support for the improvement of the living environment of the residents and to imprint a change of image. In fact, this new account, made of a collective heritage that ceases to be a stigmatized factor to become a capital for the future, should help changing the perspective of the visitors but especially that of the entire population on the same.

The recognition of the value and quality of this heritage makes it worthy to be preserved and to evolve in accordance with its quality, its features and value.

The individual assets of mining activities (both built and neo - natural) should be considered as a pushing factor for the improvement, development and attractiveness of the mining basin.

Moreover the conversion offers a new life for old mining sites: some of them are in the heart of the economic recovery plan, tourism and enhancement of the quality of life and they are seen as elements that can positively connect the territory.

### The memory sites

The technical sites that have been preserved almost in their entirety form the main memory sites for which it was essential to find a new function to ensure their sustainability. The *Delloye* pit in Lewarde was converted back in the early 80s to host the Historical Mining Centre (a big mining

[7] Apourceau-Poly, C., Bertram, C., Mission Bassin Minier Nord - Pas de Calais (Eds.). *Plan Local d'Urbanisme et patrimoine minier inscrit sur la Liste du patrimoine mondial de l'UNESCO*. Comines: Qualit'Imprim, 2015, p. 13.

museum, resource and archive centre). The three other technical sites are currently the object of development projects, carried out by the agglomeration community since 2000[8].

These projects are organized around three different and complementary themes[9]:

- The "chain of musical practices and tourist development" for *9 – 9 bis* pit in Oignies: concert halls, recording studios, practice rooms, etc;
- The "sustainable development and the performing arts" for *11 – 19* pit in Loos en Gohelle: business incubator and National Scenario of Common Culture;
- The "image" for the *Arenberg* pit in Wallers: research centre, filming site, Centre of Scientific, Technical and Industrial Culture of the image.

A fifth site of memory is a mining town and not a technical site: this is the City of the Electricians in Bruay - la – Buissière, the oldest city in the Nord – Pas de Calais, whose purpose is the reconstruction project in which a residential function coexists with the Mining Landscape and Habitat Interpretation Centre[10] and it will welcome cultural and tourist entertainment, such as residences for artists, cultural programs, outdoor stays etc.

Figure 3. The Cité des Electriciens in Bruay - la - Buissière. Source: www.euralens.org

[8] Association Bassin Minier Uni, Mission Bassin Minier, Centre Historique Minier de Lewarde, Ministère de la Culture et de la Communication et al. (Eds.). *Synthèse du dossier d'inscription*. Comines: Quality 'Imprim, [sd], p. 66.

[8] Ibidem, p. 10.

[9] Ibidem, p. 15.

[10] Ibidem, p. 16.

## Mining towns

Approximately 24,000 mining residences are inscribed in the World Heritage List and are mostly held by two local administrators, *Housing and Towns Soginorpa* and *SIA habitat* group[11]. Mining towns are, by definition, virtually living heritage since being a park of social housings that have already been transformed thanks to the renewal of business since the 70's. Today their inclusion in the list, the recognition of their architectural, urban and landscape quality, but also the central role that they played in the urban structure of the Mining Basin and the fact that they host numerous plants put them at the core of restructuring projects and revitalization of the area. The need to improve the comfort, especially the heat linked to the objectives of the *Grenelle de l'Environnement*[12], the scenario of life of current and future residents and the urban intensification plans especially around the transport axis, push these cities to keep changing and modifying:  far from being a brake to these transformations, the taking charge of their quality is a possibility and it must incite to the qualification of urban and architectural designs.

## The neo - natural sites

Being aware of the peculiarities of this area – such as high urban density, the presence of numerous abandoned and unused spaces, weak presence of natural spaces, and so very atypical landscapes – the main actors of the improvement in the mining basin have pioneered the creation in 2003 of a green and blue texture scheme, initiated by the Mission Bassin Minier. The purpose of this process is the preservation and development of this ecological wealth in natural "classics" spaces such as forest, moist and *calcicolari* environments but even in the most unusual present on *terrils* and on abandoned mining areas; this is the same way to give a chance to a population of significant size to appropriate these spaces through raising awareness towards the environment and the practice of leisure[13].

The characteristics of some mining sites are in this sense very favourable: for example the old railways mines, called *cavaliers*, are the main support of the routes in a softer manner compared to a territory heavily marked by urbanization and by many types of intense infrastructures. The *Terrils* are formidable landscape exhibits and offer remarkable views on the most emblematic mining sites; they are also home to a rich biodiversity of species and are privileged places for the practice of activities related to nature.

[11] Apourceau-Poly, C., Bertram, C., Mission Bassin Minier Nord - Pas de Calais (Eds.). *Plan Local d'Urbanisme et patrimoine minier inscrit sur la Liste du patrimoine mondial de l'UNESCO*. Comines: Qualit'Imprim, 2015, p. 16.

[12] The *Grenelle de l'Environnement* is an open sided debate enhanced in France, which brings together representatives of national and local governments and various organizations – of the industry and the working work, professional associations and non-governmental organizations – with a fair decision-making power with the aim of unifying the initiatives on a specific theme. The *Grenelle Environment Round Table* purpose, driven by the former President of France Nicolas Sarkozy in summer 2007, is to define the key points of public policy on the problems of the ecological and sustainable development in the following five years. See: Apourceau-Poly, C., Bertram, C., Mission Bassin Minier Nord - Pas de Calais (Eds.). *Plan Local d'Urbanisme et patrimoine minier inscrit sur la Liste du patrimoine mondial de l'UNESCO*. Comines: Qualit'Imprim, 2015, p. 16.

[13] Apourceau-Poly, C., Bertram, C., Mission Bassin Minier Nord - Pas de Calais (Eds.). *Plan Local d'Urbanisme et patrimoine minier inscrit sur la Liste du patrimoine mondial de l'UNESCO*. Comines: Qualit'Imprim, 2015, p. 17.


Figure 4. Terril 98 in Estevelles. Source: www.bassinminier-patrimoinemondial.org

### A diverse heritage

The latent time between the cessation of the economic activity that has structured the territory during three centuries and the awareness of its historical value are mostly due to the heritage acknowledgment: the disused mining heritage is in fact rich and diverse and includes both a built heritage and a neo-natural heritage, contributing to a very specific and yet multifaceted landscape.

Whatever its nature, the heritage of the mining basin is constantly disputed both by the need to continue with the general development of the area and the need, on the other hand, of a vision for the future which respects the fundamental characteristics. The pressures which it undergoes are therefore mostly related to urbanization, land pressure and the risk of progressive obliteration of its quality and for this reason the scientific program seeks to identify for each type of heritage existing threats and qualities to be preserved from an urban, architectural and landscaping point of view [14].

### Mining towns[15]

Mining towns were built by private Companies that saw this production of workers' housing as a way to attract and control the workforce. The competition between the different mining Companies pushed them to be innovative in the way these housing were conceived: beyond the

[14] Apourceau-Poly, C., Bertram, C., Mission Bassin Minier Nord - Pas de Calais (Eds.). *Plan Local d'Urbanisme et patrimoine minier inscrit sur la Liste du patrimoine mondial de l'UNESCO*. Comines: Qualit'Imprim, 2015, p. 19.

[15] Atelier de l'ISTHME, Urbicand (Eds.) *Etude pour la qualification et la protection des paysages miniers remarquables*. 2015, pp. 40 - 45. Available in: http://www.bassinminier-patrimoinemondial.org/wp-content/uploads/2015/03/Etude-paysages-miniers_phases-1-et-2.pdf

comfort they offered, although in a very early way, the houses of the mining towns were equipped with an undeniable architectural quality. The interest turned to the gardens, the design of public spaces and the construction of general services has created sets of individual settlements which in turn created some real cutting-edge neighbourhoods for urban and landscape qualities[16].

### The qualities to be preserved

- The varied urban structure and high-quality public spaces: from the historic roads and streets to the great *avenues* that offer perspectives on the routes of the mine shafts or on utility services.
- The homogeneous urban morphology constituted by the housing that group many dwellings, set to accompany the urban structure: alignment on the road, along the streets, points of intersection, differentiation of types in accordance with the road hierarchy etc.
- The architectural richness linked to the diversity of materials – clay brick, painted brick, milestones etc. – the work done by the structural elements such as lintels, foundations, joints, frames, etc. and the richness of the decorations.
- The houses with gardens, surrounded by traditionally low and homogeneous fences, and often plants that offer the permeability to the gardens and even participate in the quality of the landscape of the city.

### The threats[17]

- Houses demolition.
- The building of new houses, by filling the empty spaces, whereas they are not well integrated, calling into question the homogeneity of urban morphology and architectural coherence.
- New housing construction in the densification programs, whereas these distort the overall composition and the morphology.
- Extensive construction, with outbuildings and a garage whereas they are scarcely integrated with the original building and/or they overshadow totally or partly the housing complex.
- The renewal when this disfigures the building for the façades finishing choices and/or covers: the addition of a coating material that masks the original decoration, openings or windows closures etc.

[16] Ibidem, p. 19.
[17] Ibidem, p. 20.

- The transformation of fences and perimeters that deceive the city, overshadow the sight towards the garden – with the removal of plant hedges, construction of full round enclosures etc. – and the declension of the public space.


Figure 5. Coron Town La Parisienne in Drocourt (Cie. de Vicoigne).

Source: www.bassinminier-patrimoinemondial.org

### The social, cultural and religious infrastructures

From the late Nineteenth century the social performance of mining Companies has fully devoted in the buildings and infrastructure construction in the heart of the towns in order to offer to the miners and their families all the facilities they could need. If the will to frame the miner's life after birth until death is subjected to social policies put in place, the collective infrastructures are intended to multiply and diversify according to the claims and trade union conflicts, to the evolution of the French legal rights for workers and commissioning work, very early in France, and to a specific social protection for miners. So the mining towns were equipped with schools, churches, dance halls, sports facilities, health centres etc that attested the Paternalism and the philanthropy by which the private mining Companies were contradistinguished. As like as the mining towns these facilities, often of great architectural quality, were used to express and magnify the style of each Company that had originated them[18].

### The qualities to be preserved

- The presence of these structures as landmarks in the city and their role in the urban composition.

[18] Apourceau-Poly, C., Bertram, C., Mission Bassin Minier Nord - Pas de Calais (Eds.). *Plan Local d'Urbanisme et patrimoine minier inscrit sur la Liste du patrimoine mondial de l'UNESCO*. Comines: Qualit'Imprim, 2015, pp. 21-22.

- The architectural richness linked to the diversity of materials, i.e. clay stuff and bricks, painted bricks, milestones etc. , the work done by the structural elements, i.e. lintels, foundations, frames, joints etc. and the richness of the decorations.

### The threats

- The demolition of all or part of the building.
- The renovations that distort the building due to the choice of façade treatments and/or covers: the addition of a coating material that masks the original decoration, openings or windows closures etc.
- The extensive construction and/or outbuildings that are not easily reconciled with the original building.
- The new developments in the vicinity that distort the urban overall composition and can impair their legibility or that can still break the bond between the implant and its original environment.

## The technical buildings

Given that the exploitation of coal was conducted entirely in the subsoil of the region, it has however resulted in a development on the surface of an entire technical arsenal for the mines condition. The numerous mining shafts that were installed in the area were made of more technical buildings, each with different functions: buildings for machinery, mining castles (*chevalements*), workshops, toilets and showers for the workers etc. These buildings offer a reading of the operation of the coal mining and underscore the evolution of the techniques of extraction in the course of time; furthermore they often have architectural and construction quality related to its own style of each mining Company that originated them.

### The qualities to be preserved

- The architectural richness linked to the volumes, the role of the structural elements and decoration.
- The landmarks in the landscape and the role in the urban composition.

### The threats[19]

- The demolition of all or part of the building.
- The renovations that distort the building to the choice of façade treatments and/or covers: the addition of a coating material that masks the original decoration, openings or windows closures etc.

[19]Ibidem, p. 23.

- The extensive construction and/or outbuildings that are not easily reconciled with the original building.
- The new developments in the vicinity that distort the urban overall composition and can impair their legibility or which can still break the bond between the implant and its original environment.

### The Neo – Natural Heritage

### The *Cavaliers*

Unique elements of the mining system, the *cavaliers* were used to transport coal until the disposal of mining. Today they have in fact lost their primary function to become essentially structural elements of the mining area. On the asset frame, the *cavaliers* constitute the baseline to the understanding of the shipment and coal transportation, but also for the bonds they form with other types of heritage: shafts, *chevalements,* the *terrils,* mining towns and infrastructure areas. They are therefore an integrant part of the valuable social and ecological heritage that offers contact points throughout the region and they are transformed into ecological corridors creating a resource for the new means of *soft* transport.

### The qualities to be preserved[20]

- The mesh of a very fragmented territory that can be supportive for the ecological development, ecological corridors and tourism asset, i.e. the ability to network the different elements of the mining area and social means of *soft* travel, sports and leisure.
- Their integrity: the Cavaliers still preserve in some cases their tracks and/or stringers and/or ballast and they are accompanied by additional built in elements – i.e. stations, houses of toll collectors, exchange booths etc. – or works of art. They therefore represent the witness, very rare indeed, in the history of the coal transport infrastructure.

### The threats[21]

- The break in continuity due to urbanization: land pressure, extension of the infrastructural plan, population density program, urban speculation etc.
- The disappearance of the tracks within the urban or agricultural areas.
- The disappearance of the vestiges and elements of identity associated with the *Cavaliers* as weirs, barriers, artwork etc.
- The attack by the vegetation.

[20] Ibidem, pp. 23-24.
[21] Ibidem, pp. 24-25.


Figure 6. Stub cavalier in Haveluy. Source: www.bassinminier-patrimoinemondial.org

## The UNESCO Mining Heritage in detail

### Mining towns

*The Pavilion Tows (1860 – 1939)*

The extraordinary development of workers' towns in the mining area of the Nord – Pas de Calais currently accounts for 41% of the mining housing: in the half of the Nineteenth century the slats of housing of mining areas were abandoned as too sensitive to subsidence and ground movements. The technical origin of the pavilion town is accompanied by the growing interest of the engineers and managers of mining Companies against individual dwelling issue, influenced by paternalistic and philanthropic theories of the Nineteenth and early Twentieth centuries. The intent was to support individualism and the right to housing of the mining workforce and simultaneously adjust their daily lives to avoid groupings and riots for demands[22].

The pavilion town is largely based on two principles of fragmentation: the twin house and the group of four, sometimes three houses. The plans of these cities are designed according to an orthogonal plane that frames the system of housing and urban infrastructure. Geometry, symmetry and rationalism are the key words which regulate the planning of cities: always aligned, the houses are gradually built flush with the road and are surrounded by gardens offering a green space available to working-class neighbourhoods. The width and depth of the prospects of the way, the space between the houses and squares arranged in the garden are the special features of the residential areas in the pavilion cities[23].

[22] Association Bassin Minier Uni, Mission Bassin Minier, Centre Historique Minier de Lewarde, Ministère de la Culture et de la Communication et al. (Eds.). *Synthèse du dossier d'inscription*. Comines: Quality 'Imprim, [sd], pp. 38-39.

[23] Ibidem, pp. 39-41.


Figure 7. Cité Pavillonnaire 10 Cie. de Bethune. Source: www.bassinminier-patrimoinemondial.org

Starting from 1890, the mining Companies introduced in urban planning such "collective" services churches, schools, buildings for social works such as halls of the parties, dispensaries etc. The pavilion cities since then have integrated the spaces reserved to these collective activities with those of equipment and aggregation, thus reinforcing the control and autonomy in relation to other urban centres. Built between 1925 and 1927 by the *Compagnie des Mines d'Aniche,* the collective functions of the *Cité de la Clochette* in Douai – Waziers as the group of schools, the patronage and the church of Notre-Dame des Mineurs witness the great attention promoted by some Companies towards their services and, through them, to their workers.

The introduction of collective structures joins the playback on the urban terrain of corporate hierarchy to the production area and its cultural, religious and educational, the residential area is itself divided into distinct units. At the city centre mining engineers embody the authority of patronage and their houses are up to this social position within the Company, in particular about the volumes and the architectural physiognomy, often in an Eclectic style.

The houses of employees and those of supervisors vary in size and architectural quality and are usually installed from either side of the main entrance. These buildings strategically and symbolically control the entry and exit of the miners in and out of the extraction site. La *Cité* n. 12 built in 1920s in Lens and Loos en Gohelle offer a particularly representative case study of these urban situations.

The directors of mining Companies used to have dwellings lodged between the mine and the town, sometimes even outside the mining area. For their size, the volume and the surface occupying these residences were monumental, located in the heart of large parks, such as the

*Château Mercier* built between 1901 and 1920 in Mazingarbe, which is named after the director of the *Bethune Society*.


Figure 8. Château Mercier. Source: www.bassinminier-patrimoinemondial.org

The pavilion towns finally offer an extraordinary architectural diversity and they very well testify the artistic and architectural rivalry between different companies: the houses were in fact the subject of numerous formal experiments and they became the objects of free linguistic and volumetric expression. The variations in the use of brick offer in these various decorative motifs and isolated buildings, polychrome friezes and layer and finishes with colours and bricks that accentuate the differences among the companies and among the different types of housing[24].

*Cité de la Solitude*[25]

Year: 1924

Company: *Compagnie des Mines d'Anzin*

The development of the garden city *La Solitude* is particularly representative of the urban style and the form that the Company of the Mines of *Anzin* employed in the construction of their residences during the first half of the Twentieth century. It owes its position, relatively far from the production site, to an opportunity for residential development: it occupies, indeed, the site of an earlier castle, which was built in turn on a former farm belonged to the Duke of Croÿ and it was destroyed during the First World War. The property is characterized by a curved road along

[24] Ibidem, p. 41.

[25] Bertram, C., Mission Bassin Minier Nord - Pas de Calais (Eds.). *100 sites de découverte du Patrimoine Minier*. [Nd]: [nd], 2012, p. 43.

which they develop residences of groups each constituted by two housing; some rare isolated houses are composed with each other in groups of three. From the point of view of architectural residences there are a lot of varying pottery, white brick and glass brick turquoise bricked composition. The elements of the structures, doors and windows are emphasized by arches made with, white brick, red and turquoise keystones. The boundaries and white brick files were alternated with those turquoise emphasizing the pediments, gables and cornices.


Figure 9. La Solitude in a vintage photo. Source: www.panoramio.com

*Cité Taffin*[26]

Years: 1909 - 1923

Company: *Compagnie des Mines d'Anzin*

The garden city Taffin, located near the old mine of *Avaleresse,* developed between 1909 and 1923, was named after Pierre Taffin, Jacques Desandrouin's partner, discoverer of coal in 1720. It is characterized by curved streets that form the urban islands by buildings located behind the wire path. The presence of gardens, surrounded by hedges, a small square and a leafy square garden make the city more like a country agglomerate than to a working-class city, thanks to the consistent presence of urban green. However, Taffin city is made even more special by the architectural quality of the buildings created in a context of great competition between private mining companies in the coalfield, particularly among those located in Lens and Courrieres, the garden city Taffin perfectly translates the ostentatious approach of the Society of *Anzin* against the miners' residences. The goal was not just to show off its financial power but also to maintain a certain level of workers: the residences therefore provide an extremely diverse composition of red clay brick buildings, white and turquoise glass bricks.

[26]Ibidem, p. 9.


Figure 10. Blocks of Pavillion Cité Taffin houses. Source: www.atlas-patrimoines-bassin-minier.org

*Cité d'Arenberg*[27]

Years: 1900 - 1923

Company: *Compagnie des Mines d'Anzin*

This mining town is contemporary to that of the pit to which is commonly associated. The first part, situated in front of the excavation, is organized along a single straight road. Along the way to the mine two pavilion rows often follow a curve direction which then opens to the rest of the city, arranged on blocks of streets around a large central square. The city for the most part consists largely of semi-detached houses grouped two by two and they are characterized by a rather simple rationalist architecture: bands of brick, brick arches and keystones, anchoring irons and false bay windows. The city stands out for the quality and richness of its main buildings: the church of Saint Barbara, the richly decorated ballroom featuring combinations of painted in white and blue bricks, applications of glazed ceramic of *Desvres* that show the trophies of music and a triumphal arch, the Home Economics School that has an analogous decorative language.

[27]Ibidem, p. 24.


Figure 11. Home Economics School of the Cité d'Arenberg. Source: www.bassinminier-patrimoinemondial.org


Figure 12. Hall of Parties of the Cité d'Arenberg. Source: www.bassinminier-patrimoinemondial.org

*Cité de la Ferronnière*[28]

Years: *1927 - 1928*

Company: *Compagnie des Mines d'Aniche*

This mining town belongs to a later generation than the other mining settlements: it is a pavilion city consisting of houses which are grouped into blocks of 2 or 4 units, implanted along perfectly linear roads. In some cases, the houses are placed at the bottom of large gardens, emphasizing the importance of green spaces in the design of workers' city gardens: in fact they could have a dual function as a place of rest and meeting and arable areas for the supply of fresh vegetables products. Like most of the cities of the Society of *Aniche*, on the architectural context, the *Ferronière* assumes great importance: the windows are enhanced by white and red brick arches alternating with blue brick inserts or even triangular pediments that put them into evidence. The angles and the upper parts of the façades are equally well conceived, with white bricks cut in different way according the living typology, particularly the 4 unit housing blocks.

*N. 9 Cité de Lens*[29]

Years: *1921 - 1924*

Company: *Societe des Mines de Lens*

Attached to the n. 9 – 9 bis shaft near the *Louvre* museum in Lens, the pavilion city n. 9 is a variation of the pavilion town model developed by *Lens* Society. Equipped with a church and a school block with accommodation for teachers, the city shows different types of housing from multiple shapes and remarkable volume: two floors, pitched roofs with rampant slopes. The constant presence of public green spaces enhances the residential assets thanks to the alignment of the trees along the road on which the houses stand. The materials used for the treatment of the façades are mainly brick walls adorned with painted false dovecotes, stone cut bandaged joints for the basement, which are the distinctive feature of the Company.

*N. 12 Cité de Lens*[30]

Years: *1921 - 1924*

Company: *Societe des Mines de Lens*

La *Cité* n. 12 is an excellent example of the mining heritage including all the elements of the mining cities: shafts remains, employees and engineer's houses, workers' houses, the church, schools, public squares. The city shows plural residential typologies, by grouping two or four units to the rows of *Corons* from six to ten houses. Typical of the architectural style of the Company, the treatment of the façades is of two types: false pigeon painted brick or claddings with a coating of light coloured concrete. The city still retains many original squares, whose

[28]Ibidem, p. 42.
[29]Ibidem, p. 76.
[30]Ibidem, p. 72.

design provides multiple perspectives on built street fronts. Schools are a variation of the model developed by the Company for its mining towns, while the engineers' housing and those of the employees and the keeper, located on one side and the other of the excavation n. 12, accurately reflect the hierarchy from the bottom to the top of the social ladder.

### The Corons (workers'accommodations) 1820-1890

The cities of *Corons* are the first forms of the mining towns and make up 25% of all towns in the mining basin. They were introduced at the initiative of *Anzin* Society in the 1810s and early *Corons* models were characterized by the provision in bands or groups of houses. Gradually the *coron* type evolves, particularly in terms of comfort materials and health of the environment, and it takes on a more urban physiognomy: the *Cité des Electriciens* of 1857 in Bruay-La-Buissière is a sterling example of this transition between first alignments *Corons* and a more structured city conformation. In subsequent years the size and scale of these working – class city became increasingly important: the *Corons* of about 20 or 30 meters in length are transformed into "barreaux" or in long strips frequently more than one hundred meters, as in the case of the *coron* 120 of about 1860 in Anzin and Valenciennes. The houses are made healthier, tiled and easy to ventilate, with new services for the occupants: drinking-water wells, fireplaces, individual and appreciable comforts. In general, architectural styles are cheap and without ornaments, though sometimes the window frames or string courses are highlighted by a different façade treatment hearth, individual and appreciable comforts. Generally, architectural styles are cheap and without ornaments, although they sometimes have the window frames or string courses highlighted by a different façade treatment[31].

*Coron de l'Eglise*[32]

Years: 1825 – 1826

Company: *Compagnie des Mines d'Anzin*

The housing complex for workers *l'Eglise* is currently the oldest example of still preserved workers residence. The first house was built in the second half of 1825. It included the rows of housing on one floor with small front gardens. The gables, which were left completely bare, contain only a small rectangular terrace. These terraced rows of miners' houses with gabled roof and one floor were extremely popular throughout Nord – Pas de Calais Basin since 1820. In a subsequent period, other residential blocks were added to the first group of houses. It is here of two-storey houses, more richly decorated than the other and most sought after in the following finishes: arched lintels for windows, columns and protruding grinding. The eardrum road is blind decorated with false openings that reflect the façades of houses. The row of terraced houses of

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[31] Association Bassin Minier Uni, Mission Bassin Minier, Centre Historique Minier de Lewarde, Ministère de la Culture et de la Communication et al. (Eds.). *Synthèse du dossier d'inscription*. Comines: Quality 'Imprim, [sd], p. 37.

[32] Bertram, C., Mission Bassin Minier Nord - Pas de Calais (Eds.). *100 sites de découverte du Patrimoine Minier*. [Nd]: [nd], 2012, p. 22.

the miners and the former mine of *La Sentinelle* are the oldest mining complex around the mining area.


Figure 13. Coron de l'Eglise. Source:www.bassinminier-patrimoinemondial.org

*Corons des 120*[33]

Year: 1860

Company: *Compagnie des Mines d'Anzin and Compagnie des Mines de Valenciennes*

Extended to more than 250 m along the road, the terraced 120 miners housing are built along a pattern of six perfectly aligned rows that includes a grouping of 20 “back to back” rows of houses.

Built in the Sixties of the Nineteenth century pursuing the housing models known as "*des alouttes*", namely the skylarks, the rows of houses are very far from the image of the first, unhealthy and cramped houses. Pursuant the current socio – philanthropic way of thinking of the era, this complex testifies the passage from the first models to modern ones with steady improvements in comfort levels. The 120 rows of houses were presented and awarded at the Paris Universal Exhibition in 1867 as a "model of hygiene and comfort for the worker house" for that period. Despite the simple style, the architectural vocabulary is more carefully studied than in other workers' residences for miners, especially thanks to the façade decorated with particularly elaborate blind drums; "bull's-eye" windows, triangular gables, false bay windows. Flanked by a large square which was designed to accommodate the public gardens, *the Coron* of the 120 is revealed as the monument itself proper of the working population next to other prominent buildings.

[33] Ibidem, p. 19.


Figure 14. Corons des 120. Source: www.bassinminier-patrimoinemondial.org

## Chevalements

The *chevalements* are the mining castles scattered throughout the territory of the mining basin from the '30s of the Twentieth century: some are still integrated with the so called "acceptance" buildings, where the carts full of coal stationed before descending once emptied; others, deprived of their relevance to the buildings have been preserved for the identity and symbolic value that preserve and reproduce the features of those of the ancient mining sites that have gone missing. This series of *chevalements* expresses, through the constructive technology that characterizes them, the different historical stages of the mining basin.

The metallic trellis beamed *chevalement*s have a slender and aerial structure: their height typically reaches about twenty meters. To differentiate themselves from those rival, the Companies have often given their castles a particular allure, often through the use of ornamental accessories: lightning rods, swags, wheels and so on. The castle n. 1bis of the Carboniferous Company of Liévin and n.3 of the League of Lens Mines perfectly illustrate this revelry of style: they are lower than twenty meters, although located on the same municipality but not on the same concession. Both date back to 1922 and as the n.1 castle is enough sober while the n.3 of Lens is crowned by a bell tower with lightning rod surmounted by the sign of the mining Company (two crossed pickaxes).

In the reconstruction period following the First World War some companies took the opportunity to apply new techniques for the construction of small castles: for they would be achieved quickly and at the same time have a solid structure, *chevalements* were made of reinforced concrete, as that of Dutemple pit of 1921 in Valenciennes.

During the Nationalization of the mines the *chevalements* assumed the configuration with girders with full core, identifiable because of the total absence of ornamentation, considered superfluous, and for the rectilinear physiognomy. The heights reach generally 50 meters, and then take a considerable monumental impact, as in the case of *chevalements* of the shaft *Sabatier* (1951) in Raismes or that of the shaft 9 in Roost – Warendin[34].

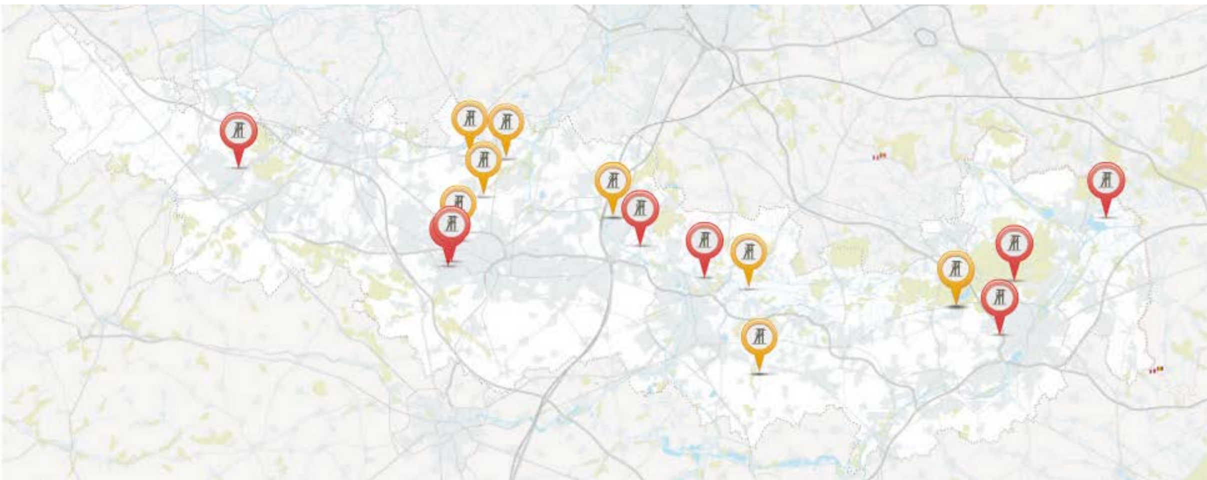

Figure 15. The Chevalements: red ones enrolled in the WHL. Source: www.atlas-patrimoines-bassin-minier.org

*Chevalement Dutemple*[35]

Year: 1920

Company: *Compagnie des Mines d'Anzin*

This mining site is one of those rare sites that experienced a constant activity period from the Nineteenth to the Twentieth century. The two conducts in Dutemple mine were excavated in 1764 and completely rebuilt after the First World War; the second excavation was then implemented in 1920 with a reinforced concrete castle, made with a central supporting tower with two supports ("legs"), and with a platform for the toothed wheels to less than 36 m in height from the ground, thus revealing a carefully studied architectural conception.

With a central staircase that runs throughout the height of the stand and which allows access to all levels, this pit is provided with three platforms that stand out with an elaborate forepart respect to the main perimeter. The exploitation stopped in 1940 and the mine was used as a ventilation shaft until 1949. Today *Dutemple* mine and its towering structures stand solitary within a public space built over the old mining site. Aside from its identity and symbolic value of the mining past, the *chevalement Dutemple* also testifies to the massive destruction of productive infrastructure implemented throughout the mining area during the First World War.

[34] Association Bassin Minier Uni, Mission Bassin Minier, Centre Historique Minier de Lewarde, Ministère de la Culture et de la Communication et al. (Eds.). *Synthèse du dossier d'inscription*. Comines: Quality 'Imprim, [sd], pp. 24-26.

[35] Bertram, C., Mission Bassin Minier Nord - Pas de Calais (Eds.). *100 sites de découverte du Patrimoine Minier*. [Nd]: [nd], 2012, p. 20.

Figure 16. Chevalement Dutemple. Source: www.bassinminier-patrimoinemondial.org

*Chevalement of the n. 2 Shaft in Marles (or St-Emile)*[36]

Year: 1921

Company: *Compagnie des Mines de Marles*

The Old Two (*Vieux - Deux*) plant belonging to Marles Company and its machine for the extraction are the remains of the mine n.2 in Marles, which was composed of 3 shafts: 2, 2 bis and 2 ter. Excavated in 1854, the first pipe of the mine n.2 collapsed in 1866 and was abandoned. The Company installed again the mine between 1906 and 1914 at the same site and planted the duct n.2, which mainly served as ventilation and service until its final disposal in 1974. The gantry structure is dated 1921 and consists of a main towering, load-bearing structure with lattice riveted beams. It was modified in 1950 – 1951 when the mine became a highly concentrated site during Nationalization: its buttresses were reinforced by additional scaffolding due to the subsidence of the land caused by the progressive exploration of the subsoil. The building that houses the mining machine also includes a small museum showing the tools and many photographs of mining activities.

*Chevalement of the n. 8 Shaft in Dourges*[37]

Year: 1922

Company: *Societé of Mines de Dourges*

The Cornuault mining complex now includes the metal frame of the n. 8 mine (or mine Cornuault), belonged to the Dourges Company, and the nearby town Cornuault garden. Begun

[36] Ibidem, p. 99.

[37] Ibidem, p. 47.

in 1913, the activity at n.8 mine abruptly stopped during the First World War and started again only in 1927. The structure of the central bearing tower has four supports ("legs") with two platforms for supporting the sprockets of 6.50 m in diameter.
Since 1961 the mine is particularly concentrated around the shaft n.10 in Oignies, used as a ventilation duct and service. The shaft n.8 stopped its activity in 1973 in a definitive manner.

*Chevalement of the n. 3 Shaft of Lens*[38]

Year: 1922

Company: *Societé des Mines de Lens*

The castle of n. 3 mine is the last remaining after the dismantling of the mine n. 3 of the Lens Mining Company (1859 – 1978). Today it is in the heart of an industrial estate. This stand is the twin of the n. 11 of Lens mine and its structure is dated 1922, built with a central tower with load bearing, riveted lattice beams equipped with four cranes also made with lattice girders. The platforms are equipped with barriers and a central tower with four faces, surmounted by a lightning rod and the Company's symbol. It is an example of the first post war period when Lens Society decided to standardize the holdings of its mines and symbol of the largest mining disaster in post war France, happened on 27 December 1974, due to an explosion that trimmed part of the structure killing 42 people.

[38] Ibidem, p. 77.

Figure 17. Chevalement of n. 3 pit in Lens. Source: panoramio.com

*Chevalement the Shaft n. 1 bis of Liévin*[39]

Year: 1922

Company: *Societé de Houillère Liévin*

The gantry of the n. 1 mine is the last remaining of the infrastructure of the mine 1 of Liévin (1858-1976) and dates back to 1922. The stand consists of a central tower with supporting riveted trusses and two cranes, with lattice girders also. The toothed wheels are arranged in parallel on a carrier block with metal barriers. The structure is topped by a bell tower with four sides. This *chevalement* and that of Lens Mining Society perfectly illustrate the rivalry in styles between the two companies, which in any case are very similar in appearance of the mining castles.

Separated by ten meters, these stands are in the same municipality, but they are obviously not part of the same concession and while that of Liévin Company is exquisitely linear, that of the Lens Company is configured in the most meticulous way.

[39] Ibidem, p. 79.


Figure 18. Chevalement of the shaft 1a in Liévin. Source: www.bassinminier-patrimoinemondial.org

*Chevalement of Ledoux Shaft*[40]

Year: 1951

Company: *Groupe de Valenciennes*

The main structure is the last survivor of the dismantling of Ledoux mine, commissioned in 1905 and modernized in 1950 to become a mouthpiece of highly concentrated mine and permanently decommissioned in 1988. It was symbolically preserved to bring to life the testimony of this ancient mining complex and the history of the site. Dated 1951, its "cap" structure is typical of the nationalization of mines period and it is configured with an asymmetric pyramid shape for the load bearing structure, full core beams stabilized with four "legs" as reinforcement. The two toothed wheels located on top are housed on a platform with a metal balustrade. Erected as a totem, this *chevalement* dominates on the site and on the lakes Chabaud – Latour with its silhouette on the horizon.

*Chevalement Sabatier*[41]

Year: 1951

Company: *Groupe de Valenciennes*

Located in the heart of the 174, 175, 175a and 176 landfills, which have been covered by vegetation, this structure is the last bastion survived the dismantling of the Sabatier mine (1912 - 1980). Dating back to 1951, it comes from the Clarence mine belonged to Bruay – Auchel

[40] Ibidem, p. 6.

[41] Ibidem, p. 14.

Company and it was moved to the number 2 shaft in the Sabatier mine in 1955. Originally the asymmetrical pyramid-shaped gantry, supported by full beams and by four "legs" as reinforcement, contained two platforms for the gear wheels (six meters in diameter each) and a metal lattice tower, now disappeared.

The remaining inlet of the mine has been transformed into a pedestrian path and subjected to a practice of forestation which, however, thanks to the presence of *chevalement* Sabatier does not nullify the industrial past that characterizes the entire region.

Figure 19. The Chevalement Sabatier. Source: www.bassinminier-patrimoinemondial.org

*Chevalement the Shaft 9*[42]

Year: 1955

Company: *Groupe de Douai*

The structure of the mine n. 9, known as the Escarpelle, is dated 1955 and derives from another inlet at high concentration, the n. 13 in Sains en Gohelle. Being more powerful than its predecessor, it replaced the latter in the Escarpelle in 1975. The carrier has the shape of the central tower porch and consists of full steel beams. Designed for a double extraction, only two of its four toothed wheels of eight meters in diameter, placed on top, were reinstalled when the stand was transported from the previous mine. It is located not far from the famous survey of 1847 through which was determined the direction of coal deposits, travelling along a trajectory toward northeast, and promoted coal mining activities in the Nord – Pas de Calais region. This *chevalement* also stands as a mark of the end of the mining activities in the region, being the monument of the last mine to be closed in the basin in October 1990.

[42] Ibidem, p. 45.

## Technical Buildings

*The Sarteau Pit Fire pump*[43]

Years: 1826 - 1827

Company: *Compagnie des Mines d'Anzin*

The *Sarteau* mine location was chosen for its proximity to the left bank of the River Escaut (a.k.a. Scheldt), but this proximity made the exploration of the ground difficult because of water seepage in the tunnels. Completed in 1927, the building of a fire pump housed a steam engine that ensured the water drainage. By a large size, the pyramidal structure of this construction is unusual but it was designed to prevent the slipping of the building above the unstable ground. A large opening was made in the upper part of the south-eastern façade to position the balancing pole.

The building is also topped by battlements and false trap doors, with no functional purpose but used as some medieval – like patterns, common to the industrial architecture in the first half of the Nineteenth century. The fire pump ceased its activities in 1861, but the building survived and shows traces of the Second World War. The *Sarteau* tower was converted into a fort in 1939: the openings were capped, the façades were drilled for the slits and behind the building was built a casemate.


Figure 20. The Sarteau fire station. Source: www.bassinminier-patrimoinemondial.org

[43] Ibidem, p. 10.

### Railway stations

In 1838, after less than twenty years since the invention of the railroad, the mining Company of Anzin began the work of one of the first railway lines in France, called *cavaliers*, with 1,435 meters of standard gauge. Built until 1874, the railway network covered approximately 40 kilometers, connecting all the Company's shafts, from Somain to Peruweltz in Belgium: a part of this old cavalier was redeveloped and converted to free space for outdoor activities, while some signals, trading posts and stations of origin have been preserved as the station of Saint - Waast of 1838 in Valenciennes and the station Fresnes – sur – Escaut of 1874.

Figure 21. Gare Saint - Waast. Source: www.bassinminier-patrimoinemondial.org

Each mining Company had its own network of railways, in order to be totally independent from one another and the construction could be carried out with three different techniques: tracks laying at ground level; the building in excavation; or predominantly lifting the land to lower the ground level in order to create docks and platforms with elevated tracks on schist fillings that support the railway route. The realization of the *cavaliers* was often accompanied by the construction of bridges, real engineering works of art, which allowed to overtake other railway lines, roads, canals and rivers. The railway also permitted the transport of coal and the sorting stations of Somain and Lens were in that sense the most important junctures for the coal expeditions by train[44].

[44] Association Bassin Minier Uni, Mission Bassin Minier, Centre Historique Minier de Lewarde, Ministère de la Culture et de la Communication et al. (Eds.). *Synthèse du dossier d'inscription*. Comines: Quality 'Imprim, [sd], pp. 33-35.

*Fresnes - sur - Escaut Station (with exchange point)*[45]

Years: 1868 - 1874

Company: *Compagnie des Mines d'Anzin*

The Mining Company of Anzin was the first to install its own railway network to transport coal, the *cavalier* Somain – Peruweltz, one of the first real railroads of France with a standard gauge of 1,435 meters.

Built between 1868 and 1874, this line connected all the Company's mines in the Valenciennes region and measured 40 km. Located in the last section opened in 1874, the Fresnes - sur - Escaut Station is among the most important stations of the *cavalier*. A simple one-storey building was built in 1874 but at the beginning of the Twentieth century a new station with important architectural features, given especially in patterned red, gray and white bricks was built. Inside the main lobby as well as the original interior furnishings have been perfectly preserved. Behind the station, traces of the rails, the tracks and the covered gallery are still visible, as well as a signalling cabin made of riveted steel and brick cladding. Today the site is subjected to a converting plan to become an urban and landscape *promenade*.


Figure 22. Gare de Fresnes. Source: www.bassinminier-patrimoinemondial.org

*Lens Station*[46]

Year: 1927

Company: Compagnie des Chemins de Fer du Nord

In mid-Nineteenth century the Lens station became the neuralgic centre of the coal transportation for the Nord – Pas de Calais mining Companies. Completely destroyed during

[45] Bertram, C., Mission Bassin Minier Nord - Pas de Calais (Eds.). *100 sites de découverte du Patrimoine Minier*. [Nd]: [nd], 2012, p. 11.

[46] Ibidem, p. 71.

Second World War, it was rebuilt and inaugurated in 1927. It is the work of the architect and Building Manager of Northern Railways Company - today *Societè Nationale de Chemins de Fer* – Urbain Cassan and the engineer Forestier. With an Art Deco style, the building rises by taking the form of a locomotive, made of 11 reinforced concrete compartments that can be moved separately since they are not joined together. In the foundation the building is based on a metal arc, manoeuvred by hydraulic jacks, and therefore it can follow the movements of the terrain; the latter in fact presents subsidence phenomena being affected by mining excavations.

Dominated by the 23 meters high clock tower, the whole building stands out with 86 meters of extension: the central section corresponds to the lobby, covered by arches covered with mosaic glass that illuminate the space; a ceramic mosaic frieze signed by Labouret dominates on the interior with a scene linked to mining production.


Figure 23. Lens Station after the reconstruction. Source: www.cdclens.fr/cp-gare-depot.html

*House of the Miners' Syndicate Union*[47]

Year: 1926 (reconstruction)

Along with those of Montceau - les - Mines and Carmaux, the House of Lens Miners' Union is a one of the three syndicate houses built in France. It testifies the social history of the Nord - Pas de Calais coal basin and of the entire nation. In 1911, its inaugural year, the building became the headquarter of the Union of Miners. Destroyed during the First World War, it was rebuilt in the same location and reopened in September 1926: it then became a multiple complex of Unions, including the headquarters and the seat of the printing and sale of the Syndicate's publication *La Tribune*. The main façade, made of brick and stone and elevated on two levels, consists of three main elements: the central span and two projections on each side. A balustrade

[47]Ibidem, p. 70.

used as a stage during the strikes, marks the separation between the first and the second level. The whole building is surmounted by a gable with a central curved section that shows a bas-relief depicting three glorious scenes of miners' work: the extraction of coal on the knees with a pickaxe, the rounds of sedans and the reinforcement of the main galleries (*bowette*) with containment timber.


Figure 24. Maison Syndicale de Lens. Source: www.panoramio.com

### The Grands Bureaux

Among the many types of social housing, community, health and administrative buildings, the *Grands Bureaux* certainly represent the largest category of the most impressive, eloquent and rhetorical mining architecture: if in the residences of workers and employees the masonry was decorated with various synthetic and economic decorative motifs made of brick and enamel, in these huge complexes space is fully let to a "heavy" decoration, representative and celebratory of the mining Companies and their financial and managerial power over the territory. The architecture of these buildings is imposed in the context of large gardens and parks that surround them, appealing to all formal and volumetric quantity that architects can dare: the result is often a monumental and imposing impression, enriched by sumptuous decorative motifs and Eclectic languages, often filled with Late – Renaissance and Baroque formalisms[48].

[48]Association Bassin Minier Uni, Mission Bassin Minier, Centre Historique Minier de Lewarde, Ministère de la Culture et de la Communication et al. (Eds.). *Synthèse du dossier d'inscription*. Comines: Quality 'Imprim, [sd], p. 48.

*Grands Bureaux of the Société des Mines de Thivencelles*[49]

Years: 1905 - 1906 (transformed into the dispensary)

Company: *Societé des Mines de Thivencelles*

The Mining Company Health Centre was once home to the offices of Thivencelles Mining Company (1841-1944). A first building was acquired between 1860 - 1870 and renewed by the Company so that it could house the offices inside. The central hall dates from 1905. Made of concrete, the façade of the central hall is inspired by the Mannerist architecture of the beginning of the Sixteenth century: columns, pediments, Tuscan columns. The arch located on top of the large door is decorated with a pattern showing a medallion of the miners' tools: hard hat, rod, shovel. The iron gates bear the initials of the *Société des Mines de Thivencelles*.

After the Nationalization in 1946, the offices were converted to house the health centre of the Miners' Association. On the opposite side in the same soil there is the *Château* Stanislas Desandrouin, in honor of the administrator of the Society of Anzin and grandson of Jacques Desandrouin, the man who discovered the presence of coal in Fresnes - sur - Escaut in 1720. Featuring a Neoclassical style, the castle shows the prosperity and power that at that time the Company exercised on the territory of Anzin.


Figure 25. Grand Bureau of the Society of Thivencelles. Source: www.wikimedia.com

[49]Ibidem, p. 12.

*Grands Bureaux of Societé de Houillère Liévin*[50]

Year: 1920 (reconstruction)

Company: *Societé de Houillère Liévin*

Located on the Riaumont hillside, in the heart of Liévin, the Great Offices of Liévin Mining Company gathered together the central departments, technical, administrative and financial business of the Company. When the mines were nationalized, they were converted into a clinic and a maternity ward for the Society for the Welfare of the Mine Workers. Currently they house the municipal departments of the city of Liévin.
The architecture of this large rectangular building is simple: entirely built with bricks, it stands on three levels and is covered with a slate roof; all the façades on the first level are made with embossed bricked stripes; other brick decorations in the bow windows mimic a curved stone arch. The upper part of the central body is embellished with a stone block citing *Grands Bureaux* written with very large letters. The façades of the second and third level include reliefs bearing the emblems of the miner. Together with the blocks bearing the words Great Offices, these are the only remaining motifs that recall the original function of the building.


Figure 26. Grands Bureaux of the Society of Liévin. Source: www.bassinminier-patrimoinemondial.org

*Grands Bureaux of the Compagnie des Mines de Vicoigne-Noeux-Drocourt*[51]

Years: 1874 and 1930

Company: Compagnie des Mines de Vicoigne - Noeux - Drocourt

The central offices of the Vicoigne – Noeux - Drocourt mining Company were built near the mine n. 1-1 bis in two phases: the first from 1873 to 1890, the second during the Thirties of the Twentieth century. Designed with a classic style, the oldest offices extend along the national road and are recognizable by the large detached central building, with an entrance for carriages and topped by a mansard roof slate. During the World Wars, the Great Offices were modified: the left building was renovated and extended with another building, on whose back there is a

[50] Ibidem, p. 78.

[51] Ibidem, p. 88.

pavilion in Art Deco style. The façade was partially scratch coated and painted with some vertical bands left out with decorative bricks. Today this part of the *Grands Bureaux* is a private residence.


Figure 27. Grands Bureaux of the Company de – Vicoigne – Noeux – Drocourt. Source: www.wikimedia.com

*Grands Bureaux of the Compagnie des Mines de Lens*[52]

Years: 1928 - 1930

Company: *Compagnie des Mines de Lens*

The Great Offices of the Lens Mining Company, display of one of the most important mining companies within the coal basin, are located on a promontory and preceded by a French garden, which constitutes a more urban than rural dimension. The former offices of the Company, made in 1907, were destroyed during the First World War and the reconstruction was entrusted in 1926 to Louis Marie Cordonnier (1854 – 1940) in collaboration with his son, Louis Stanislas (1884 – 1960). The Great Offices are made with a reinforced concrete structure and count on a five levelled central body and two lateral wings which contain two internal courtyards. The main façade extends for 81 meters. The architectural style of the Grands Bureaux is typical of Cordonnier, emphasized by its regionalist features: the repeated use of 35 meters high terraced arched gables in New Flemish decorative style, bulbous elements and bow windows. For the furnishings of the interior the architects called the prestigious studio Majorelle[53]

[52] Ibidem, p. 69.

[53] Louis-Jean-Sylvestre Majorelle (Toul, 1859 - Nancy, 1926) was a cabinetmaker and French decorator belonging to the Art Nouveau current of the Nancy School, of which he was also vice president. See: Fanelli, G., Bonito Fanelli, R. *Il tessuto moderno: disegno, moda, architettura 1890-1940*. Firenze: Vallecchi, 1976, pp. 117-120.

of Nancy, associated with Daum[54], and other small artisanal enterprises: the results are wooden objects, chandeliers, furniture in the Art Deco style. Today the Great Offices host the *Jean Perrin* Faculty of Sciences of the University of Artois.


Figure 28. Grands Bureaux of Lens Society. Source: www.bassinminier-patrimoinemondial.org

### Pits

*La Sentinelle pit* [55]

Years: 1824, 1854 (converted into a church)

Company: *Compagnie des Mines d'Anzin*

The actual Sainte Barbe church corresponds to the former mine shaft of *La Sentinelle* and it is the oldest technical testament of the mine. The excavation of the pit *La Sentinelle* began in 1816 and the mine was opened in 1818. The first real plant corresponded perfectly to the typical rules of the mineral deposits of the Eighteenth century, with wooden structures, ponies and a hippodrome with a racecourse and a lifting and lowering system (winding gear) pulled by horses. The *d'Anzin* mining Company commissioned a new building, made of bricks, for the purpose of housing a steam engine: the construction arose extending in length to distance itself the most from the extraction shaft, located at the present entrance of the church and originally topped with the pit metallic frame, that is the mining castle. Lightly larger and taller than the

[54] House founded in 1878 and specialized in processing of crystal and glass. See: Daum, N. *Daum: One Hundred Years of Glass and Crystal*. Washington [?]: Daum et Cie. and the Smithsonian Institution, 1978.

[55] Bertram, C., Mission Bassin Minier Nord - Pas de Calais (Eds.). *100 sites de découverte du Patrimoine Minier*. [Nd]: [nd], 2012, p. 21.

aisle, the building that houses the presbytery originally contained the boilers of the steam engine machine as well as the former high – pressured engine.

The corridors run along the entire length of the base that once led to the entrance of the mine and to the tunnels. The mining activity ceased in 1830 and the *d'Anzin* mining Company planned to transform the building into a church in 1847, completing the work in 1854. The church was eventually expanded to the sacristy and the baptismal font from 1872.


Figure 29. Church of Saint Barbara, former the Shaft of la Sentinelle. Source: www.bassinminier-patrimoinemondial.org

*Arenberg Pit* [56]

Years: 1900 – 1902 and 1961

Company: *Compagnie des Mines d'Anzin and Groupe de Valenciennes*

The Arenberg mine has two perfectly identifiable technical complexes: each of them is characterized by its own architectural style. The first refers to the early extraction period, which began in 1902. It includes two collection buildings for pits number 1 and number 2, with metal structures, and a number of buildings including the auxiliary machinery room, the extraction of the engine room, laboratories and warehouses. The complex is characterized by the exceptional clearness of the façades, made of stone and brick masonry, testament to the elegance of research and decorative finishes for this "jewel in the crown" of the Company. The second complex dates to the nationalization of the coal mines: in 1954 the mine began its program of renovation and modernization to become a powerful mining site with a high concentration, equipped with the most modern machinery. This section includes the *conciergerie*, the administrative offices, bathrooms and showers, the hall of the lantern, collection buildings for

[56] Ibidem, p. 23.

the shaft number 3, surmounted by an impressive metallic frame of 1961 and accompanied by two rooms of mining machinery and from the electric substation. In this complex the functionality enhances the modern language: orange bricks and continuous ribbon windows.


Figure 30. The complex of Arenberg Shaft. Source: www.bassinminier-patrimoinemondial.org

*Mathilde Pit* [57]

Years: 1832 - 1854

Company: *Compagnie des Mines d'Anzin*

*Mathilde* mine is an exceptional testimony to the history of mining techniques from the beginning of the Nineteenth century. The excavation of the shaft was started in 1931 and the basin exploration began in 1832. It is made of bricks and followed the standard model of the time, known as "T". According to this model the rectangular building that houses the shaft is extended by another building arranged in the transverse direction. The lower level housed the workers' cottages, the concierge as well as the tunnels that facilitated communication. The upper level contained the structure of the mining castle that covered both the well and the machinery. The purpose of the access ramp was to facilitate the exchange of machinery parts. At the end of 1852 the Company made modernization plans of the mine by replacing the barrels with extraction cages and lifting the structure of the headframe. This new extraction method required a more powerful mining equipment that had to be moved back: an impressive added section for accommodating the extraction machine was therefore built in the back of the headframe. Since

[57] Ibidem, p. 26.

1863 the Company decided to transform the mine into housing for foremen and it still retains this configuration.


Figure 31. Mathilde pit. Source: www.bassinminier-patrimoinemondial.org

*Shaft n. 1a*[58]

Years: 1886 - 1887,

Company: *Compagnie des Mines de Vicoigne-Noeux-Drocourt*

The pit n. 1-1 bis of Noeux-les-Mines is an important witness to the history of mining in this area: it was among the first shafts made in the Nord – Pas de Calais Department in 1851 and one of which to have introduced powerful steam and horse powers machines by means of metal cages moved along the excavation tunnel. From an architectural point of view the shaft is characterized by the predominance of the typical industrial architecture of the Bassin Minier materials, namely iron, steel and forged elements on site in the workshops of the mine.

[58] Ibidem, p. 89.


Figure 32. Shaft n. 1 bis. Source: www.bassinminier-patrimoinemondial.org

*Pit 11 – 19*[59]

Company: *Société des Mines de Lens*

In the town of Loos en Gohelle, a few hundred meters from the Louvre – Lens museum, this mining site created by *the Societé des Mines de Lens* operated from 1894 to 1986 and has retained much of its facilities. Along with the *Arenberg* Pit in Wallers, the *Delloye* Pit in Lewarde and the 9 / 9a in Oignies, it is one of the four most emblematic shafts in the history of this mining region.

The slag heaps and the mining village also reflect the profound influence of the mining system on the landscape. The 11/19 shaft is currently under renovation and conversion based on the themes of mining history, culture, economy and the environment as part of a project for the sustainable development.

*The Société des Mines de Lens* enumerated its shafts as they were excavated, hence the use of the numbers 11 and 19 to designate this site. There was even the custom to give each pit the name of Company's Directors – in this case Pierre Destombes – for which reason the Pit n. 11 is also known as *Saint Pierre*. The shaft was built between 1891 and 1894 and it touched the maximum extraction tip in 1904 with 383'450 tons of coal.

The building's architecture is like that of other sites opened by the same Company in the late Nineteenth century and the period up to the Great War. In addition to the use of bricks, it is characterized by the use of a steel structure. In 1907, the complex was expanded with the opening of another shaft a few hundred meters from the Liévin city, not used for the coal extraction but to ventilate the shaft n. 11[60].

[59] Ibidem, p. 73.

[60] Country of Art and History of Lens - Liévin (Ed.) *Listen to the story of the 11/19. Lille*: The Artésienne, 2012 [?], p. 5. Available in: www.tourism-lenslievin.co.uk

During the First World War the shaft n. 11 fell within the theatre of war and it was captured by the Germans in October 1914. Immediately the invaders managed to make the mine useless by blasting the essential equipment and the cables of the shafts, causing the fall of the cages to the bottom of the galleries. Only in 1917 the shaft n. 11 and its surroundings were liberated during the Canadian expedition to the hill n. 70.

After the war, the reconstruction showed up to the *Societé des Mines de Lens* as a modernization and growth opportunities: based on studies and tests conducted to restore the shafts as part of the effort undertaken by the Technical Commission of the Groups of the invaded coal basins, it was possible to install new machineries and modern extraction systems. Thanks to the introduction of the electric power it was possible to install two-cylinder pistons in place of those that were fuelled by coal and, for reasons of speed and economy, buildings and shafts were reconstructed using standard models. Standardization is also extended to the structures, the materials and the decorations of mining buildings. While the general distribution of the structures was changed according to the specific characteristics of each site, the structural configuration and the architecture of washeries, engine rooms and laboratories was maintained identical in all the Company's shafts.
Completed in 1925, the shaft 11 is a perfect example of this modern style, with particular attention to the use of materials: bricks and reinforced concrete, both modern and inexpensive, replaced the pre-war metallic structures and in addition to the increased efficiency requirement also the aesthetic interest in the issue was taken into account; the alternation of materials such as stone, bricks and concrete, combined with classic or decorative regional motifs, reflects the thinking of the Society for the representative prestige of the mining site[61].

The shaft itself consists of an imposing metal structure 45 meters high and weighing 350 tons. At the base there are the wheels on which run the cabins of the mine, guided by suitable machinery, for the transport of coal and miners up and down the shaft. The wheels have a diameter of 5.50 meters and are surrounded by a dock with a guardrail, surmounted by a tower crowned by the sign of the mine tower. The shortage of materials and the standardization policy pursued in the 1920s explain why an identical pit is located in Saint-Amé mine in Liévin, the site where the shaft n.3, belonging to the same *Société des Mines de Lens*[62], stood.

[61] Ibidem, p. 8.
[62] Ibidem, p. 9.


Figure 33. Shaft 11/19 in an old photo. Source: www.apphim.com


Figure 34. The complex of 11/19 Shaft today. Source: www.bassinminier-patrimoinemondial.org

*Shaft Delloye*[63]

Years: 1926 – 1931

Company: *Compagnie des Mines d'Aniche*

Located in the south of the mining basin around, away from *terrils* and houses, the site of the *Fosse Delloye* differs from the classical of shaft – waste – housings typology. The shaft was dug in 1911 in the n. 1 site and was followed by that of the shaft n.2 in 1927, in the post-war climate. The final stop of the activities took place in 1971 and in 1982 the State and the coal Companies in the Nord – Pas de Calais Mining Basin (HBNPC) decided to form the Association of Historical Mining Centre, which definitely opened in 1984.

Figure 35. The Historical Mining Centre of Lewarde. Source: www.bassinminier-patrimoinemondial.org

[63] Bertram, C., Mission Bassin Minier Nord - Pas de Calais (Eds.). *100 sites de découverte du Patrimoine Minier*. [Nd]: [nd], 2012, p. 36.

# PART 3

## CASE STUDY: THE MONTEPONI MINE

## Mining Sardinia

To understand the complexity of mining archaeology in Iglesias and Monteponi, even if the thesis focuses mainly on the events referring to the restarting of exploitations from the mid-Nineteenth century, we cannot help but starting from the history of the Catalan – Aragon occupation of the island, which put the bases for the further settlement and expansion of the mining industry in Sardinia.

As for the previous mining history, particularly characterized by Punic-Roman[1] presence in the Island and the subsequent Byzantine and Vandal period[2], we suggest to read the specific literature on the subject, which is not lacking in references to the Phoenician extractive practices and to the exploitation of mineral resources by the Romans, in particular for what concerns the galena in *Cungiaus* area, in Monteponi[3][4].

A brief description of the main events that led to the settlement of mining exploitations in the area of Iglesias since the Pisan occupation in the 13th century is provided in the appendix at the end of this chapter.

*Catalan – Aragon period from the Fourteenth century to the Eighteenth century*

The end of Pisan rule[5]in fact it occurs about a century after the formal investiture of James II of Aragon by Boniface VIII, with the real invasion of Sardinia by the Catalan - Aragon Kingdoms,

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[1] *The Phoenicians established precisely in the great mining district of Sardinia, in the provinces of Iglesias, not pulled undoubtedly the copper which is very rare, but they already mined galena deposits, a raw, unrefined lead, which they sold to their neighbours of nuraghe. These exploitations of the Phoenicians and Carthaginians, have been mentioned by ancient authors, that's true, but some of subsidence jobs and coins, pottery lamps that have been found, made it possible to date them.* See: De Launay, M. 1892. Minière de l'Histoire en Sardaigne industries. In *Annales des Mines*, Series 9, 1892 Volume I, p. 515.

[2] To the mining activity carried out by Romans in the fifth and sixth centuries the Vandal and Gothic rule, as well as the Byzantines under whom-sensitive variations in post mining Roman doldrums were not remarkable.
The main productive activities were characterized by the intense cereal crop and related structures, belonging to urban aristocracies. In the island, in the inland areas pastoralism was widely practised, as businesses were animated by flows of goods that crossed the Mediterranean from North Africa, Spain, the Aegean islands and the Turkish coast. See: Spanu, P. G. 2006. La Sardegna Vandalica e Bizantina. In Brigaglia, M., Mastino, A., Ortu, G. G. (eds). *Storia della Sardegna 1: dalle origini al Settecento*. Bari: Laterza, 2006, p. 64.

[3] Ottelli L. *Monteponi. (Iglesias – Sardegna) Storia di eventi e di uomini di una grande miniera*. Sassari: Carlo Delfino Ed., 2010, p. 95.

[4] Manconi, F. *Quintino Sella. Sulle condizioni dell'Industria mineraria in Sardegna*. Nuoro: Ilisso, 1999, p. 45.

[5] *Having become masters of two different branches of south-eastern Sardinia, the Donoratico allowed its development, boosting the mining and revitalizing the city of Villa di Chiesa. After the death of Ugolino, only Gherardo retained its domination of the Sulcis and Caputerra, the only part of the old Cagliari Judicate that had not Been acquired by the Municipality of Pisa, which also increased its third part of Cagliari territory.* Despite the heavy defeat at the Battle of Meloria against Genoa in 1284, Pisa strengthened further its dominion over Sardinia, with the exception of Logudoro, where the Genoese forced Sassari, in 1294, to conclude an agreement that subordinated the political choices and trade to the will of the Ligurian Municipality.
See: Galoppini, L. 2004. La Sardegna giudicale e catalano – aragonese. In Brigaglia, M. (eds). *Storia della Sardegna*. Muros: Stampacolor for Edizioni della Torre, 2004, pp. 152-153.

begun with the landing of *Infante* Alfonso in the Gulf of Palmas in 1323. This progressive advancing of the Aragon army in fact marked the beginning of the occupation and the subsequent capitulation of the Sardinian cities, including Iglesias and Cagliari, and the vassalage of Arborea and Sassari, belonging to the Doria and Malaspina families.

Only the Judicate of Arborea had survived the division between Genoa and Pisa, but the subjugation and alliance with the Crown of Aragon lasted only until 1327 with the reign of Alfonso IV of Aragon: from that moment in the Arborense Judicate several ignite of rebellion outbroke against the Spaniard invader, featuring political and military actions moved by Mariano IV, Judge of Arborea, by the Judge Eleanor and Brancaleone Doria, culminating in the battle of Sanluri in 1409 which signed the defeat of the Sardinians against the Aragon. The rights over the former kingdom of Arborea, sold by Viscount of Narbonne – who had been offered the sceptre of the Judicates in 1407 – to Alfonso of Aragon[6] in 1420 in fact marked the ending of Arborea rebellion and the capitulation of the city of Sassari and the extra judicial territories, which were then added to the final configuration of the *Regnum Sardiniae et Corsicae*. The defeat of Leonardo Alagon in 1478 was finally the last bastion of resistance against the Crown of Aragon, which inevitably resulted in a defeat and a growing assertion of the Aragon control over the entire island.

*The Spanish Sardinia*

Throughout the Spanish age, from the capitulation of Alagon to the Treaty of London (1479 – 1720), Sardinia remained institutionally engaged as part of the Crown of Aragon, along with the Principality of Catalonia and the kingdoms of Aragon, Valencia and the Balearic Islands, but it was inevitably reduced to a peripheral role[7]. To sign an insurmountable distance between the city and the countryside in Sardinia is the prevalence of large urban centres than in rural areas throughout the period of Spanish rule.

Towns in fact enjoyed a number of special concessions (privileges, in fact) that guaranteed a kind of self–government for the majority of the urban centres: the first Aragon privilege, the so-called *Coeterum*, was up to the city of Cagliari in 1327 and it extended to the Catalan settlers in

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See: Ortu, G. G. I Giudicati: Storia Governo e Società. In Brigaglia, M., Mastino, A., Ortu, G. G. (eds). *Storia della Sardegna 1: dalle origini al Settecento*. Bari: Laterza, 2006, pp. 108-109.

A More strength of the Municipality of Pisa dominant position on the political and administrative life of its possessions in Sardinia, add the repute the local administration was centralized with regard to the appointments of notaries, guardians of the salt, sergeants' castles and meters grain etc. at the hands of reformers, or inquisitors, Elected by the Council of Elders of Pisa and not so Local Authorities of the Sardinian city. See: *Ortu, G. G. La Sardegna dei Giudici*. Nuoro: Edizioni Il Maestrale, 2005, p. 239.

[6] The Viscount of Narbonne had agreed the sale of rights on the Judicate for about 150,000 florins, which were paid to him and to his heir during a decade (nor even entirely). The transaction was guaranteed by an offer made by the great feudal lords of the realms, old and new, of the Crown of Aragon, but ended up burdening especially on the Sardinian Kingdom finances, and in particular on Logudoro, who had been the Viscount's last bastion on the island. See: Ortu, G. G. La Sardegna nella Corona di Spagna. In Brigaglia, M., Mastino, A., Ortu, G. G. (ed). *Storia della Sardegna 1: dalle origini al Settecento*. Bari: Laterza, 2006, p. 157.

[7] See: Ortu, G. G. La Sardegna nella Corona di Spagna. In Brigaglia, M., Mastino, A., Ortu, G. G. (ed). *Storia della Sardegna 1: dalle origini al Settecento*. Bari: Laterza, 2006, p 168.

the Castle of Cagliari the municipal right of Barcelona and a number of rights proper of the subjects of the Aragon Crown[8]. In 1331 the *Coeterum*was extended to Sassari and in 1441 to Alghero. In general, all the cities tended to keep their legal systems in a relatively autonomous manner, since the monarchy did not renounce to exercise close control over the selection of the urban *elites* responsible for the city offices and the most important economic and administrative measures[9].

With regard to mining, the Catholic Monarchs modified the law regarding the extraction of minerals, introducing the distinction between the mine property and the property of soil and causing the first belonged to the State and therefore to the King. This principle, called *regalia*, introduced the license to third parties in return for an annual fee, proportional to the extracted products, when the State itself did not run the mine.

A number of concessions began to be bestowed for the exploitation of the island's mines, including *Calabona* in Alghero, while Iglesias was run directly by the King. However, due to the depletion of the surface argentiferous veins and the lack of funds to upgrade the exploiting methods, the mining industry in Sardinia was progressively decaying, feeding the abandonment issue of Sardinian mines. In 1456 the State Council opted for the continuation of excavations in Iglesias[10]but the economic and commercial destiny of Sardinia was intended gradually to deteriorate because of social and political changes of those years: the union of the crowns of Aragon and Castile changed the interest in the island, since the trades in India and the discovery of America with its mineral deposits meant the end of the trade of metals in the Mediterranean.

Until the Seventeenth century the mines were still considered a property of the State, which allowed the exploitation after a fee for a number of years. The referent was the Real Prosecutor and his deputies, who took care of putting them on sale and monitoring all the matters between the *arrendatori*, i.e. the tenants, and the workers. Date back to those years the concessions to Alagon family in Trexenta and the San Giovanni mine in 1550 and finally in 1557 all the mines were rent to the Florentine Francesco Tusci[11].

In the early Seventeenth century there were again reports of mining concessions on the island, most notably that of 1603 granted to Soler for the mines of Iglesias and Barbagia, one of the 1614 to Martino Esquirro for mines in Oristano and in Teulada, those relating to iron mines in Arzana and finally those of Gerrei, Sarrabus and Sulcis in the years between 1622 and 1629[12].

At this time, the words *montepaone* and *Monte de Ponis* – the current Monteponi – can be collocated in the documents stored in the National Archive of Cagliari, cited by Sella in its report[13].

[8] Ibid., p. 172.
[9] Ibid., p. 172-173.
[10] Manconi, F. *Quintino Sella. Sulle condizioni dell'Industria mineraria in Sardegna*. Nuoro: Ilisso, 1999, p. 56.
[11] Ibid., p. 59.
[12] Ibid., p. 59.
[13] Ibid., p. 60.

The last fifty years of the Seventeenth century, however, narrated a progressive crisis in the mining industry and the attempt to curb it with a single concession for all the mines to a single tenant; in 1642, for 40 years the entire industry was granted to Bernardo Tolo Pirella and Nicholas of Nurra, only followed by the license of equal duration to Michele Olives by Charles II[14].

*The Savoy period*

In the early Eighteenth century the Sardinian political situation changed following the London Treaties in 1718 and The Hague in1720, for which it went to Vittorio Amedeo II of Savoy who aggregated the hereditary States of the House, formed by the Principality of Piedmont and from the Duchy of Savoy. The London Convention guaranteed to Sardinia its autonomy and the preservation of its laws, rights, privileges and customs: *it became a composed State, formed by the union of several members, which kept each one's quality of States, but without constituting a new subject superior to them, a new State*. "[15]

The control of the island was entrusted to the Viceroy as a general intendant, to whom also belonged the financial administration and the mines. The latter continued to be regarded as property of the state and – only one year after the signing of the Treaties – they were all licensed to the *Nieddu & Durante* Company for twenty years in return for a fifth of the obtained incomes.

In 1736 the Englishman Charles Brander turned to the Ambassador of Sardinia in Paris to get an equal concession for a number of years, while the Consul of France Paget in Cagliari pleaded the cause of Brander at the Viceroy Count Rivarolo. Eventually the Sardinian Government, given the favourable impressions expressed by the general intendant, granted Brander a thirty year concession of the Sardinian mines since 1741[16]. He formed a company with the German Carl Holtzendorff and the Swedish Consul in Cagliari, Carl Gustav Mandel, who had the supreme direction of the licensed mines. Mandel, an expert of the thriving Scandinavian mining industry, began the building of a foundry in Villacidro near the Eleni creek and invited Christian Bösen of Hildesheim to direct the work as an inspector and head of foundries. Bosen's task was also to train, along with fifty German miners he had with him, the Sardinian miners to use gunpowder to resume work in San Vittorio in Monteponi. This mine had been abandoned during the Spanish reign and it was run again with the explosives in 1744 by Pietro Diana, instructed by Mandel to resume the works in that region.
Soon due to the poor results obtained with the search for new deposits and the failed attempts to extract copper, Mandel was dismissed by the General stewards despite the observed benefit that the recovery of ancient fields and the digging of new shafts had brought to the inhabitants of the affected areas, as reported by the Sella[17]. In addition to the use of local miners which have become experts, the galena businesses to Genoa and Livorno became quite prosperous

[14] See: De Launay, M. Minière de l'Histoire en Sardaigne industries. In *Annales des Mines*, Series 9, 1892 Volume I, p. 528.
See: Manconi, F. *Quintino Sella. Sulle condizioni dell'Industria mineraria in Sardegna*. Nuoro: Ilisso, 1999, p. 60.
[15] Casula, F. C. *Breve Storia di Sardegna*. Sassari: Carlo Delfino, 1992, p 187.
[16] Manconi, F. *Quintino Sella. Sulle condizioni dell'Industria mineraria in Sardegna*. Nuoro: Ilisso, p. 61.
[17] Ibid., 1999, p 63.

and the lead was sold in good quantities at the Royal Arsenal in Turin and the Direction of the Duane to Cagliari.
The bitter and ongoing litigation in 1758 cost Mandel his concessions and, despite the appeal filed at the time of his death in 1759, the business was passed to the officer Vincenzo Mameli[18]who ruled it until 1762, when the foundry was seized and administered by a government commissioner. In 1769 all the mines were entrusted artillery officer Peter Belly, who had been trained in mining and mining in German schools. Belly continued the works on the Montevecchio vein, by melting the minerals in Villacidro, and reactivated even extractions Monteponi taking an idea of the Roman predecessors to employ convicts and forced into mining operations. The idea was not so happy clearly because the convicts coming from Villafranca penal colony[19], they had to be accommodated in the city of Iglesias and escorted all the days until the mine with a considerable waste of time and money for the payment of the watchers. Not even the realization of a life sentence in September near the San Vittorio was able to raise the budgets of the firm, which then suffered a much higher cost of revenues as hoped by Belly.

Meanwhile other interested investors obtained concessions for the exploitation of Sardinian mines: the Earl of Castillo, in partnership with local Sardinian and continental partners, got the plombiferous mines in Sarrabus and those of iron in Arzana, which could produce sufficient quantities for export. Fate, however, wanted the smelter for the treatment of the iron was arise in such an unhealthy locationthat most of the Piedmont workers died there and ironworks lasted no more than six months; this was added to the bad fate of some employees who swindled the firm itself and brought it to bankruptcy in 1770.
In a few years another fact contributed to worsening the situation of the Sardinian mines: the discovery of antimony in Macomer, in Mandas and Ballao did deceive that it can overcome the Hungarian competition for the supply of antimony to Spain, France and Italy. Inevitably, their expectations were dashed, throwing into turmoil the administrators of the mines and the same Belly had to admit failure in 1782 to the local General Administrator in Cagliari[20].
In the last decades of the Eighteenth century the mines were not audited by the State Government interest, mainly because of the Napoleonic riots that shook the European dynasties and so it was no surprise that in 1797 the Villacidro smelters were closed and that the Monteponi mine could been made to know the meagre figures.

*En ce qui concerne les mines, nous avons seulement à signaler, en 1741, un acte de concession générale pour trente ans en faveur d'une société juive représentée par un certain Carlo Gustavo Mandell, mais avec de telles conditions et de telles exigences religieuses, qu'on seborna à extraire un peu de minerai de Montevecchio (8.700 tonnes de galène, de 1751 à 1758).*
*Aussi, lorsqu'au début de ce siècle le général la Marmora, qui devait tant faire pour la Sardaigne, commença à découvrir ce pays ignoré, ne put-il donner, dans les deux premières parties de sa description de file, qu'une*

[18] Ottelli, L. *Monteponi. (Iglesias – Sardegna) Storia di eventi e di uomini di una grande miniera*. Sassari: Carlo Delfino Ed., 2010, p. 105.
[19] Manconi, F. *Quintino Sella. Sulle condizioni dell'Industria mineraria in Sardegna*. Nuoro: Ilisso, 1999, p. 64.
[20] Ibid., p. 65.

*assez courte mention à l'industrie minière. Seule, lamine de Monteponi, reprise en 1791, vivait tant bien que mal entre les mains de l'État ; de 1832 à 1838, elle occupait80 personnes et parvint à fournir en tout 250.000 fr.de plomb. Quant à la riche mine de Montevecchio qui a produit des millions depuis cinquante ans, l'inspecteur général savoyard Despine déclarait qu'elle ne valait pas la peine d'être travaillée*[21].

*The Nineteenth century*

In 1803 superintendent the Chevalier Vichard de Saint Real was appointed as General Manager and he entrusted the thirty – year concession of all the mines to Earl Eduardo Vargas Kiel, head of a company also made by Baron Schubart, Samuele Molco[22] and Giuseppe Maria Serra. The fate for this company was short and unhappy despite the initial enthusiasm also honoured by the visit of Queen Maria Teresa in Monteponi and the continuation of the excavations in San Vittorio and in Saint Real regions with new tunnels: in 1809 in fact the lack of revenue and irresponsible handling of the work led to the failure and to the ending of the concession by the Government.

The next two decades showed no new interests for the Sardinian mines and the few concessions demanded to the Government resulted in the ruin of the reckless dealers. In Monteponi the only activity was a modest extraction of minerals, partially processed in Villacidro and in a small washery erected in Domusnovas.

In the same years the Inspector Carlo Maria Despine was commissioned by the King Carlo Felice of Savoy to act as a Director of the Savoy Royal Mines and Foundries, to draw up a report on the Sardinian mines. Despine examined the situation and proposed in 1829 the engineer Francesco Mameli[23]as a supervisor to investigate the potential and the convenience of the resumption of mining works. Among Mameli's first operations there was the realization of a laboratory in Cagliari and he studied the previous conditions of Sardinian mines, in particular that of Monteponi. This was still managed by the State but in a smaller scale and under Mameli's

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[21] De Launay, M. Minière de l'Histoire en Sardaigne industries. In *Annales des Mines*, Series 9, 1892 Volume I, pp. 529-530.

[22] Minister of Denmark in Florence; Director of the Royal foundry of Pisa. In Sella Q. *Sulle condizioni dell'Industria mineraria in Sardegna*, p. 66.

[23] Engineer in the actual body of the native island's mines, until 1826 which had been demanded to Fulfill his mineralogical studies in Moutiers. There, between the mines and Pesey Macot and the foundry of the Savoy Albertville Government it had set-up a mining school, designed to Provide the subalpine kingdom of mineralogical engineers, of which it lacked for mines of Savoy, Piedmont and Sardinia. See: Manconi, F. *Quintino Sella. Sulle condizioni dell'Industria mineraria in Sardegna*. Nuoro: Ilisso, 1999, p. 67.

Francesco Mameli fell out of favour with the King for his liberal ideas. Graced by Carlo Felice in 1829 he completed his engineering studies at the mining school of Moutiers, and immediately he was sent to Sardinia in finding mission, excellent work documented in a still appreciated today's report. Mameli's work, aimed to "lush flourishing Sardinian mining industry", wanted to return to the private with appropriate safeguards and control by the State. It was hindered by bureaucrats and died without seeing fulfilled his dream in 1847. See: Manis, F. La Sardegna è terra di pastori, contadini e minatori. Breve storia del Piombo, dell'Argento e dello Zinco. In AMiMe Associazione Minatori e Memoria (eds.). *Sardegna*: *Minatori e memorie*. Cagliari: Arti Grafiche Pisano, 2008, p. 20.

supervision the activities in the San Vittorio and Saint Real regions were restarted and new tunnels were dug: the *Despine*, the *Delaunay* and *Gastaldi*, linking them to the earlier ones.
The happy reality of Monteponi however was contrasting with that of other Sardinian mines, mostly devoid of dealers. On October 22th 1836 new concessions of metalliferous mines were banned to private companies with renewable license to explore for six months and revocable only in case of abandonment of work for more than a year. The limits granted an area of 100 by 20 meters and it was to be paid a fee of maximum 5% on the value of mineral products.

*The perfect fusion.*

The administrative and political situation of Sardinia from the early Nineteenth century is marked by an important legislative event, namely the Edict of 1807 which established the prefectures and actually increased control over the territory by the Savoy State. Already with the abolition of the feudal judicial power and the increase of the central government on the Island in 1771[24]with the establishment of communication tips, the Kingdom of Piedmont had strengthened the protection of its interests in Sardinia.
After 1807 the Island was divided into 15 provinces, each of which was headed by a prefect with administrative, financial and tax functions and monitoring of health and municipal decisions. The next step for the legislative reorganization of Sardinia by the Savoy takes place with the promulgation of the Feliciano code in 1827, which systematically collected the current regulations in the Kingdom and deleted definitely the previous *Carta de Logu* of Judicial Institution and the Spanish derivation procedures, unless those expressly maintained in the legal text[25].
Twenty years later it performs the actual act of political, administrative and legal unification of the island with Piedmont States, in the spirit of the growing ideals of the Risorgimento. Sardinia is so plagued by broad patriotic and liberal movement in order to obtain economic, social and political reforms by absolute monarchies, which is generally reflected in public dominion and culminated in 1847 with the *Perfect Fusion* with the Member of the Mainland. Carlo Alberto announced that year the end of the Kingdom of Sardinia and of the *Feliciano Code*, giving the Island the Savoy Statute and the opportunity to participate in the meetings of the sub–Alpine Parliament.[26]

The *Perfect Fusion* with the other territories of the Kingdom of Savoy also allowed Sardinia to benefit from the Mining Law of 1840, which had important effects on the future of the Sardinian mines: first and foremost, it distinguishes the attitude of metal ores, fossil fuels or from the fields of stone materials used for building or ornament[27], which belonged to the owner of the land on which they are located and who can use them at its discretion. For the first, instead, it splits – as

[24] See: L'età dei Savoia (1720 – 1847). In Brigaglia, M. (ed). *La Storia della Sardegna*. Cagliari: Edizioni della Torre, 1982, pp. 77-78.

[25] See: Passano, M. Passano, M. La legislazione. In Brigaglia, M. (ed). *Storia della Sardegna*. Cagliari: edizioni della Torre, 1982, p. 150.

[26] See: Ortu, G. G. T L'Ottocento: la "grande trasformazione". In Brigaglia, M., Mastino, A., Ortu, G. G. (eds). *Storia della Sardegna 2: Dal Settecento a oggi*. Bari: Laterza, 2006, pp. 52 - 54.

[27] Manconi, F. *Quintino Sella. Sulle condizioni dell'Industria mineraria in Sardegna*. Nuoro: Ilisso, 1999, p. 69.

happened under the Spanish rule – the properties of soil from the ground and therefore the mines, which were arranged by sovereign concession and were the only ones to be recognized as exploitable by the law. Searches could be conducted by anyone who enjoyed the permission of the Prefect of the provinces and the consent of the land owner, which can be solved if there are no reasonable grounds to refuse[28].

If the research work showed the actual existence of the deposit it proceeds to the mining engineer of that district to certify the extent and to declare the mine as licensable, with priority concession for the discoverer. The extension of the lot was very large and allowed to include a large proportion of useful strands as reported by the same Sella[29]:

*This limit is very large, being able to comprise an area of 400 hectares, equivalent to a square of side 2 Kilometers, and so it comprises an expanse of strands or well enough layers to a large and regular processing. [...] The license is perpetual and non–divisible, subject to consent of the Government. It may be revoked if the works have been abandoned for two years, except in cases of force majeure.*

A law of this kind opened a real race to the grant, since the extensions were large and allowed the dealer to proceed with peace and security in the works since it was not to clash with the owners of the property. On the other side they had reached a situation such that the richest deposits were fleeced of the material up to the most accessible parts with non – advanced techniques and it was therefore essential to produce new means and new techniques for digging large pits, with downward galleries and deep vertical shafts, which were fruitful only when performed on a large scale.

*The new concessions.*

Already in 1848, the Montevecchio mines was granted by Royal Decree to Antonio Sanna, captain of Genoese namesake company, established with a capital of 600,000 lire[30] and a very large extent.
In 1851 the Union Society, from Genoa, was granted four plombiferous mines including three in Sarrabus and one in south of Iglesias. The following year a mine of lignite in Gonnesa was licensed to the Sardinian Company *Timon–Varsi* and similar to the Tirsi–Po Company. In 1854 increasingly close to Iglesias were given two iron ore deposits to Raffaele Issel, who then passed to the *San Leone* Company of the *Pétin–Gaudet*[31]; in the same year a Genoese company took possession of the copper deposits of Tertenia and moreover other mines in the years went to various Ligurian companiesthatseemed interested in investing in the Sardinian mines.

[28] *Research by mines can be by anyone, provided he has given permission steward's (now prefect) of the provinces. It requires the consent of the land owner; However, if this consent is denied without reasonable grounds, it is otherwise in the steward's right to grant permission to research. See:* Manconi, F. *Quintino Sella. Sulle condizioni dell'Industria mineraria in Sardegna*. Nuoro: Ilisso, 1999, p. 70.
[29] Ibid., p. 70.
[30] Ibid., p. 71.
[31] Ibid., p. 71.

Monteponi's lead mines in Iglesias, active since 1832 on behalf of the government, failed to achieve excellent results because of the slowness and backwardness of extraction techniques, as well as the resentment of years of mismanagement. Fortunately, in 1850, after being granted by the Monteponi Company for a period of thirty years, the fate of the mines took a favourable direction and the new management restarted the excavations, which produced more than 100,000 tons of galena per year against maximum 10 thousand achieved in previous years, with a value of over 2 million.

The benefits of the new legislative framework on mining matters were the driving force in Sardinia that launched the race to the grant: first and foremost was Giovanni Antonio Sanna from Sassari, suggested by Mameli, got in perpetuity in 1848 the Montevecchio field. This began to pay off already after the first year of exploitation, convincing so many Italian and foreign companies to invest in the Sardinian mineral. In addition to Nicolay, who in Genoa founded the Monteponi Company and obtained the Iglesias concession mines, it should be also remembered the concessions of the Rosas mine, Marco Calvo in *Gennamari* and *Ingurtosu* in 1853 and the *Societée Civil des Mines*that took over in 1855, *Masua* and *Palmari*, the *Fortuna* Company in *Planu Sartu* and Malfidano in 1852that soon left the place to the *Société Civile des Mines de Malfidano*, which became later *Anonymes*. In 1857 the exploration license for the mines of Masua passed to the *Anonymous Society of Montesanto Mines*. With the discovery of deposits of calamine, a mineral that until then had never been mined, in Planu Sartu in 1864 by Johan Eyquem a real "Zinc fever" snapped, which called in Sardinia experienced engineers who had studied at the *Ecole des Mines de Paris* and had experience in the fields of South Africa[32].
Even the attention of the central organs of the State addressed the Sardinian mining, which despite the great innovations and discoveries made in less than twenty years suffered from tare condition intrinsic to the Island and backwardness in the development and in an overall growth. The envoy of the Government, the Minister Quintino Sella, made his inspection trip in 1869 and in 1871 published the results of his work in a parliamentary report which played a key role in the taking of measures and interests with regard to the infrastructure development of the Island.
In a few years the School for Head Miners Iglesias arose and in 1872 the Mining District was moved from Cagliari to Iglesias, which had become the leading centre of mining industry.
The development of the mechanical washing plants, which replaced those with hand – sorting and processing of minerals saw a real scientific and technological application to mining operations, by creating hydro – gravimetric washeries, enrichment plants, dewatering systems of water boilers and steam pumps, electrical energy for feeding the plants.
Towards the end of the Nineteenth century, however, the crisis of the lead and zinc market – suffering from the meddling of foreign products from North Africa or from Eastern countries – led to the decision to bring together engineers and Industrialists and investors of the mines sardines in an association with headquarters in Iglesias, the Sardinian Mining Association, founded in 1896 and presided by the Chevalier Giorgio Asproni; among the members in those

[32] Manis, F. La Sardegna è terra di pastori, contadini e minatori. Breve storia del Piombo, dell'Argento e dello Zinco. In AMiMe Associazione Minatori e Memoria (eds.). *Sardegna*: *Minatori e memorie*. Cagliari: Arti Grafiche Pisano, 2008, p. 22.

years includes the Engineer Erminio Ferraris, Gustavo and Umberto Cappa of the firm *Vieille Montagne* and the *Nebida* Company, Roberto Cattaneo CEO of the Monteponi Company, Mezzena Director of the *Malfidano* Company, Edoardo Sanna Director of the Gennarnari Ingurtosu Mines, etc.

*The Mining Law of 1859.*

After the annexation of Lombardy to the Kingdom of Italy in 1859, it was passed a decree which established a new mining law to reform the previous law of 1840. In it is mostly defined the concept of the exploration permit, the right of first refusal on by giving the discoverer of the field and the limits of the order granting prevent damage and disputes. Two measures were introduced to facilitate the mining activities, in particular: the right to passage with tunnels or other works for the drainage of groundwater and the creation of ventilation channels of the same; the possibility of forming consortia of dealers nearby mines or contiguous to perform common works for the purposes of safety and preservation of the mines. A further important factor in the upward flight of the Sardinian mines was the interest addressed by the government – and the Minister Désambrois in particular – to the importance of education and training of engineers who were studying at Italian universities, translated into practice in the participating schools and major foreign laboratories in order to learn the techniques and the latest knowledge in the field of construction and infrastructure. In his parliamentary report[33] Sella cites a number of works whose merit is precisely to national engineers that contributed to their design, including the railway Torino–Genoa, locomotives for the Giovi[34], the Cenis tunnel and aqueduct of Cagliari.

*New mines and new foundries*.

The promulgation of the new law gave start to a number of concessions on the Island, which passed quickly from a few to about 300 in 1870[35] and that affected Genoese companies but also French, German, Belgian and British and are reported in the Island papers written by Alberto La Marmora following his trip to Sardinia[36]. The quality of the work in the mines was much modernized: the ability of engineers coming out of the mining engineering schools or military schools was reflected in the large downside galleries, colossal shafts, at high power steam engines, in mechanical washeries implanted for sorting and enriching the raw ores extracted from the mines.

With the discovery of deposits of calamine to the production of lead was added that of zinc leading metal businesses to flourish, following the progressive decline of production in similar mines of Rhenish Prussia and Belgium, the repute until a short time before was not taken into consideration because of too high costs for extraction and transport in comparison to the extractable amount.

[33] Ibid., p. 73.
[34] Ibid., p. 73.
[35] Ibid., p.76.
[36] Ferrero della Marmora, A. *Viaggio in Sardegna*. Cagliari: edizioni della Fondazione Il Nuraghe, 1926.

After the extraction of the zinc smelting operations were mostly carried out abroad – in England, Prussia and Belgium – for lack of suitable fuel, while the lead was led to the Pertusola foundry both in La Spezia, in France, Belgium and England. With the growth of production, however, it became more and more evident the need to treat and melt at least a part of the production of lead and zinc and to obviate the transport in existing foundries exploited the abundance of local coal and imported for feeding two new foundries: the first in 1859 in Domusnovas, Fluminimaggiore then finally being reactivated to Villacidro. In these foundries also they treated the inert slag left in ancient times and still so rich in lead and silver to the point that it deserves to be unsorted with the most modern techniques. After finishing the waste to be treated, minerals of second and third quality were fused, particularly in Domusnovas, and later there were erected three new smelters, respectively in Cagliari, Masua and Fontanamare, where the silver–lead ores were then sent to Genoa or France for refining. The same fate touched the iron ores produced in San Leone near Capoterra, which were sent to the French foundries passing through the railway from the mines led to the Gulf of Cagliari.

Poor results occurred instead in the copper mines in Tertenia and Barisonis, antimony and manganese in Villasalto, Bosa and the Island of San Pietro.[37]

Best was instead the production of lignite in Gonnesa, subject of three concessions and mostly used to feed the boilers of extraction, but were beaten by the foreign competition because of its cost.

*Mineral Transport.*

The mineral transport to commercial ports for export and import of foodstuffs and basic necessities to be conducted in the mine was long linked to the availability of the surrounding countries of the mining sites and made by wagons to oxen or horses on existing roads or *ad hoc* created by the companies themselves. This is the case of the road from Monteponi mine that connected it to Fontanamare and its warehouses on the west coast, to board the ores by sailboats, called *bilancelle*, in the direction of Carloforte: here they were then exported on merchant ships. The Montevecchio instead exploited the harbour and Cagliari harbour for export.
For rail transport we have to wait until the construction of the 15 km long railway line "Monteponi–Portovesme", which allowed it both to send to the port of loading the minerals to be sold and to carry equipment and goods to Monteponi Scalo, from which they were sent to the main level of the mine through the inclined plane.

*Effects of the Risorgimento of the mining industry on the Island.*

The effect of such a lively and active industrial awakening happened in the twenty years between 1850 and 1870 hit the Sardinian reality in many ways. In addition to the investments in the economy of the towns and villages affected by the mining companies' businesses, trade in commodities, rentals and fees to Landowners etc., we assisted to a rational and deep

[37] Manconi, F. *Quintino Sella. Sulle condizioni dell'Industria mineraria in Sardegna*. Nuoro: Ilisso, 1999, p. 77.

infrastructure of the Sardinian territory, which previously did not offer a good quality of territorial connections, especially in the inner regions that featured predominantly a rural and agricultural setting. The creation of roads, constructions, housing and services was therefore a factor of growth and development that helped numerous satellite towns of the mining sites or the existing ones to grow. The arrival of foreign goods and personalities connected two worlds that had remained long distant or at least in a position of subordination or domination by States, Kingdoms or aristocrats who had exploited the Sardinian resources in their consumption. The privatization of the mines had instead called scientific personalities, academic and political, instructors and experts in the mining field which certainly brought to Sardinia a cultural contribution and far–reaching education, in addition to the technological contributions and technical knowledge, where they found a fertile field of application. The urban and rural transformations were important and obvious: as told by Sella in his report "*those metalliferous countries began to suffer a very visible transformation. Who in 1850 had to travel for days on horseback with hardship days, may encounter a real desert just covered with stains, no house, even rustic, and was forced to go with them food supplies, even for the horses. Now he can go from Sulcis Iglesias, Flumini, Arbus, Guspini and along the sea coast for very smooth roads. Popular homes, warehouses, washing plants and other plants begin to impress upon the appearance of an industrial country, which, in the absence of products due to a not easy cultivable soil, makes up the art applied to the extraction of minerals*[38]"
Mining villages, workers' houses, hospitals, kilns, ovens and services sprang up around the mouths mines, thus increasing the flow of traffic, people and products also thanks to the modernization of transport systems and to the economic incomes for the State due to the rents of mining companies, the duties and export taxes.

*The mines in the Twentieth century*

In 1901 Sardinia, in the field of zinc, was able to increase the revenues of the produced materials. It should be noted that in Sardinia zinc production was boosted by the great impetus given to the cultivation of blende, whose deposits had a great potential, but even more because the mechanical preparation for the enrichment of the blende was finalized. We can deduce that the *sphalerite* had to confront the decrease in production of calamine.
The periods between the start of the new century and the World Wars irrevocably marked the crisis of the mining industry, from regional to world scale. The oscillatory behaviour in metal prices, the increase in energy costs, the difficulties of transport, the decline of labour due to conscription, rationing and wartime embargoes led to a gradual closure or dismantling of numerous Sardinians plants. Only the period of the First World War marked a positive step by creating the electrolytic plant in Monteponi, but it was troubled also by the frequent workers' struggles, the strikes and the continuous whipping of the metals market;
To overcome the current difficulties, the Sardinian mines joined in a procurement entity called Consortium of Mines of Iglesias, useful to find the few and scarce materials traceable in the markets, but it certainly was not able to revive the fortunes of the mines before the mining crisis that since 1918 decimated traffics and revenues.

[38] Ibid., p. 85.

The '20s were the last positive period for the Sardinian mining reality: on one hand there was the resumption of mining activities even under the pressure of the new-born fascist regime – which promoted the development and intensification of mining and metallurgical activities, to which it was added the industrial chemistry to boost the branch of metal works and alloys – but on the other the take–off of products on the market would be hard to arrive and they glimpsed the first positive changes only in 1926. The global crisis set off by the New York Stock Exchange in October 1929 did not spare the Sardinian mines, which lost in the lapse of a month a 20% of the price of their products[39]and in a year they reduced of 2000 the number of employees in the sector. The market for lead and zinc marked a loss of value on the world scenario and even the increase of production served to save the mines from bankruptcy: Argentiera, Arenas, Candiazzus, Crabulatzu, Malfidano, Nebida and S'acqua Bona had to close, while the Montevecchio – declared bankrupted – merged into the *Montevecchio Mining Limited Company*, which incorporated capitals of Monteponi and Montecatini Groups.
The gradual shutdown and dismantling of facilities that featured the reality of the Island from the '40s and'50s brought an end to the era of the glorious Sardinian Mining Industry with the consequent loss of most of the elements that featured the pioneering age of metallurgy in Sardinia. In Monteponi, with its infrastructure that since 1850 featured the landscape, we saw many private facilities and structures such as the railway, the inclined plane, the electrolysis and many of the existing washeries, which provided a good source of materials, to be sold as scrap iron or casting.
Monteponi's history, closely followed by the surviving Sardinian mines, finally ended in 1995 with the final shutdown of the plant and the total abandonment, with the consequent deterioration of its facilities.

[39] Ibid., p. 28.

### Appendix one: the Sardinian Judicates and the Pisan penetration

In the fall of 1015 one hundred Arab ships made its ominous appearance on the southern coast of Sardinia. One year later the Arab fleet was defeated in the waters of the port of Cagliari by the naval army of Pisa and Genoa, allied of Judicates[40] in the fighting of Arab expansionism, which as well as freeing the island from the Moors threat, they countersign the starting point of Tuscany Seigneury in Sardinia.

A century later a second Pisan expedition to the Island, to support and supply for the liberation of the Balearic Islands from the Arab occupation, proved as decisive in Pisa's expansionist ambitions in Sardinia since its influence extended over all the Judicates, excepted for the *arborense* one, avulse from of Pisa and Genoa control[41].

The final capitulation of the Judicates at the end accomplished in 1257 – after the alliance in 1256 between Chiano of Massa and Genoa for the control of Cagliari against that of Pisa with Gallura and Arborea judges – with the yield of the Genoese to Pisa in the clash of Santa Igia (near Cagliari) that decreed the abandonment of the town by the Ligurians and the permanent loss of the Judicature of Cagliari[42].

The territory of Cagliari was then dismantled by the new Pisan government, which reversed the administrative and legal setup and ratified the dissolution of the former Judicature of Cagliari: the eastern area was assigned to Giovanni Visconti, who already hold the Gallura; the central area until the lower Campidano went to William of Capraia; western area was up to the Donoratico family, which further divided it into sixth parts that comprised the Sulcis and Caputerra (assigned to Gherardo Donoratico) and the Sigerro (assigned to Ugolino della Gherardesca). The Municipality of Pisa instead hold the direct control of the city of Cagliari.

Meanwhile, the threat of an Aragon incursion for control of the territory became stronger after the secret agreements between Boniface VIII and James II of Aragon, who was appointed by the Pope "Perpetual Lord of the two islands"[43] in 1297, and therefore at the end of the Thirteenth century a Catalan – Aragon expedition was at the door.

*Villa di Chiesa: the "town of silver"*

The settlement of Villa di Chiesa by Ugolino della Gherardesca between 1257 (Battle of *Sant'Igia*) and 1272 (first mention of the city[44]) marked the beginning of the formation of a large medieval village where the demographic recovery was accompanied by the growing demand for agricultural and livestock products, followed by the reactivation of the activities in the mine near

[40] *For the Sardinian judges, lacking any defence on the sea, the Pisan military protection – well accepted or merely suffered – perhaps since the beginning propitiated by a gradual interweaving of exchange relationships and friendships with individual owners. A few years later Pisa begins to roll out the network of its economic and political interests also in the Judicate of Cagliari and Gallura.* See: Ortu, G. G. *La Sardegna dei Giudici*. Nuoro: Edizioni Il Maestrale, 2005, p. 64.

[41] See Ortu, G. G. 2006. I Giudicati: Storia Governo e Società. In Brigaglia, M., Mastino, A., Ortu, G. G. (eds). *Storia della Sardegna 1: dalle origini al Settecento*. Bari: Laterza, 2006, pp. 97-98.

[42] Ibid., p. 105.

[43] Ibid., p. 109.

[44] Ortu, G. G. *La Sardegna dei Giudici*. Nuoro: Edizioni Il Maestrale, 2005, p. 211.

the town for the extraction of argentiferous galena. The resumption of mining operations was an attractive target for non–Sardinian entrepreneurs, as evidenced by the news of a joint venture with Lucca, Genoa and German people in 1253 with the aim of reactivating the exploitation of argentiferous veins in Sardinia[45]. The prosperity derived from mining activities was also reflected in the urban connotation of Villa di Chiesa, with the construction of the Cathedral and numerous worship places, the defensive walls and the silver coins mint[46].

The will of the Donoratico family to empower the economic and military domination on Sigerro territory and that of Tuscan enterprises to take advantage of Iglesias strands became evident, resulting in a period of economic and civil growth perpetuated by Pisa and its families that control the Sardinian territory.
In the specific context of Villa di Chiesa, the Pisans therefore encouraged the resumption of Roman inspection pits and new tunnels were dug, plotted along the vertical area on top of the mine called *Cungiaus* in *Montepaone*[47], survived in part till nowadays.

With the fall of Ugolino in 1289, the town passed to the direct control of Pisa, which endowed it with a certain judicial autonomy and a statute, *The Breve di Villa di Chiesa*, which will remain in force until 1848. In those years the administration was entrusted to two Rectors appointed by the Municipality of Pisa, whose autonomy overwhelmed the castellans in Cagliari as decided by the Council of Elders of Pisa, which preferred to retain full control over the mining city of Iglesias by directly appointing the judges, the chancellors and the notaries to adjust the financial and economic activities.
Villa di Chiesa was configured at the beginning of the Fourteenth century as *the most populated city and the richest of the island, with one of the most dynamic territory, for the early people exemption from the chains of servitude*[48], as evidenced by the safeguard policies contained in the *Breve* for all those who live in the city and for the silversmiths, foreign or indigenous[49].

*The Pisan Breve on mining.*

The *Breve*, a true real mining code analogous to other ancient manuscripts such as the *Massa Marittima Code* stated the freedom to dig and search for any individual or company who should infer the presence of a mine, providing to observe any previously initiated excavations by others. There are no references about the soil ownership or the amount of compensation to the owners

[45] Ibid., p. 214.

[46] *"So again, they become masters of the country, the Pisans dismantled Iglesias and Domusnovas forts and fortified castles of the same valley, i.e. those of Gioiosa Guardia and Acquafredda, including that of farther Baratii. It is since then that the excavation of the mines in the region had a greater development; and It is more or less at the time that the establishment of a mint in Iglesias for the Municipality of Pisa can be established, from where they would exit those silver coins, which have become very rare today, posing on a line with an eagle written Federicus Imperator eagle, and on Facta Villa Ecclesiae pro Communi Pisano*". Longhi, M. G. (eds), Ferrero Della Marmora, A. *Itinerario nell'Isola di Sardegna*. Nuoro: Ilisso, 1997, p. 298.

[47] Ottelli L. *Monteponi. (Iglesias – Sardegna) Storia di eventi e di uomini di una grande miniera*. Sassari: Carlo Delfino Ed., 2010, p. 96.

[48] Ibid., p. 215.

[49] *Breve di Villa di Chiesa*, II, 45. Op. Cit. In Ortu, G. G. *La Sardegna dei Giudici*. Nuoro: Edizioni Il Maestrale, 2005, p. 215.

for inspection pits digging or for any damages caused by the miners, probably because most of the excavated land was fallow or under public domain. Mining activity passed from punishment for convicts and criminals to a work of a certain value, secured by a small allowance of actual crimes and privileges[50].

The main figures listed in the *Breve* included:

- *Masters of the mountains*[51] those who inspected the pits, mines and guarded on the mountains, punishing evildoers etc.
- *Masters of inspections pits*: they directed the work of mines and looked after the workers in the mine after working for five years.
- *Meters and weights of minerals*: employed to weight and measurement of the material respectively with the basket and municipal *statéa*[52].
- *Maestri "sminatori"* (Coppellatori): helpers, *tractori*, *guelchi*[53] employed in the foundries.

Thus, the precise definition and the rule in relation to labour legislation and the great proliferation of ancient excavations in southwest of Sardinia testify the importance and attention paid to the extraction activity, which was for a source of wealth and power all over the territory both in the whole island and in *Villa di Chiesa*. After the Aragon conquest and the end of the rule of Pisa*, the Breve* was approved and adopted by the Crown of Aragon in the person of King Alfonso in 1337 – when the city had already passed to the Catalan domain – because the monarchs of Aragon kept maintained and validated legislation codes as they had obtained by their predecessors before the conquest, thus confirming for the mines the special measures promulgated by the Thirteenth century by Pisa.

*Techniques for extraction and processing of mineral.*

During the domination of Pisa as well as in previous times, Sardinia was the goal of mining extractions primarily for its deposits of silver. The abundance of excavations and descendants wells along the metal–bearing vein is often cited by Sella[54]and also shown in Table A in his Parliamentary Report, where they are visible in the soil of Monteponi concession. In addition to them, the *Breve* also included spoils (wells), the channels (tunnels), the *dorgomene*[55]. In general the dugs had reached the depths of 50 meters due to the difficult digging conditions, the presence of groundwater and the lack of modern techniques, excepted for the use of fire[56] when

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[50] Manconi, F. *Quintino Sella. Sulle condizioni dell'Industria mineraria in Sardegna*. Nuoro: Ilisso, 1999, pp. 50-52.

[51] The director of a district mines in Germany is said *Bergmeister*, the mountain master. Ibid., 51.

[52] Measuring tools of the time.

[53] From Medieval Latin *guercus*, *wercuse* from German *Werk* work, opus. Manconi, F. *Quintino Sella. Sulle condizioni dell'Industria mineraria in Sardegna*. Nuoro: Ilisso, 1999, p. 52.

[54] Manconi, F. *Quintino Sella. Sulle condizioni dell'Industria mineraria in Sardegna*. Nuoro: Ilisso, 1999.

[55] Vesme considered them crosses, from the Germans *durchgehendei*. Ibid., p. 49.

[56] See: Ottelli, L. *Monteponi. (Iglesias – Sardegna) Storia di eventi e di uomini di una grande miniera*. Sassari: Carlo Delfino Ed., 2010, p. 98.

they found hard rock called *monte sodo*[57]but in some cases, they reached a depth of 100 meters or even 200[58].

The ore, said vein, underwent a first operation in front of the forecourts pit, where it was crushed and washed with water jets, which required a continuous and effective channelling supply; then followed the foundry where the lead was obtained through the roasting of the ores and subsequently separating the lead from silver by means of a demining process. Finally, the graders had the task of weighing and assessing the silver obtained and then send it to the sale.

The ovens of minerals were made of refractory bricks, with a system for air insufflations actuated by bellows in turn moved by the water force, and they were exhaustively built outside the city walls. The same ores, excluding authorized exceptions, could not be conducted in the town[59]. Several washeries, foundries with roasting ovens and ovens were built in various places along the waterways, especially in Villamassargia, Domusnovas, Canonica, Grugua in the north of Iglesias and Fluminimaggiore, as testified by the plombiferious heaps of waste dating back to Pisa.

The silver was in part worked in the local mint, to produce the Pisan *minuti*, and partly exported from the port of Cagliari to continental markets. The traffic was interrupted in 1324, as the Aragon settled and silver was used to coin the *alfonsini*, i.e. the currency.

[57] Manconi, F. *Quintino Sella. Sulle condizioni dell'Industria mineraria in Sardegna*. Nuoro: Ilisso, 1999, p. 49.
[58] Ibid., 49-50.
[59] See: Simoncini S., S. Mezzolani. *Sardegna da salvare.* Nuoro: Stock Photo Sardo, 2007.

## The Monteponi Mine in the Sardinian mining "epopee" of the 1800s

### From the " Nicolay concession " to Julius Keller

The Monteponi mine has certainly distinguished itself in the Sardinian mining landscape, together with Montevecchio, for the successful administration and the technological advancement that distinguished the second half of the Nineteenth century. Unlike many others, it was the only one to remain active before liberalization promoted by the Mining Law of 1848, being managed on behalf of the Savoy State. Even its historical vicissitudes testify that its importance for the understanding of the mining industry is more than deserved.

Already we have previously spoken of the ancient past of the mines in Sardinia which, in Monteponi, featured precisely the digging of wells since the Roman and Pisan exploitations. The proliferation and development of these excavations are clearly indicated in the above mentioned table A by Quintino Sella, who identifies the "old wells" not only in the summit of *Cungiaus* – which was then at about 350 a.s.l.[60]– but also in the westernmost region and lower San Severino and east to San Vittorio areas and beyond. The presence of such a quantity of wells certainly testifies the vivid mining activity that was interested in the veins of silver galena outcropping on the surface and explored by ancient workers for depth of even one hundred meters in the vertical direction. Near the holes were also present wastes and processing residues that only with the modern technique of bursting the minerals in mechanical washeries were treated to recover the levels of lead still present.

If during the Spanish government and the beginning of the Savoy sensitive events cannot be registered in the mine – except for the exploration of San Vittorio and Saint Real regions and the excavation of Delaunay, Gastaldi and Despine galleries – the real turning point for Iglesias'mine arrives in 1850 with the establishment of the Monteponi Company by Paolo Antonio Nicolay from Genoa. The grant obtained from the Monteponi was thirty –year long and provided for an annual rent of a 32,000 lire the mineral area and the extension of 2 km of side of subterranean works, which is a 400 square hectares of surface.

Once established the new company, to Nicolay was evident the problem of the links for the transport of minerals and the accumulation of too many processing wastes in the vicinity of the mouths, due to the works in Saint Real, Despine and San Vittorio galleries. It still existed the building for life sentenced that, while handling Belly and Pietro Diana, had housed 200 employees forced to work in the mines. To improve the situation of road links between the mine and the coast, Nicolay did make a road passable by ox–drawn carts to transport the material to be shipped to Carloforte up to the warehouses, specifically built on the beach. The figure beside the President at that time was Giuseppe Galletti, first director of the mine from 1851 to 1852.

Early in the second half of the Nineteenth century, many experts, engineers and technicians came to Monteponi to study its mining potential both to resolve and implement the necessary

[60] Manconi, F. *Quintino Sella. Sulle condizioni dell'Industria mineraria in Sardegna*. Nuoro: Ilisso, 1999, p. 160.

technical processing and job management in order to make the mine a modern mineral factory. Among the most important there are certainly Julius Keller, Teodor Haupt and Johan Eyquem, who visited the mine proposing in their relations strategies to develop and improve the yield of the material: one of the suggested proposals was creating treatments for ores processing directly on site, where the material can be enriched and eventually melt. Even in the works of excavation incorrect procedures and beliefs had emerged, resulting in the yield in mineral not to its full potential since too much time was lost in the passages between the extraction from the rock and the still handmade - duct transport to the outside; the sterile material, moreover, was deposited in non-momentarily employed galleries with the consequent accumulation of slag that created confusion and hindrance in the work. At the decision to resume the activity in the gallery occupied by the scoria they had to spent additional time for the evacuation, at the expense of production. Keller's appointment as a director of the Monteponi was therefore a happy and guessed choice, given his critical observation and his training as an engineer: first he proceeded to detailed survey of mineral deposits and underground works, which until then were performed without precise topographical plan at an appropriate scale. Even the conduction of excavations in precise direction did not follow the vein, but it deviated by several meters from the best path, thus leaving the most distant galleries encumbered with sterile and with that part of the material containing lead that was not marketable for the lack of enrichment plants. Until then, in fact, it was only the removed material with at least 80% of lead that could be enriched with sorting by hand once outside.

Even for internal transport Keller opted for the modernization of galleries and the speeding up of the passages, by installing the rails with carriages to recover further quantities of mineral and avoid the bulk of aggregates inside the tunnels. For the treatment of that part of the mineral that was not treated due to lack of adequate washery, he made the first handmade washery realized right at the entrance of Saint Real tunnel below San Vittorio level.

In the mining management, Keller was also interested in the workers' accommodation by proposing the construction of a block of flats to house them and protect them from weather, an act that made him clash with the Direction, who was more interested in profits than investment in favour of workers. To overpass this problem, however, it was adapted the building of the former life sentenced in lodging for the two yards of San Vittorio and Saint Real miners.

Keller's proposal went beyond the modernization of yards and suggested the construction of a lead smelter that would allow him to recover large quantities of product so far left as inert: the first option was to build the facility on Island of San Pietro in *Giunco* area, till then left as bulk, but it was later converted into the proposal to realize at Monteponi itself, to reduce transportation costs. Despite the foresight by which Keller perceived the mine situation, according the Company's point of view his proposals might be too hazardous and futuristic for that time and even the promise of huge revenues from direct trade date of the finished product was sufficient to follow his advice. His too ground-breaking ideas ended up costing Keller the direction because of continuing differences of opinion with the Presidency, but allowed him on the other hand to be able to continue his work as a consultant for other mining Companies and to share a business with Angelo Nobilioni, from Iglesias, with whom he built a washery in

*Fontana Coperta*, near Gonnesa, to treat minerals from Monteponi. Within a short time the Monteponi Company, which for a long period had denied Keller the further development of his ideas, ruled him out to buy the washery.

Before 1856 the most active galleries were*San Vittorio*, the *Despine* and *Delaunay*; during that year the Nicolay gallery was added and remained the main mining tunnel together with *Delaunay* and *Saint Real* until 1858. In later years, *Villamarina* Gallery started by Mameli and taken by the Company also reached the strands and soon, *San Severino* would be added to the major digging tunnels for the lead field.

### *The PellegriniEra*

Among the figures who most leadMonteponito a high technical, productive and infrastructural levelstands certainly the engineer Adolfo Pellegrini who assumed, at just 23 years, the direction of the mines in 1861. The technical and scientific expertise that characterized his work are still now a source of admiration and example of both Sardinian and ItalianNineteenth centuryconstructive and miningculture. Upon his arrival the mine could count on 1420 most continental mineworkers[61]and subject to frequent bouts of malaria, which cost in long delays in work and continuous breaks. Thanks to Keller'ssurveysworksfinally followed a horizontal direction with coherent the fields and it must be said that a rationalization of the excavations both in the tracks of the galleries and in the management of mineral heaps had been made. A new gallery was opened in San Severino area, which was soon marked by a yard with accommodation and washery. Meanwhile, as reported by the photographs of Monteponi in 1865, the building stock of the mine already had the *Delaunay* Hospital, built in the homonymous region, the houses in San Vittorio, the jail, the workshops, the building of the old Directorate and the *Cungiaus* area, still intact. A new gallery was started in *Villamarina* region and a dense maze of other excavations began to intersect almost all mountain areas thus increasing the galena production in a few years. The most important works completed under the direction of the "Illuminated" Eng. Pellegrini are the masterpieces of the extraction and dewatering of water shafts made in 1863: the first, Vittorio Emanuele Pit, was built to a design by Franz Stiglitz and Charles Marcellis[62]; the second, the Great Sella Pit, was built in 1875 always on a Stiglitz's project to accommodate the large water dewatering pumps, mechanical workshops, carpentry and the iron foundry: this building, impressive in its size and in its volumetric and architectonic articulation, is identified with the highest expression of architectural and constructive language, which, through the stylistic Eclecticism forms of the Eighteenth century, enhances the technical power and modern technology and structural approach, characterized in those years by the highest manifestations of engineering in the United Italy. In 1865 Pellegrini designed and built the building for the new direction headquarters, *Bellavista*, which was to host the mine's offices, along with the Manager's family. Just two years later another innovation interested the genius of Pellegrini and his collaborators: the cultivation of a

[61] Ottelli, L. *Monteponi. (Iglesias – Sardegna) Storia di eventi e di uomini di una grande miniera*. Sassari: Carlo Delfino Ed., 2010, p. 145.

[62] The drawings found in the ASCI report the projects by Franz Stiglitz and Charles Marcellis, dating 1869 and 1867. Source: ASCI, Fund MP - MV Case n. 108, inventories n. 1 – 66.

calamine field that was placed on top of the mountain in *Cungiaus* area, discovered by engineer Johan Eyquem. The discovery was of enormous importance for the fate of the mine because it allowed Pellegrini to add to the already produced amount of lead and silver galena a fair amount of zinc, mineral of which the calamine is made in the form of silicates and carbonates. For the cultivation of the deposit they created a huge excavation proceeded to a funnel, which in fact still configures the morphology of the area being a huge crater in the top. The extracted material, after a sorting to assess weight and volume, was treated in shaft kilns or calcination and roasted to enrich them in zinc content.

However, Pellegrini had to solve the problem of the new mineral transport and thus he acquired numerous and strong oxen wagons needed to get both within yards and to Fontanamare for boarding. The abundant production – about 18,000 tons / year – demanded increasingly large efforts to the organization of transport and ultimately led Pellegrini to the construction of the railway from Monteponi that would reach the coast for the final boarding to Carloforte. The landing point was Fontanamare anymore but the cheapest Porto Vesme, opposite to San Pietro island. The railroad began in 1871 over a distance of 21 km and it involved the use of locomotives of Canada Works, which came specifically for the purpose[63]. The first section between Porto Vesme and Gonnesa was built between 1871 and 1875 and in this past year it was added to the branch Gonnesa–Monteponi. The picture of the situation before and after the railway is made clear in an excellent way right from Sella in his parliamentary report when describing the hours of transport from the mine to Carloforte:

*Mineral Transport*

*The products of this mine [...] are shipped off the island, except for a few third qualities that give way to the nearby foundry of Domusnovas, as all the minerals of the west coast, they are sent first by ferries to Carloforte, where they then pass on transporting ships. The boarding on boats is in part held in Portoscuso, in part in Fontanamare, in which it is first transported by means of Sardinian oxen wagons or horse carts. [...] Very serious difficulties arose in recent years, given the poor condition of the road from Gonnesa to Portoscuso, which would be the most natural point of embarkation, so the company had to decide on its own to the construction of a 15 kilometres railroad from Gonnesa up to Portoscuso*[64].

*[...] As long as Monteponi's production was only 40 to 50,000 tons a year, it sent them to Fontanamare which is not far from the mine but roughly eight Kilometres. Therein, they were closed in warehouses built by the sea, and whenever the east wind blew the boats out from Carloforte in September and went to pick their cargo of galena. But sometimes it happened that whole months for this occasion did not show up, so the minerals were piled up, thus immobilising very heavy capital and making impossible the regularity of deliveries*[65].

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[63] Ottelli, L. *Monteponi. (Iglesias – Sardegna) Storia di eventi e di uomini di una grande miniera*. Sassari: Carlo Delfino Ed., 2010, p. 167.

[64] Manconi, F. *Quintino Sella. Sulle condizioni dell'Industria mineraria in Sardegna*. Nuoro: Ilisso, 1999, p. 292.

[65] Ibid., p. 171.

With the addition of calamine production, this scenario was no longer cost – effective or safe and they had to opt for an alternative solution. The port chosen was therefore further and more expensive but at least it avoided the stagnation periods due to adverse weather conditions to sail off.
Sella at this point cites one of the reasons for the construction of Monteponi's private railway, attributing the causes to the lack of road maintenance from Cagliari's province in that track way between Gonnesa and Portoscuso – whose defined conditions were disastrous and even barbaric[66]due to the passage of 400,000 tons of ores per year and the brittle substrate trachyte – and to the abandonment of the road by the Provincial Council once the national government had allocated funds to achieve it. Another reason was the uncertainty of terms in the works for the Iglesias–Cagliari railway with detriment to Monteponi Company until that it was more convenient establish their own railway rather than wait for the competition by the public one; of course it emerges from Sella words also the setback against Cagliari, which by its inadequacy, it would lose the benefits of the mineral traffic from the port of its own. The cost of the railway – which Sella identifies as completed by June 1871 – is estimated at one million lire.

*Monteponi Company is then building a narrow gauge railway of its unique property, which must link its mine at Iglesias to Porto Scuso, which stands on the west coast that is in the face of Carlo Forte in San Pietro island. Now indeed the main trunk from Gonnesato Porto Scuso is already working, or more rightly Porto Vesme, neighbouring point, and the present year, being works already very advanced, even the last trunk will be completed, thus joining Iglesias to the sea, and is undoubtable that the Company, by means of appropriate wages, will grant it to public use. In its entirely, this line will have a distance of 25 km*[67].

The railway construction was not an isolated episode in infrastructure and rationalization of mining transport: the level on which the Monteponi Scalo Train Station stood, +116 m above sea level, was in fact connected to the main mine Nicolay level to + 206 m a.s.l., by means of an inclined plane, which allowed to carry the ore on trolleys on rails to be loaded in Portovesme and to load foodstuffs and fuels from Bacu Abis, with which the machines were fed. The inclined plane, an engineering work of extraordinary beauty, overcame the road to Gonnesa by an arched bridge made of bricks and of which only one trace survived the demolition of the sixties of the last century.

[66] *But then it happened to repute you would say incredible, whether with colleagues in the Commission we had not checked on site. The provinces of Cagliari, which incurred after the construction done by the Government, had passed the maintenance of the road, he did nothing to keep it in good condition. I know that it is now found reduced in such a condition and the transportation is done in such a way so deplorable and so barbaric that those who saw it can only have an idea.[...] Of course the maintenance of a road for conveying 400,000 tons of hours per year is very expensive. [...] the greater part of this road is on trachytes, which is too brittle and easily decomposable material gravelling [...] But with all this we cannot hide the view That the Cagliari Provincial Council would badly provide, of not taking this road in good order. It's too painful sensation you feel When you see how, after requesting and requested the streets Government and then the streets, after the government, despite the critical state of the public finances, constructs, surrenders then a road because the maintenance costs too much, namely because it is very distressed, that is why it is very important*. Ibid., p. 172.

[67] Corbetta, C. *Sardegna e Corsica*. Milano: Libreria Editrice G. Brigola, 1877, p. 151.

Pellegrini in the meantime had decided to build a smelter for galena treatment and in agreement with Enrico Serpieri, first President of the Chamber of Commerce of Cagliari, he built it in 1867 in Domusnovas, in the vicinity of the smelter built by the same Serpieri for the treatment of smelting slag left by Pisan and Roman mines in the area of Iglesias.[68]

Pellegrini's work went on well and in the same year it created the 8km long aqueduct that from *Bellicai* carried fresh water for the mine, thus avoiding the transport of ox–drawn carts, passing inside the *Gastaldi* tunnel and coming out in the cistern that today stocks the wooden models nearby the *Delaunay* site.

The hard work of Pellegrini and his associates was rewarded by the visit in the late '60s of the Parliamentary Commission of Inquiry on mining conditions in Sardinia, which was followed in 1871 by the enthusiastic critical and objective albeit of Minister Quintino Sella's report, presented to the Chamber of Deputies in May. From the reading of the report it is revealed a precise description of the Sardinian mining situation and rich in historical details, social and economic factors that help the reader understand the changing environment of Sardinian mines and especially of Monteponi. For it is in fact devoted a long chapter in which Sella describes the mines operating conditions and maintenance, technical innovations and products of the process, with human, financial and social costs.

The aforementioned Table A of the Atlas accompanying the report also shows the whole building heritage at that time:

- Villamarina region had now built up with houses, services, crushing plant and washery near the entrance;
- The Manager's House, the *Bellavista* Building, built in 1865;
- the general store in Nicolay square, today seat of Mining Archive;
- The cistern which stocked models for the cast iron foundry;
- The Delaunay hospital;
- The Saint Real Washery, built in 1853 for the treatment of the lead ores from Saint Real and San Vittorio regions;
- Vittorio Emanuele Pit, in 1863;
- The areas of *Cungiaus* not yet affected by the calamine extraction works and propped from Roman and Pisan wells;
- the ovens in the calcinations sites, located in the north side of the mountain;
- the old gunpowder storage, dating back to the period of Vargas' or Mameli's management.

Among the buildings no longer existing, mentioned in the paper, there are:

- the yard of calamine calcination;
- the ancient prison built by Belly, which then housed the workers under Keller;

[68] Ottelli, L. *Monteponi. (Iglesias – Sardegna) Storia di eventi e di uomini di una grande miniera*. Sassari: Carlo Delfino Ed., 2010, p. 152.

- the Nicolay washery;
- the Villamarina washery;
- the armoury;
- the San Severino washery, with housing and namesake gallery;
- the guardian box system placed at the bifurcation between the main road for Gonnesa and the Nicolay road to Villamarina;
- the avenue leading to Villamarina from Iglesias town and which will later be modified and expanded with the building of the Twentieth century.

During the years 1863 – 1875 Pellegrini had to face another great complication due to the presence of a relevant quantity of groundwater in the galleries. We have already mentioned the completion of Vittorio Emanuele Pit, built in '63 and it started working in 1869, to accommodate the dewatering pumps. In addition, this building, placed at +206 m a.s.l., was chosen as the point of coordinates x = y = 0,00[69]for the quotation of the whole mine.

With new excavation works brought forward in plombiferous columns in 1865 the depth of +85 m above sea level had already been reached and then there were just 15 meters from the aquifer below[70]: therefore it was essential to prepare as soon as possible a new plant to keep dewatering the galleries. Having noted in fact the failure of the pumps in Vittorio Emanuele Pit, Pellegrini promoted the construction of a second pit, the Sella, which started working in 1874. The dewatering pumps were designed and imported from Belgium by the *Marcellis* Company. However, he soon realized that they were not powerful enough to effectively reduce the groundwater level. To overcome this problem, the water was carried through the pumps to the San Severino gallery, which was converted into a drainage tunnel and it was also connected to the *Giordano* level. Nonetheless, despite the efforts, the problem of underwater was still far from being solved.

At that time the external framework of the general situation and of the employed people is well described by Sella, who in 1869 indicates that the number of hired workers had increased, gathered in the case of mutual aid in cases of illness or injury; the Delaunay hospital housed 40 beds; the quarters for the workers who do not stay in Iglesias had sprung up inside the mine, as well as factories, washing plants, shafts and sorting areas to witness the enormous amount of money that the Company had invested to equip the mine facilities and roads.

In concluding Monteponi's framework, Quintino Sella widely praises the work of the Company and its directors, Vesme and Pellegrini in particular, for their technical competence, order and "*humanity for the worker*" to emphasize the advancement of mine as a true and right industrial centre. In conclusion, he makes an invitation to both to be responsible for the afforesting of the lands to be able to house the miners' families and to worry about the education of the population involved in the mine.[71]

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[69] Ibid., p. 162.
[70] Ibid., p. 162.
[71] Manconi, F. *Quintino Sella. Sulle condizioni dell'Industria mineraria in Sardegna*. Nuoro: Ilisso, 1999, p. 173.

*Ferraris' management*

After Pellegrini direction, which ended in 1875, another technician took over in Monteponi thanks to its forward–looking organizational skills and excellent engineering expertise: the engineer Erminio Ferraris. He first had to deal with the perennial problem of groundwater that his predecessor had completely failed to resolve despite the construction of Vittorio Emanuele and Sella pits.

First Ferraris presented to the Company a report which stood the difficulties to continue his work with the water level too unstable since "*[the water] appeared wherever those works had gone beyond this depth penetrating between the layers and occupying every empty space both natural and artificial. From the day this obstacle stepped to the normal development of the work of the mine, it was not possible to continue the regular exploration and the preparation of metallic clusters as you expect from a technically well administered mine*. "[72]

The solution proposed by Ferraris was to create an overboard discharge tunnels that would have minimized the lifting of water; if on one hand it might seem immensely costly and far–reaching, on the other it is configured as the only possible choice to not frustrate the presence of dewatering shafts and the resumption of work at levels below 70 meters.

The first step was to use the Vesme gallery instead of San Severino as a drainage, in order to lower the height of the pumping and to increase the range, passing thus from a level at 72 meters to 44 meters a.s.l.. The water, which flowed into the Scalo area, was carried in the San Giorgio creek and then conducted to the marsh *Sa Masa* near Fontanamare. The results, however, were not satisfactory because of the flow rate of the pumps installed in Sella pit and they opted for the construction of a drainage tunnel that departed from the sea level and ended below the Vittorio Emanuele pit.

The occasion of the construction of the drainage tunnel was for Monteponi a pretext for an agreement with the State for selling the mine to Monteponi Company due to the fact that the cost charges for the construction of the tunnel would be too high without being guaranteed to go on exploiting the mine for a sufficient amount of time.
The sale agreement was therefore signed in December 1879 and it fell to the Company the obligation to build the tunnel with approval of the Government, which held it in the public interest since it would be beneficial to most of the undertakings in the same metalliferous basin.

The design of the drainage gallery, named after the King Umberto I, provided for in the first instance to a development of 4'975 meters with a slope of one per thousand between Sella pit and the marsh *Sa Masa*, only to change in favour of the 5'750 meters long tunnel between Vittorio Emanuele Pit and the outlet to the sea; finally in 1880 the project was approved and implemented. The plan provided by Zoppi[73] illustrates how, as well as inlet and outlet, other

[72] Ferraris, E. *La questione delle acque nella miniera di Monteponi*. *Studi e proposte al Consiglio di Amministrazione*, ASCI 1876.

[73] Zoppi, G. *Memorie descrittive della carta geologica d'Italia. Vol IV. Descrizione geologico – mineraria dell'Iglesiente (Sardegna) e Atlante*. Roma: Tip. National Reggiani and Co., 1888.

intermediate shafts would be present – Baccarini pit and Cattaneo pit – to accelerate the excavating operations using mechanical drills; these latter, propelled with a modern compressed air system, were also awarded at the Universal Exhibition in Paris in 1878 and earned Erminio Ferraris an honourable mention[74].
During the excavation of the Baccarini pit it was employed for the first time the electric current by means of Siemens dynamos and since then it increased more and more the use of this innovative form of power.

Thanks to the dewatering gallery, after just five months the water level was lowered to + 26 m[75].

Ferraris' talent did not stop only on the issue of underwater but concentrated especially on the mineral processing and metallurgical question, already aimed by Julius Keller to achieve greater autonomy in the processing of finished products and their consequent trade. In fact the uncertainty of the markets and the costs for the construction of metallurgical plants had have repeatedly delayed the decision to undertake its construction and, in addition, also the type and quality of extracts had heavily influenced the decision: the conformation of minerals, little impurities and the type of rocks resulted in a difficult separation of inert in the manual washeries and in the mechanical one realized in Scalo.

For this reason, in 1879 Ferraris transformed the Vittorio Emanuele Washery, located in the proximity of Bellavista, in a mechanical washery for the treatment of plombiferous materials to derive the merchant galena. Another type was the Sacchi washery, located in the railway station area, to whichwas soon added Pilla washery, constituting the Sacchi & Pilla group for the treatment of the lead lands from San Marco area and other difficult separating materials. But the most important of all treatment plants was built only in 1887 with Calamine Washery for the treatment of calamines from *Cungiaus*, which had lower zinc contents and thus were hardly accruable by normal calcinating procedures. In this system Ferraris installed his most famous invention, the oscillating table, which earned him numerous awards, also in the technical literature of the time. The system worked for about fifty years, ensuring the Company's high zinc production. To complete the processing on calamines Ferraris designed, created and patented another solution for calamines containing iron oxides that were hardly separable from zinc: the magnetic washery, where the iron oxides were magnetized and separated by a magnetic sorter, invented by himself, which left the zinc free. The two washeries were made in the vicinity of Nicolay and Delaunay gallery, in order to be close enough both to the other workshops and to the inclined plane to carry minerals to the railway.

In 1893 the Sacchi & Pilla washery was modified and converted in the new Mameli washery. Meanwhile, two major bronze and cast iron foundries were built, in order to supply independently to the needs of sparing parts for the machinery using wooden moulds made in the carpentry and used for castings.

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[74] Ottelli, L. *Monteponi. (Iglesias – Sardegna) Storia di eventi e di uomini di una grande miniera*. Sassari: Carlo Delfino Ed., 2010, p. 183.
[75] Ibid., p. 185.

Ferraris' interest for metallurgy, driven by also Vesme until his death in 1877, continued tireless and culminated with the construction of the smelter for lead and silver, which finally saw the light in 1894near Vittorio Emanuele pit. The supply of building materials could be secured from *Doglio* workshops in Cagliari and Bacu Abis coal deposits. The foundry system therefore guaranteed continuous melting processes, refining, distillation and cupellation that allowed to obtain a finished product in 50 kg loaves, almost totally pure and directly marketable, as well as Julius Keller had proposed just forty years before. The conduit of the foundry fumes, today significantly degraded but still visible, climbed along San Vittorio entrance line and exploited whenever possible the old galleries, culminating in the summit with a tall chimney. The following year Ferraris bought the coal mine of *Terras Collu* connecting it with nearby mine of *Culmine*, whichwas already held in the concession and guaranteed to procure significant quantities of coal to power steam engines, as well as Pellegrini did with the lignite in Fontanamare.
With the coal from *Terras Collu* Ferraris could also feed already in 1899 the gas ovens of gas generators that assured to obtain supplies of substantial quantities of coal to power the steam engine.

The new century began with the participation of the Monteponi, the Montevecchio and the Malfidano Companies at the Universal Exhibition in Paris, where the Monteponi gained extensive praise and concerns by the whole of the industrial world, with particular attention for the machines patented by Ferraris.

In a few years the electrical current spreads in plants and metallurgical foundries and in 1906 the compressor room started working. Finally, in 1908 – 1909 the mammoth work of construction of the dewatering gallery – the Umberto I – finally came to reach Vittorio Emanuele pit, its final destination, lowering the groundwater level to only +13 m a.s.l. The gallery, as foreseen by the Government, led benefits to the other mines in the area such as Monte Agruxau, Nebida, Masua, Campo Pisano, San Giorgio, Cabitza, Seddas Moddizzis and San Giovanni.[76]

### *The Directorates under Sartori and Binetti*

In 1907 Ferraris left the direction, replaced by engineer Francesco Sartori who had come to Monteponi in 1899. The unfortunate period of the First World War marked the difficult years for Sartori, who had to deal with the crisis that hit the mining sector, but he still managed to focus on the metallurgy of lead and zinc by developing new plants in collaboration with the engineer Andrea Binetti. He had come to Monteponi in 1913 and he was responsible for the construction of a plant for the production of white zinc in Scalo region, which came into activity in 1914: the finished product, derived from the processing of poor in zinc minerals, contained a certain percentage of lead sulphate, which gave it excellent coating properties for coating the ships.

Also the Mameli washery was the subject of modernization thanks to a direct connecting bridge to level Giordano, designed by engineer Musio, and the construction of the cable car that put it in communication with the Scalo.

[76] Società di Monteponi (eds). Società di Monteponi 1850 – 1950. Turin: Tipografia Vincenzo Bona, 1950, p. 100.

In 1920 Andrea Binetti became the manager of the whole mine and he distinguished himself for choosing to entrust Livio Cambi, Professor at the University of Milan and industrial chemical expert, the construction of a colossal zinc electrolysis plant: the large complex surged over the former Vittorio Emanuele Washery and it was entrusted to Dr. Virginio Toia, future director of the mines in 1960s.

A year later the Company acquired the thermal power plant in Portovesme, which had been abandoned by the Sardinian Electric Company, to cope with the continuous energy needs of metallurgical plants and dewatering.

In 1928 Binetti built the sulphuric acid plant to supply to the electrolytic process recently activated: this facility was built in Scalo near the white zinc factory and the railway line.

From 1930s onwards in Monteponi sensitive innovations did not occur in the productive apparatus, except only for the *Galletti* facility built in 1961 for the treatment of calamine, although it was stopped after only one year of operation along with most of the washeries that had worked in the mine for more than a century. With the deep crisis that crossed the metals market and the period of the Second World War the Monteponi Company ceased to exist as in its original conformation of 1850, merging and joining several times with other mining companies to form a common front to soaring costs and the decline in metal prices; the history of the mine, rich in innovations and success gained in just seventy years, lapsed into an irreversible downward spiral in the early Sixties and saw the demolition, the selling and the dismantling of its facilities.

The building heritage in Monteponi

The buildings that make up the architectural heritage of Monteponi mine only partially survived intact to nowadays: some of the most important, which have already been listed in the historical context, are no longer existing, replaced by more modern facilities or demolished or fallen into a serious state of disrepair.

The oldest part built in Monteponi was located in San Vittorio and Saint Real regions, during Belly and Keller's control, and consisted of the prison, the old powder storeroom from Mameli period and the Saint Real washery, to which the housing block for the workers in San Vittorio was added at a later date. Of these only the washery in Saint Real still survives, however falling into private land and sloping in a series of degradation; the prison was converted into housing but is no longer existing.

The following description of Monteponi buildings, listed in chronological order of the various directors – given by the difficulty of direct retrieval of documentary sources and access – refers to the publication by Alfredo Ingegno, Lorenzo Ottelli and Salvatorico Serra entitled *Monteponi - Catalogue of Resources* and published by Ifras[77].

- Pellegrini's management

  - Delaunay Hospital

    Construction period: first half of the Nineteenth century.

    Function: the mine hospital, then the Delaunay archive.

    Project :?

    Located in an isolated and dominant position with respect to the complex of production facilities, the building stands out in the neighbourhood for the pinkish hue that Although faded, still characterizes the façades. The building is composed of a main body with a rectangular plan and rises in elevation on three floors, marked with stringourse bands and by an overhanging ledge below the cover.
    The south facing façade, corresponding to the long side, it is punctuated by the regular rhythm of voids arranged on seven axes of openings, some walled and others with remains of wooden frames. On the back and on the east side it is flanked by a second body, probably of relevance to a later period, with independent access by an elevated terrace and reachable through an external staircase.
    The construction is realized with elevated structures in bearing masonry stones and bricks, with plaster finishes. The cover is composed of two portions with double-

[77] The publication is available at the Tourist Office of the City of Iglesias. The Scientific Committee is composed of Alfredo Ingegno, Lorenzo Ottelli, Salvatorico Serra.

pitched roof, side by side with different heights, both with mantle of clay tiles. The interior of the building is not accessible.
Delaunay building is one of the oldest buildings of the entire mining compendium both antecedent to the ancient building of the Direction and to the *Bellavista* building. It was built in the mid-Nineteenth century and housed the old hospital of the mine. In lists of properties owned by the company Monteponi the good is called "ancient Hospital Warehouse Delaunay" and, after 1925, "former barracks." More recently, it was used as an archive of the mining company.
The building, while subject to different uses, has been preserved by maintaining the original appearance, as can be seen from the photo archive.
Although we can not access the inside of the building, it has been found to contain various types (delivery notes, documents, tables, etc.) and furniture (wardrobes, shelves).

- Old Direction

Period of construction: first half of the Nineteenth century.

Function: Directorate headquarters of the mines, then the chemical laboratory of the lead smelter.

Project :?

The building no longer has significant traces of the original configuration and use as an ancient "house of direction." Currently it is configured as a civil building featuring the '900 sober and linear characters with a compact volume, flanked by two laterally construction of lesser height line. It rises two floors on the street side and three on the side facing the foundry.
The supporting structure is made of masonry, with coverage carried by wooden trusses without struts and ceiling joists. The stairs that goes from ground level to the one below stand out on a rampant brick arch. On the main front there are five axes of openings, with a central entrance, equipped with wooden frames. The cover with a gabled roof is preceded by a crowning cornice which runs along the entire perimeter. The finishing of the exterior walls of masonry is made of "Terranova" cement plaster; the roof covering is made of clay tiles.
The chemical laboratory was built in 1894 - 1895 in conjunction with the start of the metallurgical cycle for the production of marketable lead, lead oxides, silver and metallic mercury. It was located on the ground floor of the building which then housed the "Direction of the Mines of Sardinia", immediately adjacent to the buildings of the Lead Foundry and Vittorio Emanuele Pit and held on analysis of foundry products and numerous washing plants, in addition to controls on water quality underground. In 1925, with the realization of the production of electrolytic zinc, the laboratory was transferred to local facing the latter plant.

- New Direction, the "*Bellavista*"

Period of construction: 1865

Function: Manager's House and Offices

Project: Adolfo Pellegrini

The building is located in a dominant position in the *Bellavista* square, surrounded on three sides by a garden on the east side and connected with a body perpendicular to the next epoch. The garden, dominated by specimens of palms belonging to the original building, houses the bronze bust of Erminio Ferraris and it retains the elegant railing on which there are two entrance gates.
Designed by engineer Adolfo Pellegrini, manager of the mine from 1861 to 1875, the building is the symbol of the start of the heroic period of the mining company. For the inherent requirement of representation that was to transmit, it was equipped with a solid and monumental appearance and Neoclassical stylistic references, which combined with architectural and decorative elements also dating back to later ages, to give typically Eclectic impression. The different transformations over time and linked to functional requirements have made changes and expansions in both the planimetric configuration in prospectuses and in coverage, as documented in archival images dating back to various eras. A first operation dating back to 1920s involved the expansion of the ground floor, with the addition of a body covered in terrace which occupied the space between the wings and several added volumes leaning against the right-side elevation, in correspondence with the new entrance, and on the back. Subsequently, the first floor terrace was covered by a roof in precarious material and the second floor was further covered by a terrace closed by an aluminium window and occupied at the lateral ends by two volumetric accretions. The roof has been rebuilt at least two occasions, with the appearance of a tower with battlements from which one could access the large terrace which was then covered by the roof.

The building, also equipped with underground premises, presents on the ground floor an almost rectangular plant and two upper floors (in addition to an attic), which compose the original "C" shaped plan, consisting of a rectangular with two lateral symmetrical wings. The façades on the long sides (north and south) have nine accesses and six openings in the lateral prospects; to the west, on the ground floor an arcade is accommodated marking the entrance.
The north façade has a symmetrical composition respect to the central axis and is tripartite in elevation with two lateral bodies advancing from the central one: on the ground floor the terminal parts with two axes of openings are configured as a base, also because of the treatment blocks imitating an ashlar, while the central portion is divided by an order of pilasters into five bays within which they are arranged the same number of openings with wooden fixtures and railings liberty. Above a string-

course setting, the main floor retracts in the central part to accommodate the terrace, enclosed between the two monumental header bodies, bipartite by individual pilasters of Tuscan order, coupled at the ends; these pilasters accommodate a respectively a pair of framed windows, surmounted by a jutting-decorated lintel.
The second floor, more simplified in the architectural elements, presents smooth-plastered walls with openings aligned with the underlying ones, framed by linear cornices; two small symmetrical bodies are placed against the sides of the terrace facing the central part. A mighty frame of entablature, whose overhang is supported by trachyte brackets, dominates the construction and, on top of a high-end crowning, there are the pitches of the pavilion roof.
The building, built according to the traditional techniques of the Nineteenth century architecture, is made of load-bearing masonry plastered with horizontal elements to the floor and hipped roof, supported by a fine wooden structure trusses and purlins with a layer of roofing tiles on battens. In the south-facing side they emerge from the coverage of the structures of three dormers, with elevating masonry structure and a tiled pitched roof.
In the various floors the planimetric configuration is no longer the original one, which is no more detectable as a result of the numerous extensions, modifications and alterations suffered over the decades. The last intervention, aimed to reuse the Villa as the seat of the University of Sulcis Iglesiente in Iglesias, has been responsible for the restoration and functional adaptation of the plant, maintaining the typological-distributive approach with a central aisle lined with two rows of rooms. Those that showed precious finishing such as stucco ceilings and parquet flooring have been restored, in addition to the beautiful internal staircase that opens in the inlet. Even the supporting structure of the coverage, with wooden trusses and beams, has been restored and left visible in the crawl space floor.

- Vittorio Emanuele pit

Construction period: 1863

Function: Mine Shaft; minerals and personnel transportation; housing dewatering pumps.

Project: Franz Stiglitz, in January 1869.

The pit is one of the most representative building of the entire mining complex, despite it retains only part of the original structure of the castle, in a decidedly classical style: it stood as a sort of temple on a high podium to the south and with a giant order paired Doric pilasters connected by a sequence of three round arches with oculi westward.
The following modifications that have affected the building by altering the architectural features, plus the substantial transformations of the neighbourhood with the construction of the lead smelter and other adjacent buildings (such as the

compressors hall), have modified permanently the original configuration of the main body and its perception from the surroundings.

The pit is accessible from the west through a metal walkway that starts from the power plant and passes transversely over the main road, leading directly to the entrance. On this side, less concealed by the volumes that were subsequently placed against the castle, is readable the volume of the main body that features pilasters and blind arches, marked by frames and oculi while, in the lower part the arched openings have been filled with masonry.

Above a notched frame, which originally preceded the roof, an added floor was elevated over the former structure to accommodate the latest winch room, ended by a frame and covered with a pavilion roof. In the short side, to the south, there is the 'inscription "POZZO VITTORIO EMANUELE", above the lintel which overhung the original entrance, closed by a masonry and fibreglass panels. In addition, the upraised volume does not harmonize with the oldest part, due to the alteration of the proportions and of the languages by using reinforced concrete, with a clear contrast in the stiffening frame that is superimposed on the structure and the insertion of rectangular openings.
From the drawings found at the Historical Archives of the Municipality of Iglesias, it shows the presence in the origin of a wooden cover for the pavilion roof structure, whose section in the table inventory n. 65 illustrates a system of false wooden trusses in three king posts, of which at this internship of study there is no certainty of the actual realization.

The excavation of the well was started in 1863 at the centre of the mine at an altitude of 206 m a.s.l. and came initially up to 70 m a.s.l., where the permanent level of water was located. Its section was divided into three compartments: in one run the extraction cages, one was intended to house the dewatering pumps and the third housed the stairs. The castle was built around1870 on a project by Franz Stiglitz, as documented by the drawings of the "Front to the South," signed and dated Monteponi January 1869, and "Façade towards West" (without signature or date) kept at the Historical Archive of the City of Iglesias. Following the construction of the drain gallery Umberto I (1889), the well was dug up at an altitude of 211 m below the entrance and in time, with subsequent cultivation works in the lower galleries, it reached the total depth of 314 m. at -100 m a.s.l.

Vittorio Emanuele Shaft, in addition to serving for the extraction at various levels, was used as a link between some external production plants and facilities. Around the first half of 1960s, with Sartori project, it was intended solely for the transport of personnel and this meant the installation of a new vertical hoist operation (housed in the elevated volume) and new transport cages. The winch is of the type with pulleys Koepe K1 type (manufactured by Pomini company), driven by a three-phase asynchronous motor of Siemens.

The Pit was discharged in 1997 with the decommissioning of the -200 m level pumping.

- Sella Pit

Construction period: 1872 - 1874

Function: The pit houses the pumps of the dewatering plant for San Severino level, which served as a drain tunnel; mechanical workshops, foundry, and carpentry.

Project: Charles Marcellis, Liege in January 1868. Franz Stiglitz, in January 1873.

The complex consists of a central body with a rectangular plan and the shaft castle, which is symmetrically flanked by two long building whose height is half of the castle; a third shorter one storey body is placed transversely on the rear side, while a metal structure covered by a canopy is leaning against the east side.
The street front, on the top of a high and protruding base which regulates the steep slope of the terrain, features an order of round arches marked by frames and pilasters within which the openings are arranged. The central body is divided into two orders of different heights by a frame and it is punctuated by slender pilasters connected by round-arches containing two types of openings align: arched, simple and tripartite, equipped with wooden frames tilt and circular ones above. In the façade, above the inscription "Pozzo Sella", there is an old clock inside enclosed central oculus.
The construction is made of load-bearing masonry of thick stones, filled bricks and regularizing reinforcement in the corners and in the arches; the floors are made of stone and brick vaults. The pavilion roof on the turret and the cabin in the lateral bodies are governed by wooden trusses with iron rods and overlying mantle of planking and clay tiles.
The foundry department, placed in the west wing of the central body, has been restored since it was largely collapsed, voided of the perimeter walls and the cover; on the decking, the old machineries have been restored and replaced in numerous slots. The mechanical workshop department, placed in the eastern building of the central body, is configured inside as a single and large well-lit room, where there are still present all the machinery and the bridge crane, supported by a structure of iron pillars and beams, with runners along the side walls. The flooring is made of cast iron plates with grooves, placed diagonal to form diamond-shaped patterns. The valuable mixed truss type "Polenceau", with wooden struts and the rest of the iron structure, support the double-pitched roof, on a 15 m to light. Through a beautiful spiral staircase in cast iron, we can lead to the upper floor of the central body where the carpentry department overlooks the floor below. The joinery is also accessible from the rear of the building, in correspondence of the body to a floor leaning against the tower that leads directly to the top level. The interior is divided into two

areas communicating through three arches; it presents characteristic wooden flooring, made with dowels obtained from dissected trunks.

- Central warehouse

Construction period: end of the Nineteenth century

Function: storage warehouses

Project :?

The complex called "central warehouses" comprises a series of contiguous buildings, arranged in an articulated way with protrusions and recesses, along a path that starts from the entrance of Nicolay tunnel and, after a straight stretch with a NE-SW trend, it turns on the right leading to a large dirt yard. On a total area of over 2,000 square meters we can identify six bodies, differentiated by age, type and construction technique, as well as for the height of different sets of floor.
The oldest part of the building, matching the one in the square, dates from the late Nineteenth century, as documented by the plaque on the south-west elevation that shows the date 1892. It is on two floors including three inside rooms: two on the ground floor, each with an inlet passage and one on the upper level, accessible by a raised square which is reached via an outside staircase placed on the left side of the main elevation. The latter area is lit by three windows, one on the front and two lateral with iron grates with Art Nouveau motifs. The construction is made in mixed-bearing masonry stones and plastered bricks. The reinforced concrete cover with double-pitched roof, rebuilt with the recent intervention, is surmounted by wooden truss with iron tyrants which surmount framed beams and wooden table.
The second body (former warehouse of electrical materials) faces in part on the square, with a front window also has input, and in part on the road, where, for a blind portion, joins a rectangular shed with two levels of openings, closed by a reinforced concrete cover double-pitched which stands on a strip with skylight windows. The original structure made of stone has been integrated into the next epoch with pillars and reinforced concrete beams that allowed to have higher rooms and to create larger free surfaces; with the recent intervention in the main body, with an area of almost 400 square meters, a mezzanine accessible by a concrete ladder and from contiguous rooms at a higher level has been realized.
The third body is arranged longitudinally to the road on which it finds access through a big door; inside it is enclosed by two rooms, of which the main one is equipped with a three pitches coverage, bore by a double row of three iron uprights sustaining two large wooden beams and the secondary frame, to which the Marseilles tiles are tied.
The fourth body is constituted by two rooms, the most ancient one with perimeter walls made of stone and the other one, in the head of the corner position, subsequently partially reconstructed with a reinforced concrete structure and filled of

concrete blocks. The latter is equipped with independent access through a wooden door, it has two windows on the SE prospects and the same number on the NE, with wooden frames and protective iron gratings outside. The original cover was recently demolished and rebuilt with flat slab in reinforced concrete, with paving.
The fifth body is a rectangular shed, with a mixed bearing structure, masonry brick filled with a further integration encountered in the visible frame of reinforced concrete pillars and beams. It has an access and large gap openings tape with iron fixtures in the upper part in the SE front and a single entrance surmounted by a window in the NE. In the unique inner room the roof is supported by four "Polenceau" trusses resting on pillars along the walls, to which were added during recent works two uprights that hold each three semi-trusses for supporting the strata of the head of the pavilion roof.
The last body is longitudinally adjacent to the previous one, but elevated approximately 3.5 m; it is divided into four areas, one of which has a separate entrance at the rear. The façades, with the exception of SW, which is blind, have rectangular openings with iron and glass fixtures.
The construction is made with a supporting structure of masonry stones and bricks; above a crowning cornice one can see the flaps of the pavilion roof with a layer of asbestos cement slabs resting on iron beams.

- Nicolay Washery: No longer existing. No documented traces.

- San Severino Washery: No longer existing. No documented traces.

- Monteponi Scalo Station and railway

Construction period: circa 1880.

Function: connection among the mine, Gonnesa and Porto Vesme.

Project :?

Situated on the south-eastern sector of the Monteponi Scalo, in the vicinity of the FMS station, it is on the right of the gravel access road, after passing the former locomotive depot.

The building is a two-storey building with a "L" shaped plan, made of plastered masonry and equipped with a pavilion roof, which is grafted on a gabled sector, with a layer of roofing tiles. A one storey volume with a separate entrance, originally intended to accommodate the toilets, is set against the cylinder head east of the building and has a casing made of visible wooden planks. The main façade facing south is divided into two portions: one, to the left, marked by a regular series of four axes of openings and another, on the right, moved by the crowning of the gable roof. The latter, with a single axis of bipartite windows, features a mixed-line frame crowning of the mullioned window on the first floor. On the north front a canopy is

leaning on the ground floor, a prolongation of the local coverage of services, resting on a structure of wooden beams and supported by a thin column of cast iron. Although not accessible inside for safety reasons, it detects the presence of a staircase with two ramps and the remains of the original finishes which are facing extreme degradation: a lime-based plasters, wooden window frames and wrought iron grilles, paving with hexagonal tiles.
The building, intended to be the Monteponi Main Station, was presumably built in 1880, the year of the opening of the line service to the public (passengers, luggage, cargo). The service will be dismissed in 1920.
Since 1926, with the entry into operation of the branch Iglesias - P. Suergiu by the Sardinian Southern Railways F. M. S. (*Ferrovie Meridionali Sarde*), the building was used as a service building for the transport of goods and minerals until 1963, year of the suppression and disarmament entire network.
The building was allegedly used as offices, like the nearby Railway Direction, until the cessation of the activity.

- Inclined plane 35%

Construction period: 1875

Function: Transport by rail wagons for minerals and goods between the main levels (Nicolay)and Scalo region.

Project: J. Goffint, Liege.

The inclined plane linking the level of the private railway station, located in the airport at an altitude of 107 meters above sea level, the square Nicolay, at an altitude 206 m, from where it departed the track route on the ground that ran through Monteponi the area. By overcoming a height difference of almost 100 m with a gradient of 30%, the structure allowed the transport of the wagons binary with minerals and various products, through the use of sliding bearing trolleys on wheels, hooked to the traction rope and moved by a pair of pulleys installed inside the winch room on Nicolay square. The inclined plane had two sliding ways, one for the descent and one for the ascent, with a gauge of 0.96 m placed about 5 m away from each other. The main structure, boar by a high and mighty stoned ballast, is still perfectly detectable, even if it has no longer the area containing the rail tracks and it was demolished in the highest section to let the new SS.126 pass through. Upstream of the roadway on the side of the red mud, opposite to the inclined plane, one can identify the ruins of a masonry building, with three arches in the basement and an elevated part divided into three compartments by dividing walls. It was probably destined to a warehouse for the storage of minerals, being close to the calcinations wells for the calamine, documented by old photographs and no longer exists. Upstream of the roadway on the side of the red mud, opposite to the inclined plane, one can identify the ruins of a masonry building stones to view. The latter has three arches in the basement and elevation part is divided into three compartments by dividing walls; it was probably destined to warehouse storage of minerals, being close to the wells for the calcination of calamine, documented by old photographs and no longer existing.

This infrastructure, known under the name "Inclined plane 35%", is displayed in an ancient plan of the area of Scalo, preserved in the Historical Archive of Iglesias (Fund Monteponi - Montevecchio, n. 187), referring to the years 1875 -1880. There are portrayed in fact both the winch room and the building of the Monteponi - Portovesme Railway Station. In the book published on the occasion of the Monteponi Society Centenary we read: "An inclined plane in which the wagons can be raised on a suitable undercarriage, connects the Monteponi Scalo head station to the Nicolay Level at 108 m a.s.l.".

The plane, 294 m long, had a capacity of 15 tons. In 1950s it was driven by a pair of grooved pulleys driven by electric motor of 150 HP and could circulate, daily, for a total of 40 wagons loads for a total of 300 tons. The work was essential for the transporting system since, as pointed out by the text, Nicolay square was headed by the totality of the transport of coke, minerals, coal, etc. for the facilities of the Electrolysis of Zinc, the Lead Foundry and various materials for the warehouse and for all the workshops.

- House of the winch of the inclined plane

Construction period: 1875

Function: Housing winch room of the inclined plane.

Project :?

The rectangular building encloses a unique room with a large opening on the short side of the south façade, placed at a height of over three meters from ground level.

Originally it housed the winch that controlled the movement of the cables for the transport of cars on the trolleys that ran on the inclined plane.

The construction is of stone masonry bearing with angular pillars and brick lintels; to the type plaster finish "Terranova" stand out to smooth plaster frames with lighter hue. At the sides of the opening there are two mirrors with lozenge decorative motifs, while in the east side, there is a tombstone with the inscription "MDCCCLXXV". At it rises above a crowning frame coverage with hipped roof, supported by wooden trusses and beams bearing a tiled mantle. Inside the machineries are no longer present and only the walls of the housings are visible.
Outside, adjacent to the west side, there are the remains of a stone staircase for access to the winch.

- Ferraris' Direction

  - **Vittorio Emanuele Washery (mechanical)**: no longer existing.

    Construction period: 1879

    Function: plombiferous processing of minerals.

    Project: Erminio Ferraris?

  - **Pilla and Sacchi Washery:** no longer existing.

    Construction period: 1877 - 1879

    Function: to treat plombieferous lands and mixed difficult separation materials.

    Project: Erminio Ferraris?

  - **Mameli Washery**

    Construction period: 1893

    Function: mechanical treatment of plombiferous soils and mixed materials by flotation.

    Project: Erminio Ferraris?

    The construction of the Mameli washery started in 1893, following the transformation of pre-existing mechanical washeries Sacchi and Pilla. The plant was intended for the treatment of mixed minerals, which were the most difficult to separate and enrich, in particular the lead and zinc soils from San Marco yard, mixed materials from San Vittorio Washery and *Cungiaus* yards. In 1898 the hydrogravimetric treatment was introduced for the treatment of sands and materials with a thickness less than 1,5 millimeter, through the oscillating table patented by Eng. Erminio Ferraris.
    In 1902 Ferraris concocted for Mameli washery a spherical millstone for grinding purposes of the granules in a wet environment, which was the first device of this kind in a closed circuit.

    The complex of Mameli washery, currently reduced to a state of ruin, is articulated in different buildings, divided by type of construction and originally intended for different functions. The first body located to the south-east was used for the flotation and stood isolated with an irregular plan, elevated up to three floors. The original reinforced concrete frame is partially demolished; the external brick cladding remains on the northwest side, along with traces of English wooden fixtures. Annexed to the system there are the loading hoppers, two reinforced concrete circular decanters and the room of the pumps.

Behind, placed transversely, there is a second body featuring a reinforced concrete structure and three levels, which further lifts and merges with a five-bays framed structure, devoid of cladding and covered with canopies, at the base of which are still present two of the three reinforced concrete hoppers.
The main body of the washery is arranged on different levels according to the typical cascade configuration, still readable despite the collapses and the decay of the structures. It still includes concrete portions and part of the oldest masonry, constituted by pillars and round arches with a mixed structure of stones and bricks; there are also remains of the iron bearing elements, beams and pillars and, in the highest part, the wooden trusses that supported the double pitched roof. There was also a part covered with a single pitched roof, of which the profile is still visible.
A two-storey rectangular plan body is placed in the north side: it is made with load-bearing masonry stones and features an emerging stringcourse, single and paired openings, surrounded by frames with mouldings; in the side, where there is a triple arched window, a frame with an embossed geometric pattern emphasizes the profile of the gabled roof, whose bearing structure consisting of iron trusses connected by wooden beams only survives.
Finally, crosswise placed on the west side, there is a one storey volume with a pitched roof, which originally housed the kitchens and services.

- Calamine Washery: no longer existing, replaced by a remittance for machines and tools.

  Construction period: 1887

  Function: processing of zinc ores from *Cungiaus*, then shed for machines and tools.

  Project: for the washery, Erminio Ferraris?

  The building is located in an area where once stood the Calamine Washery, whose remains are recognizable in the wall structure that dominates the back, placed at a higher level. It features a rectangular plan and the long side opens into a yard where we find other buildings used as warehouses of materials, machines and equipment. On the left of the main front there is a large entrance gate with sliding wooden doors on metal runners; on the top there are two rows of windows with iron frames.
  The construction is made of thick bearing masonry consisting of plastered stones mixed with bricks and mortar. The coverage features a single pitched roof with iron beams and rafters. The interior shows a three storey volume, with reinforced concrete staircases that connect the floors to a level at +3.50 m, which overlooks though arches the lower ones; another ramp connects the second floor to an upper area, bounded by a railing. The long wall corresponding to the main front features seven blind arches, within which align the two rows of openings. Finally there is the structure of a crane suspended and sliding on two rails fixed to the masonry.

- **Magnetic Calamine Washery:** no longer existing, replaced by local foundry preparation of samples, then engines stock.

  Construction period: 1931

  Function: Local preparation of foundry samples, then engines warehouse.

  Project :?

  The warehouse is located in the area that until 1931 was occupied by the magnetic Calamine washery with its appurtenances. Following the closure, the washery was largely demolished and the area assumed a different configuration, with new buildings and transformations of the existing ones. This building had a rectangular plan on a single level, protruding over the adjacent building and to the rear body, which featured two attic floors. The façades showed the presence of architectural features such as string courses, pilasters and cornice in relief. At the centre of the south- east front there was the entrance equipped with a wooden door, while iron sliding windows are placed in the upper part. The construction is made with perimetral bearing stone and brick masonry, exteriorly refined with "*Terranova*" plaster; the coverage consisted of a pitched roof with iron beams and a mantle of corrugated sheet metal plates, partly removed.
  Inside there was a unique hall: on the rear wall segmental arches were sustained by massive pillars which define a space where there was a oven of refractory bricks with metal shutters.

- **Foundry of lead**

  Construction period: 1892-1895.

  Function: mixed minerals foundry for the production of lead, silver and zinc.

  Project: Erminio Ferraris (1889 - 1894)

  The lead smelter consists of several adjacent bodies interspersed to each other by open spaces, which were originally covered by canopies, made at different times and with different construction techniques. These spaces gave the whole an inconsistent and articulated appearance. The complex consists of two main levels, with a jump of height of over 5 meters: the upper one placed at the level of the arrival of the lift of Vittorio Emanuele Shaft and the lower placed above the terracing which insists on the area used as a parking in the north of the Bellavista yard. The main body of the upper floor, accessible from the entrance of Vittorio Emanuele Pit to which it is adjacent, consists of a large rectangular shed that housed the reception and preparation of the mixtures. The shed is constructed with a mixed technique: perimetral plastered brick masonry and iron pillars, which bear the metal trusses supporting the roof, made of galvanized metal sheets. Inside there is the transport system of aerial monorails with sliding hoists, anchored at about half of the height of the pillars, while on the ground run rails for the movement of the wagons. In addition, there are the remains of a machine placed on a vertical structure in reinforced concrete, used for the preparation of fusion layers that were sent to the ovens. One of these still emerges with the upper part in the receiving and preparation department.

At the lowest level the complex is divided into three bodies of different height where there were the melting and refining wards.

The forth western body, with rectangular plan and greater height, has a structure in reinforced concrete and plastered infill, featuring large windows and central access; the coverage, a pavilion with skylight in the upper part, is equipped with beams and truss structure in iron and mantle of asbestos cement slabs. Inside there is a unique space used as a warehouse and still hosting some of the equipment used for the surveys, although it was originally part of the foundry as testified by the traces of some ovens on the rear wall.

The central body, on the outer side towards the square, shows a linear front on two levels and an inner subdivision into three sectors by pillars supporting the trusses of the roof, of which remain the backbone and some galvanized sheets. At the ground level, on the rear wall, we find the lower part of one of the ovens, divided in two by the upper slab.

In the eastern end in continuity with the complex there is the shed that housed the desulphurizing unit, enclosed by walls on three sides and, adjacent to the ruins of the house of the converters. Finally, on the upper level of the road, there is a block closed on two sides with a stone base beneath which there are the pipes for the fumes, as it was used at first as a recovery of metals from the gases produced by the foundry.

According to the first project of 1891 by Erminio Ferraris the foundry was built in one place, under the Vittorio Emanuele Pit at an average height of- 5.30 m and it was equipped with two reverberation ovens; the construction was suspended in 1893 and restarted in April 1894 on the basis of a new project which involved a more complex distribution on two levels. It was put in exercise in 1895 and since then it underwent two successive enlargements and transformations due to the allocation of new plants and machineries and to the changes in internal and external configuration of the wards during the years 1918 and 1925.

- Foundry of Cast Iron

  Construction period: 1890 ca.

  Function: Foundry of cast iron.

  Project: Erminio Ferraris?

The foundry shed stands on an area dominating the General Stores, on a sloping ground arranged with terraces on several levels through the containment walls in blocks of stone. It features a rectangular plan, with the main side E -W oriented which delimits a unique and large interior space, devoid of partitions. The bearing structure consists of reinforced concrete pillars that identify seven bays on the long sides and three in the short ones; in the east façade is located laterally the entrance, through a rectangular opening with an iron gate. Walls are made of bricks and have windows at the centre of each span, with remnants of fixed fixtures in iron and glass.
The roof is supported by seven reinforced concrete trusses, connected to each another by slender beams with circular holes, while the covering mantle is missing.
Inside the building several machineries and significant traces of the original plants are still preserved, both fixed (such as the melting furnace chamber in refractory bricks placed in the rear wall, the iron structures with the two cranes, the fusion tanks and the cement housings of machineries) and furniture (machineries used in the foundry including two rotating kilns).

- Warehouse for wooden moulds

  Construction period: 1875

  Function: Warehouse

  Project :?

  This building features a two storey plan, a bricked chimney that rises on the east side and a staircase of masonry with two ramps adjacent to the west. The first floor has a greater height and is distinguished from the upper one by a string course; on the south front there are four rectangular openings with grates.
  Masonry consists of local stones and mortar with cement plaster finishing. The cover is made up of three separate longitudinal sectors: on one front there is a single pitch, while the other two are doubled pitched; the roof covering is made of corrugated metal sheets.
  The modellers' laboratory, equipped with machineries to carve the wood, was annexed to the foundry of the mechanic workshops.

- Deck house: no longer existing. It is present only in one documentary source in the Municipal Archive, featuring a plan and a façade.

· Sartori's Direction

- White zinc factory: no documentary traces.

- Binetti's Direction

  - Plant for the Electrolysis of Zinc

    Construction period: 1926

    Function: Electrolysis of zinc.

    Project: Livio Cambi

    The plant was composed of numerous departments and sections, each intended to the various phases of the electrolysis process: from the drying and crushing of calamine to the leaching; from the decantation, filtration and purification to the electrolysis and finally to the fusion. Currently three bodies are still detectable, of which the most consistent with an area of over 7,500 square meters occupies the western area of the complex, separated from the others by an internal path. It is composed of multiple adjacent sheds that together form an articulated complex, inaccessible due to poor and unsafe conditions of the roofs and slabs fully occupied with debris and rubble.

    All the buildings are made with framed structure of pillars and beams in reinforced concrete androofs with skylights; the covering slabs have disintegrated and many portions have collapsed, while some prefabricated truss strand still. The infill, where present, features bricked masonry and concrete blocks, with large rectangular openings and iron fixtures.

    Inside there are the remains of several reinforced concrete structures, survived after the dismantling of the machineries and the removal of metal components: four large circular tanks, probably decanters, and few circular structures raised on pillars where the decanted solutions were purified.

    This huge building was built over the former Vittorio Emanuele washery, built over fifty years before. In addition, since the sulphuric acid is essential to the electrolytic process, in 1928 a factory of this acid was built in the lowest area of the mine.

  - Sulphuric acid factory: no documentary traces.

The Protagonists of the Modernization

Here, a brief reference to those who have written Monteponi history in the period of its greatest expansion and technological implementation is obliged. Without the technical skills, the scientific knowledge and the entrepreneurial foresight probably Monteponi's events would be eclipsed and buried much earlier than it actually happened and there would not still be traces of a varied and incredibly modern heritage. Formal languages, combined with significant dimensions and updated constructive choices according to the building criteria of the time, result certainly from the managers' experiences in Academies and Schools in Northern Italy and in Transalpine regions, which have trained brilliant technicians, engineers and professors of engineering, architectural, military and mining disciplines.

We then proceed in chronological order, taking care to select only three of the many protagonists who have contributed to rise the sorts of Monteponi mine, due both to the lack of available information about of the late Eighteenth century characters and because it is believed that they have actually left an undeletable trace in the Modernizing process that led this site to its highest standards.

*Julius Keller (1819 - 1877)*

He was born in Gyor (Raab) in Hungary, by the noble Ignàc Keller, courtly adviser to the Emperor of Austria - Hungary. He studied at the Mining Academy of Schemnitz, graduated in engineering and worked in the Imperial Mining Service of the Hapsburg Empire. In 1845 he made his internship at the Mint of Milan.

His sympathies for Hungarian revolutionary uprisings led by Kossuth, forced him to give up the government career to join the rebel patriots, becoming captain of artillery in the revolutionary army. After taking refuge in Turkey, he returned to his Country after the Russian intervention and, thanks to the benevolence toward his father, he was condemned to perpetual military service. Later he was allowed to emigrate to Turin and then to Genoa, where he met Giovanni Antonio Sanna, recently concessionaire of exploitation permits in Montevecchio. Sanna hired him to direct the works in the mine and Keller, after the arrival of German miners, began his mining activity. This was immediately prosperous and promising, despite the presence of malaria that decimated the foreign miners. After three years as a manager, he was called to Monteponi mine to replace Giuseppe Galletti, who became the manager of Montevecchio from 1852 to 1856. After the direction of Monteponi mine, Keller continued to offer his work to many mining entrepreneurs and to the Royal Mines Corp; in 1865 he became director of Masua mine, licensed to the Genoese Company *Decamilli*, for whom he realized a washery in the coast of Fontanamare equipped with 10 German caissons and 44 Sardinian sieves, and a foundry with six wind furnaces, propelled by a 12 HP steam engine. This washery remained on service for 22 years before being abandoned.

Moreover Keller, joined to Angelo Nobilioni from Iglesias, built a mining washery in a region called Funtana Coperta and two extractive yards in San Giorgio and San Giovanni. The purchase of the slag heaps of the old Pisan and Roman mining works near Domusnovas granted to the *Keller & Nobilioni* Company a fortune, followed by the treatment of mining slags in Fluminimaggiore led by Keller's sons.
Julius Keller, affected for years by malaria that recurred frequently in Sardinian mines, died in Cagliari on July 5, 1877[78].

*Adolfo Pellegrini (1838 - 1904)*

He was born in Turin by Henry Pellegrini, a wealthy merchant, and Pauline Caffarel. He graduated from the Turin Polytechnic and later he got the degree at the *École des Mines et Chaussées* in Paris in Civil Engineering and Architecture. Back to Piedmont, he worked on the construction of the railway lines Novara - Borgomanero and Savona - Ventimiglia[79].

In 1861 he was called by the President Baudi di Vesme to direct the Monteponi mine, where he applied to continue and expand the work begun by Keller.

In addition to digging new tunnels, Pellegrini is remembered in the mining history for having designed and built the most famous buildings and plants, such as Vittorio Emanuele and Sella Pits, the washeries and furnaces for the treatment of lead and calamine, the railroad, the inclined plane and the Manager's Villa.

Nominated local councillor of Iglesias, he promoted the foundation of the school for miners and foremen on the recommendation of the Minister Quintino Sella and the city civil hospital.

Back to Piedmont, he promoted the construction of the line Pinerolo - Torre Pellice, held a managerial position in the Canavese and Biella railway companies, was president of the Lime and Cements Company of Casale Monferrato, where he founded a social welfare institute for the workers. He was councillor of the city of Turin, he was awarded also with the titles of Commander of the Order of Saints Maurice and Lazarus and the Order of the Crown of Italy.

[78] Amat di San Filippo, P. Protagonisti della storia mineraria: Giulio Keller. In *Il Ritrovo dei Sardi*, year III, number 33, September 2006. Cagliari: Stampa Tipografia Manis, 2006.
[79] Società di Monteponi (eds). Società di Monteponi 1850 – 1950. Turin: Tipografia Vincenzo Bona, 1950, pp. 78-91.

He was vice president of Waldensias *Artigianelli* Institute, where he established a scholarship in his name, and member of the COAs of various charities in Turin.
He was one of the organizers of the International Exhibition of 1898 in Turin, where the Monteponi Company received a certificate of honour in recognition as the best national mining industry[80].
Adolfo Pellegrini died in his hometown on 29 October 1904.

*Erminio Ferraris (1852 - 1928)*[81]

Born in Ronco Scrivia on February 15, 1852, he graduated in Physics and Mathematics in 1869. Orphan of father he had come to work in Sardinia as a technician in the mines of Masua and Malacalzetta. In his three years of work he was appreciated for his technical and human qualities. He went to Germany in 1871 to attend the Montanistic Academy of Freiberg, where he graduated in Mining Engineering in 1874. To complete his technical education, he worked as a worker for several months in the *Escher Wyss and Co.* workshops in Zurich. He then was called as a director of Monteponi in 1875 at the suggestion of Roberto Cattaneo, who had become his stepfather the previous year. Here too he soon was able to be appreciated for his technical and organizational skills. His proposal to build a zinc smelter was well favoured by the Earl Carlo Baudi of Vesme, at the time President of the Monteponi Society. On 6 January 1876his design for a new foundry was presented to the Prefecture of Cagliari for the authorization to build but, due to the unfavourable trend of the international market of lead, zinc and silver, the project was aborted. Meanwhile Ferraris concocted a drilling machine with a higher performance than usual and a dynamo, improved if confronted to the one devised by Pacinotti and patented by Gramme. The two machines were rewarded at the National Exposition of Turin in 1884. Among the numerous inventions patented by Ferraris we remember the magnetic sorter in 1890, the oscillating table, the first oven propelled by gasses obtained with the lignite from Terras Collu, the hydraulic washing plants for the calamines and the reverberating ovens designed to produce antimony in Villasalto in 1909-1909.
In 1911 he was appointed Chief Executive of the Monteponi Company.

[80] Source: www.minieredisardegna.it. The bibliographical references cited in the site are: Le commandeur Adolphe Pellegrini in the *Écho des Vallées*, n. 46, November 11, 1904. *L'Avvisatore alpino*, n. 46, November 11, 1904. *L'Italia Evangelica*, n. 47, 19 November 1904. *La sentinella valdese*, n. 12, December 1904.

[81] Amat di San Filippo, P. Protagonisti della storia mineraria: Erminio Ferraris. In *Il Ritrovo dei sardi*, year III, number 33, September 2006. Cagliari: Stampa Tipografia Manis, 2006.

In 1917 he built a zinc foundry in Vado Ligure, largely described book for the Company's Centenary[82].
In 1885 he was awarded of the Military Order of Saints Maurice and Lazarus and he became a member and later President and Vice President of the Sardinian Mining Association, then partner and board member of the Association of Industrial Chemistry of Turin.
After a long illness, he died in Zurich September 22, 1928, aged 76.

[82] Società di Monteponi (eds). Società di Monteponi 1850 – 1950. Turin: Tipografia Vincenzo Bona, 1950.

PART 4

# THE BUILDING CULTURE OF THE 1800s

## The 19th century Industrial Architecture: forms and materials

The divulgation of architectural, constructive and technological concepts, theories and methods in the development of the industrial architecture and the scientific knowledge in the Eighteenth century is prevalently due to the institutional, cultural and trading circulation among the most important Countries in the field of the engineering, construction, mechanics and general production: France, German Countries, Hapsburg Empire, Italy and Hungary were linked by different ways of interpretation of the technical literature, varying from the simple translation of technical-scientific volumes – often published in German – to the cultural and explorative *voyages* and the penetration of commercial and trading exchanges to and from abroad. In the first half of the century the *Bergakademie* (i.e. the Mining Academy) of Freiberg was one of the most important centres of development of the scientific and technological culture in the European reality, so much to be considered a sort of "Athens of metallurgy"[1]: the open cultural environment that allowed to foreign technicians and students to attend the school and the workshops created in fact a multicultural interexchange of theories and educations promoted by the most important figures of the time, whose contributions were then reported in the great literature production of the time. Along with Freiberg, other schools and academies followed this path, contributing to create a wide web of communications, publications and divulgation of methodological learning, technological advancements and scientific progresses that arrived even to the United States. On the opposite side, the predominance of the German schools over the cultural and scientific panorama in the beginning of the 19th century delayed the contacts with the Anglo-Saxon world, which stayed mostly parted from the other Countries developing a proper academic path.

The relations among the German-Austrian-Hungarian world and the francophone Countries led consequently to a vast production of translations of the original handbooks, containing the most interesting innovations in the field of metallurgy and mining exploitation, chemistry, geology, geognosy and of the education of these matters in the Polytechnics and Engineering Schools. Specialized magazines, books and reviews started then a vast publication of memories and essays, such as the French version of the *Bergmannisches Journal* edited by the *Agence des mines*, while on the British front we find the editions of chemical treaties edited by several of the

[1] Brianta, D. *Europa mineraria. Circolazione delle élites e trasferimento tecnologico (secoli XVIII - XIX)*. Milano: FrancoAngeli, 2015, pp. 103 – 104.

most important scientific Societies[2]. In the transition between the 18th and the 19th the link between the French and the British worlds strengthened not only for a matter of geographical nearness but also for a political rivalry: the penetration of foreign theories was in fact fertile in the French soil mainly because of the systematic modification of the National cultural organization, which promoted deep relations between the sciences and the political power as a consequence of the revolutionary reforms in the *fin de siècle*. The growing needs of mining and metallurgical competences for civilian and military uses was in fact promptly attended by the collaboration of experts, technicians and scientist from various fields, at the service of the State. Particularly for the iron and steel industry, France looked to the other side of the Channel in order to import the techniques *à l'anglaise* to work the iron, the steel and the reinforced steel that were assuming an ever growing importance for the military and engineering industries. The attention was paid clearly to the productive processes, both through visits and publications, and culminated in a great investment by the French State for the researching on the production of steel, allowing a deep and wide application of scientific methods to the technologies that ended in the most important works by Berthollet, Monte, Vanderamonde, who finally explained the importance of the proportional combination of carbon in the chemical formula of the iron. This material was in fact at the centre of the national interests, more than the manufacture production, which aimed to surpass the British standards in a sort of international concurrence[3].

After the end of the pioneer age, the industry of iron and steel evolved into a new technical and scientific knowledge, which put the bases for the development and the use of these materials in the construction of civilian and urban facilities, such as the bridges and the railways. The Imperial Mining Corp, then evolved in the Bridge Corp, became in fact of the most important promoters in the regulation of mining activities, concessions, use of new materials and technologies that led to a complete modernization of the industrial sector since the 1820s[4].

The progressive extension of the railway web since the 1840s resulted in a even more deep education of the members of the Academies and of the Mining and Bridges Corp, in order to figure out an updated gamma of iron, cast-iron and steel products employed in the growing railway industry, which needed an innovative apparatus of specialist contributions from the

[2] Ibidem, p. 110.

[3] Brianta, D. *Europa mineraria. Circolazione delle élites e trasferimento tecnologico (secoli XVIII - XIX)*. Milano: FrancoAngeli, 2015, p. 128.

[4] Ibidem, p. 132.

scientific ambits of the chemistry of metals, mechanics, engineering and so on that were developed in the mid-century generation of schools and teachings[5].

[5] Ibidem, pp. 133 – 134.

*Technological development and style*

With the technological development – born as we said thanks to the proliferation of experiments, studies and prototypes both in the Academies of the most important industrial Countries and in the collaboration between scientists and experts with the industrial sectors – another important question was brought to light: the style[6] [7]. The entrance of the new materials in the production of industrial, transporting and civilian structures put formally in evidence the wide possibilities that steel and iron offered in the architectural panorama: the advent of the metal components – frequently presented in catalogues since the beginning of the prefabricated production – emulated and frequently replaced the traditional constructive systems, creating new spaces and buildings, innovative environments that came out as proper built sites. Since the invention of the Roman concrete there was not such an innovative constructive technology that had revolved the architectural concepts and the new materials offered similar opportunities to answer to the modern building criteria: even different typologies, such as workshops, palaces, representative offices, urban galleries and industrial sites, could take advantage of the spatial and aerial conditions offered by the use of metallic structures[8]. Customhouses, mills, mining pits, railways, machinery halls and bridges started to be affected by the use of iron or steel structures, declined both in small and big dimensions – such in the cases of distilleries, factories, dockyards and so on. Stylistically speaking the new materials presented a double advantage for the architects: on one side it could be produced in a variegated typology of dimensions, sections and sizes freeing from the conditioned qualities of wooden elements; on the other it could be covered, decorated and refined for the applications in public buildings, or concealed by appropriate finishing. The elasticity properties offered also better conditions for the application in great spaces and buildings[9] and the melting process allowed a serial production of components, beams, cantilevers and friezes that could be directly employed in the yards without further processes.

[6] Gobbo, A. *Volte in ferro e laterizio all'inizio del XX secolo. Tecnica costruttiva, casi di studio, diagnosi e conservazione*. (PhD thesis), Polytechnic of Milan, 2009 – 2011, pp. 48 – 50.

[7] Kostof, S. *Historia de la Arquitectura*. Madrid: Alianza Ed., 1988, p. 1028.

[8] Chueca – Goita, F. *Historia de la Arquitectura Occidental*. *Tomo V (El Siglo XX: de la Revolución Industrial al Racionalismo)*. Madrid: Dossat, vol. 11, 1979, pp. 15 – 17.

[9] Although it has a lower resistance to fire respect to the timber structures. See: Kostof, S. *Historia de la Arquitectura*. Madrid: Alianza Ed., 1988.

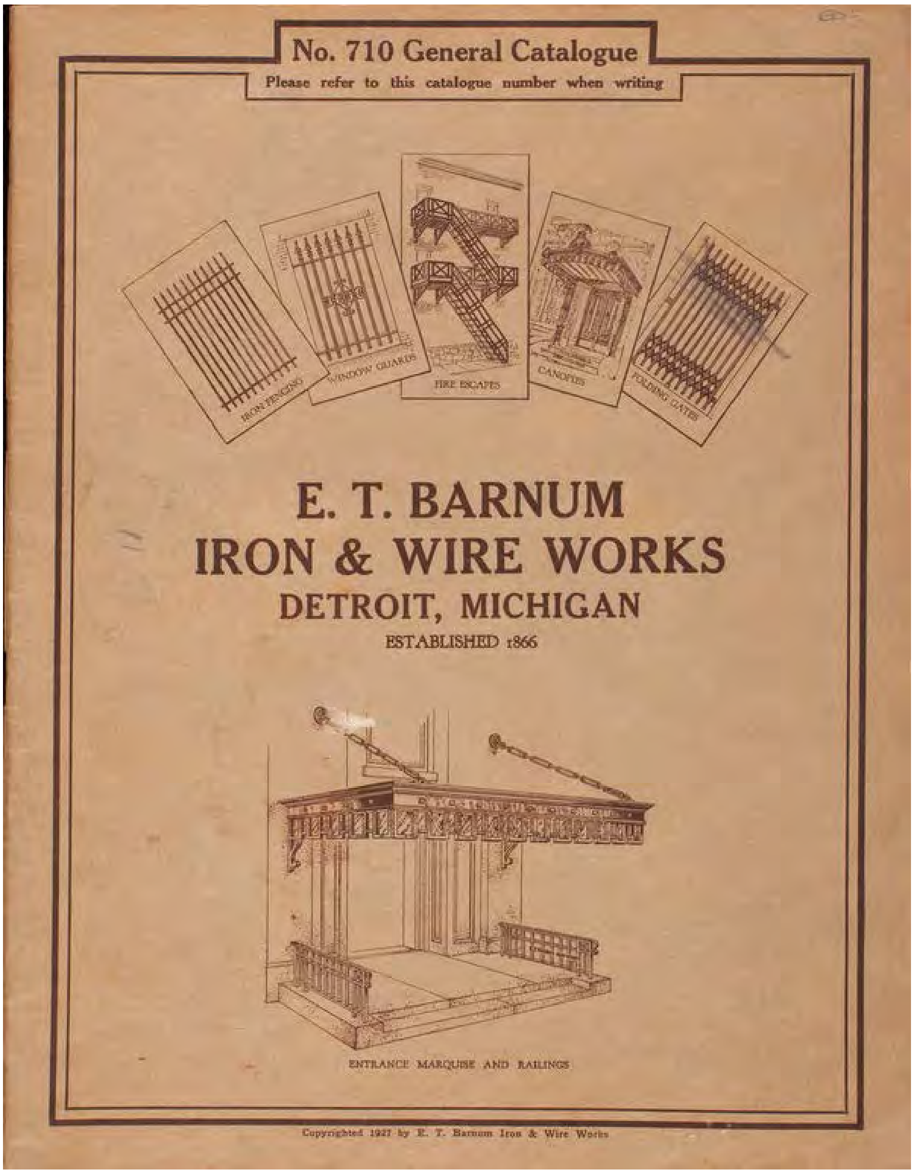


Figure 1 Frontispiece of a Catalogue of iron and wire Works. Source: www.historicnewengland.org

The stylistic approach to the industrial theme went along with the constructive design: despite the functional purpose that mainly guided the project of the industrial facilities, the formal language was in a certain way always responding to the stylistic preferences and tastes of the 19th century. The declination of Eclectic clichés applied to the buildings of production was in fact a common and a diffuse practice, since it allowed the achievement of a double target: on one side there was the application of styles, forms, decorations and inputs coming from the Neoclassic and Neo-Gothic traditions to the structural elements, in order to make them more domestic and "acceptable" thanks to the similitude with the other typologies containing modern building expedients; on the other the accordance between form and structure reflected the importance and the prestige of the industrialists, as we may notice in most of the industrial buildings where decorations went along with the constructive elements in order to symbolize the strength and the physical presence of the industry[10]. Landmarks such as towers, arcades, accesses became frequently urban signals sponsoring industrial brands and compounds and featured therefore a peculiar use of bricks, colours, frames, lintels, oculus and so on that contributed to integrate and to make acceptable the intromission of the industrial world inside the ordinary landscape.

The traditional use of masonry and bearing sections made easy supporting the iron components, which entered frequently inside the walls and the roofs as reinforcing elements, as frameworks in stone vaults (such as the Saint Isaac's dome in Saint Petersburg)[11] and as a good fireproof expedient when combined with tiles[12]; moreover it fit up to the new stylistic tendencies of that time, which preferred great halls, luminous spaces, aerial environments and big surfaces, made possible thanks to the proliferation of iron columns, pillars, beams and cantilevers sustaining the coverage and mould with a impressive variety of forms, features and finishing.

[10] Kostof, S. *Historia de la Arquitectura*. Madrid: Alianza Ed., 1988, p. 1029 – 1030.
[11] Loyer, F. *Le siécle de l'industrie*. Luzern : Skira, 1983, pp. 151 – 153.
[12] Ibidem, p. 1030.

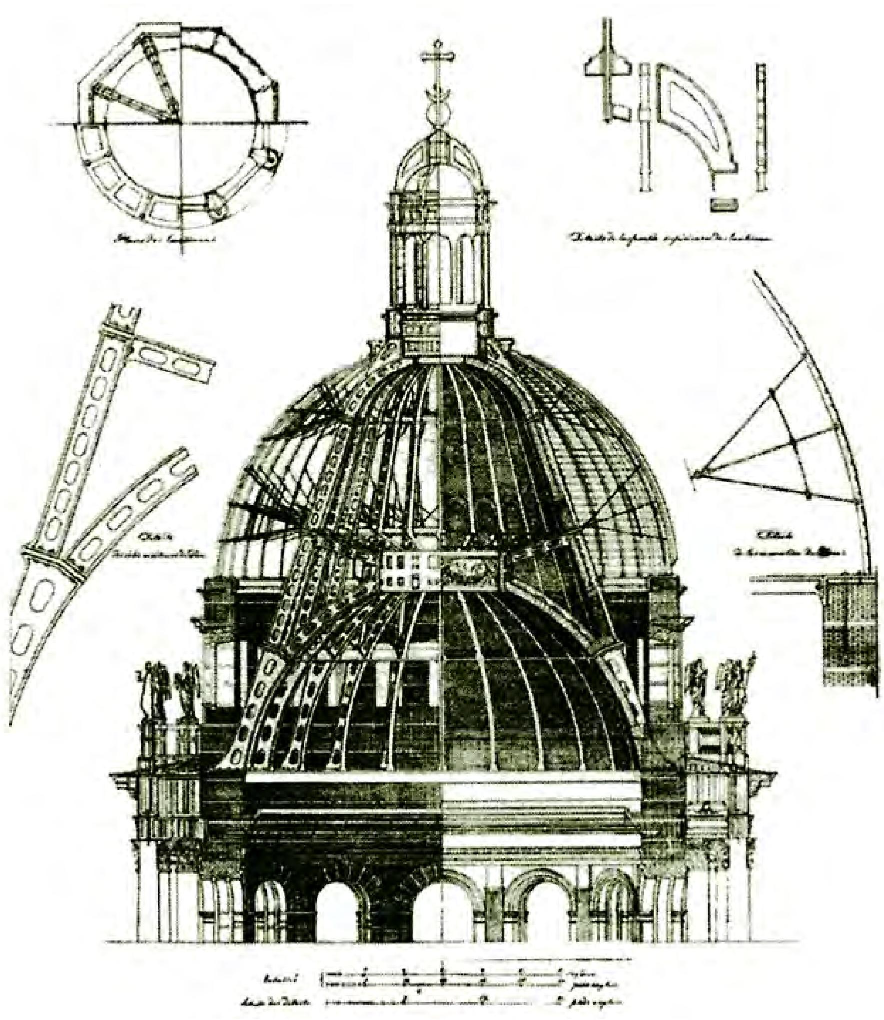

Figure 2 Saint Isaac's Dome in Saint Petersburg by de Montferrand. Source: en.wikipedia.org

The greatest field for the application of the new materials and building techniques was therefore that of public spaces, requiring a big amount of light and ventilation, such as markets, halls, pavilions, malls, libraries and winter gardens but also the infrastructures housing the railway stations and the factories. In these buildings we find in fact a proliferation of intricate iron structures, motifs and frames combined with glazed panels, creating transparent and light buildings borrowing the configuration of gothic and post-gothic architectures, where the thick masonry alternated to glazed panels, creating diaphone walls and lighted surfaces. The evolution from the gothic system, however, consisted in the possibility offered by the iron assembling to flood in the light from a zenithal direction, thanks to glazed barrel vaults and roofs sustained by traditional masonry or – in some cases-by iron vertical elements, which though are frequently concealed from the outside. The metal canopies were ideal to the commercial constructions and developed in a soft manner: in 1813 there was the first entirely iron-glazed vault covering the former circular granary in Paris and replacing the former wooden vault, while in 1830s there is the first glazed barrel vault, which became the “standard” model for the further projects of commercial and leisure spaces, such as the covered galleries and the passages that since then started to diffuse in France[13]. Another typical typology which took advantage of the new building binomial “iron-glass” was the storehouse, frequently featuring a central core providing the light from the zenithal roof and the lateral panels interposed among the vertical structure.

Public buildings, on the contrary, were initially reticent to the innovations offered by the new materials and concepts and to abandon the “predominance” of stone masonry in favour of lighter constructions. The building of the *Sainte Geneviève* Library, designed by Henri Labrouste, was in fact formerly attacked by the public opinion since it featured a sort of premonition of the progressive abandon of the full masonry and the classical elements replaced by iron arches, beams and glazed panels contrasting with a Neo-Renaissance masonry, pierced by arched openings that dissolve the impressive mass of the walls, corresponding to the structural disposition inside: the closed portion on groundfloor and the opposite perforation of the upper level through the arcades reflect in fact the presence of light flooding in from the lateral glazed panels and the shelves placed all along the walls in the lower level. The huge iron arcades sustaining the vaults are combined with the single elements, unconcealed and clearly declaring their function[14] [15] [16] [17].

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[13] Ibidem, p. 1032.

[14] Ibidem, p. 1034.

[15] Chueca Goita, F. *Historia de la Arquitectura Occidental. Tomo V (El Siglo XX: de la Revolución Industrial al Racionalismo)*. Madrid: Dossat, vol. 11, 1979, pp. 24 – 25.

[16] Pisanu, M. L’architettura dell’acciaio in Italia negli anni Trenta. La Società Nazionale delle Officine di Savigliano. PhD Thesis, University of Cagliari, 2014 – 2015, p. 16.

[17] Gobbo, A. *Volte in ferro e laterizio all’inizio del XX secolo. Tecnica costruttiva, casi di studio, diagnosi e conservazione*. (PhD thesis), Polytechnic of Milan, 2009 – 2011, pp. 63 – 64.

Figure 3 Section of Sainte Genevieve Library by H. Labrouste. Source: www.architectural-review.com

*The Universal Exhibitions*

In the second half of the 19th century the era of the great Universal Exhibition started and took seriously advantage of the spatial and constructive abilities presented by the metallic frames: the exaltation and the celebration of the industrial power was in fact achieved through the constructive expedients and the most evocative design of the pavilions, which reflected the innovative character of each Country.

The mastery of the new techniques and the echo of the industrial innovations reflected in the architectures of the Universal Exhibitions prevailed over the contents and triggered a rivalry among the different Countries.

One of the most famous hall was the Crystal Palace in London, built in 1851 by Sir Joseph Paxton. The designer was not an architect nor an engineer, but a gardener interested in the application of the structures typical of winter gardens to a greater scale. To project this structure, naturally, Paxton was helped by the engineers Fox and Henderson, who consider for the first time in a metallic structure the beams and the pillars as static entities[18]: the horizontal strains are

[18] Pisanu, M. L'architettura dell'acciaio in Italia negli anni Trenta. La Società Nazionale delle Officine di Savigliano. PhD Thesis, University of Cagliari, 2014 – 2015, p. 16.

therefore explicitly calculated in order to let them be reduced as in a traditional building, thanks to the main aisles and the lateral galleries that act like buttress. The result was in fact a sort of a huge inner garden, built with hollow cast-iron columns that drained off the rainwater, lattice girders, vaults with alternating valleys and hips, reticular bars where the prefabricated elements were repeated and combined according to a fixed module depending on the size of the glasses. The most important innovation was however more formal than constructive: the metallic structure in fact replaced the traditional and familiar masonry, creating a huge space where the repetition of small and big modules expanded the perception of the whole building in a sense of limitless. These features were surely the most innovative and far from the historical architectural concepts and in some way Paxton could be considered as a precursor of many modern concepts that would come later[19] [20] [21] [22] [23].

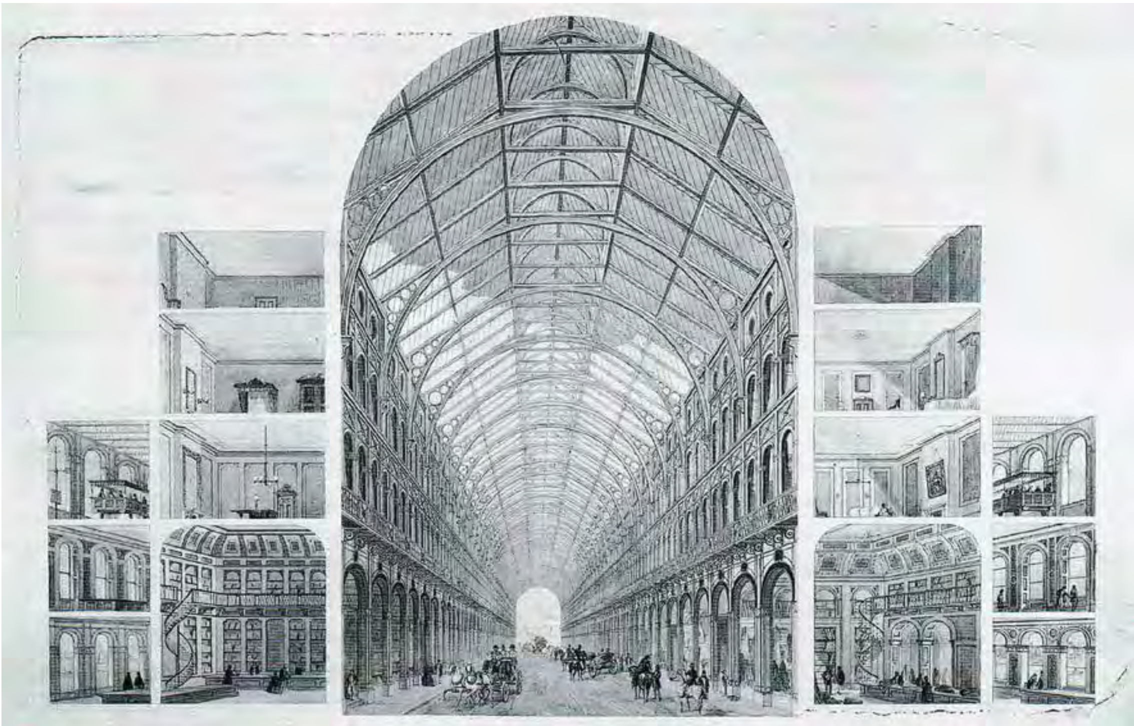

Figure 4 Section of the Crystal Palace by J. Paxton. Source: https://dobraszczyk.files.wordpress.com/2011/02/1.jpg

[19] Chueca Goita, F. *Historia de la Arquitectura Occidental. Tomo V (El Siglo XX: de la Revolución Industrial al Racionalismo)*. Madrid: Dossat, vol. 11, 1979, p. 31.

[20] Kostof, S. *Historia de la Arquitectura*. Madrid: Alianza Ed., 1988, p. 1035.

[21] Gobbo, A. *Volte in ferro e laterizio all'inizio del XX secolo. Tecnica costruttiva, casi di studio, diagnosi e conservazione*. (PhD thesis), Polytechnic of Milan, 2009 – 2011, p. 59.

[22] Hitchcock, H. R. *Architecture: Nineteenth and Twentieth Centuries*. New Heaven and London: Yale University Press, 1958, pp. 177 – 178.

[23] Gloag, J., Bridgwater, D. *A History of Cast Iron in Architecture*. London: G. Allen and Unwin, 1948, pp. 202 – 204.

In France the reply to Paxton's masterpiece came in 1855 with the Universal Exhibition in Paris, dedicated to the industrial products. The Palace of Industry was thus the main building of the whole compound and featured a rectangular plan like a basilica, with a big central nave (48 m wide) and smaller lateral aisles. The roofing consisted in a huge glazed vault, carried by hand-forged iron lattice girders, counterbalanced by the structure of the lateral aisles that avoided the need of tie rods. Although structurally impressive, the Palace of Industry was however less audacious than Paxton's masterpiece, since it did not feature the same lightness and pureness of the British Palace, resembling more a railway station than a *jardin d'hiver*.[24]

Figure 5 Section of the *Galeries des Machines* by Berthelin. Source: www.art.rmngp.fr

But the most celebrative and evocative representation of the metallic construction was presented in the Exhibition of 1889, where the iron elements triumphed in a sort of public celebration: the Eiffel Tower and the Gallery of Machineries were in fact the most memorable elements of the event. The iron was in fact the main character of both and featured a matured and aware use: the assembling of single parts forming one element is now completely achieved and matured, involving every metal part of the construction, even the double T beams and the angular sections. The Gallery of Machineries, by Cottancin, is the final result of the long path in the investigation of the behaviour of materials since it underlined the mastery of the scientific and static research on curved solutions, joining arches and pivoting elements: the constructive module consists of three-hinged arched forming porches supported by ball-and-socket joints located in the keystone and in the supports. The porch slightly elevates from the ground

[24] Chueca Goita, F. *Historia de la Arquitectura Occidental. Tomo V (El Siglo XX: de la Revolución Industrial al Racionalismo)*. Madrid: Dossat, vol. 11, 1979, p. 31.

following immediately the inclination of the coverage, featuring like a Tudor arch that forms the vault and the support together[25] .

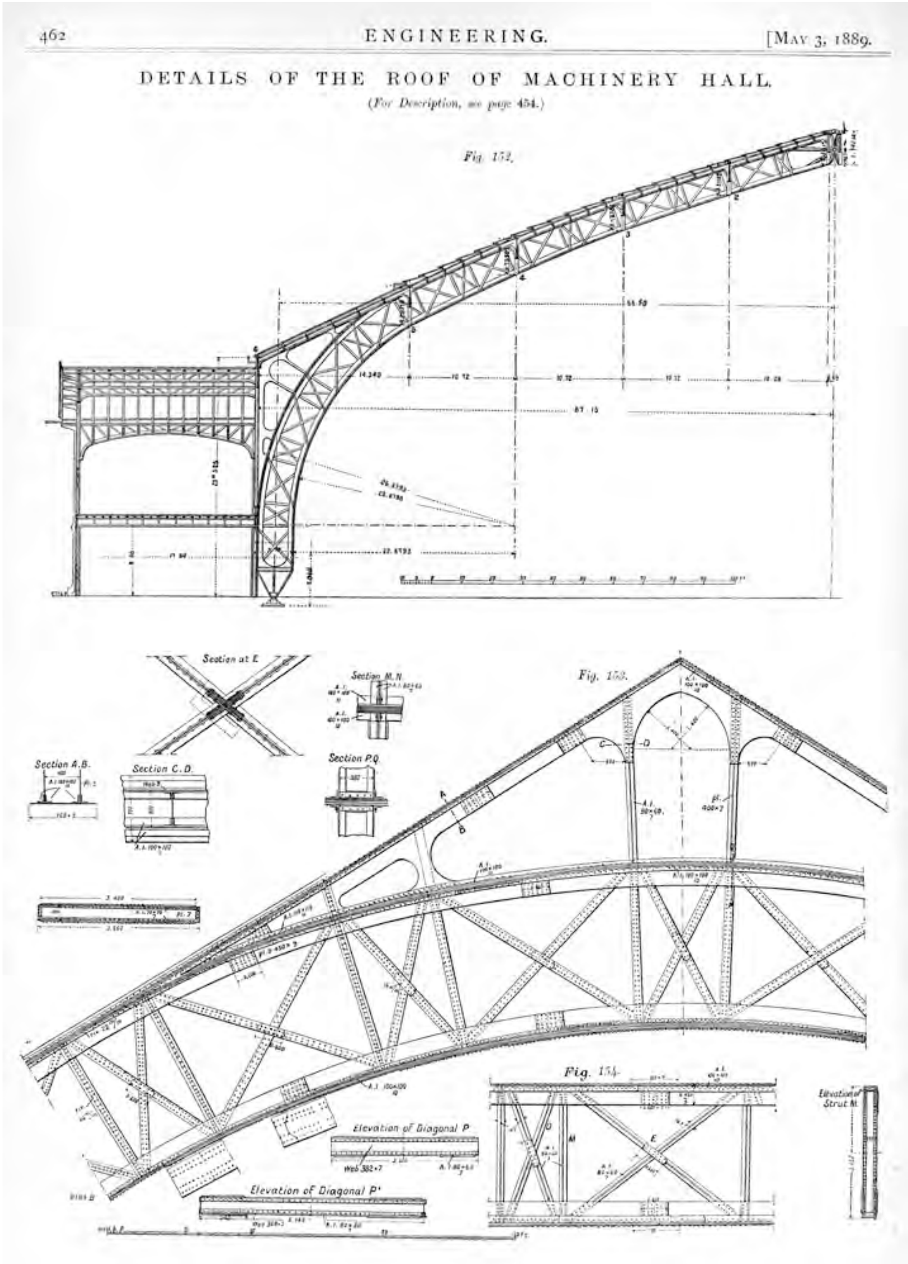


Figure 6 Details of the roofing of the machinery hall. Source: www.upload.wikimedia.org

Paradoxically the most impressive building featuring a whole iron skeleton and glazed walls free from masonry and full sections, i.e. the Crystal Palace in London, was the one which led to the progressive abandon of the iron frame since it was perceived as a new order of things in the architectural composition which was not suitable for representative and public buildings because they needed a more authoritarian and familiar composition and construction to affirm and

[25] Ibidem, pp. 31 – 35.

confirm their powerful presence. These buildings kept therefore preferring the traditional system consisting of stoned and bricked masonry as they were presented in the handbooks and treaties of the time. Iron and steel were thus destined to be employed mainly in a particular branch of the constructions, related to the industrial productions, the storages, factories and pavilions, railway stations and so on, since they were considered the ideal materials for covering huge areas with a good lighting and a great availability of serial components.

*Industrial Architecture*

Industrial architecture became soon the ideal context for the application of the new constructive typologies and techniques, mainly in those Countries where there were availability of primary goods, i.e. iron and coal, and a sensibility for the spatial and constructive skills of metallic building. Great Britain developed in that sense a very impressive number of facilities and infrastructures where the metallic components prevailed and frequently constituted the very essence of the project. In 1830 there is the building of the Crown Street Station in Liverpool, which contained the embryonic elements that will be further developed in the infrastructures of the same type[26]: a covered patio for the vehicles, services and a covered main hall housing the tracks and the trains, which will become the *leitmotif* for the further exploration of the possibilities of covered halls and factories built with an iron frame.

[26] Hitchcock, H. R. *Architecture: Nineteenth and Twentieth Centuries*. New Heaven and London: Yale University Press, 1958, pp. 170 – 172.

Figure 7 The Crown Street Station. Source: www.upload.wikimedia.org

In 1854 another great station, the New Street in Birmingham, featured a single space of 65 meters long, lighted thanks to the glazed panels on the roof, while the pavilion in Paddington Station in London featured a greater hall, 74 meters long, with a framework consisting of bow beams with inner frames following the strains. These arched vaults covering huge surfaces were concealed externally by a sort of representative or "recognizable" façade, simulating a palatial front, as like as the familiar series of columns in the Roman architecture had concealed the pompous vaulted interiors. The astonishing impression, once inside the building, was in fact the same in both cases: the railway station represented in fact the laboratory to experiment the new techniques, allowing to cover great areas with single, lighter elements, flooded with light and destined to house a representation of the incoming future, i.e. the machinery, the train, the modernity. The presence of the masonry in the façade was in that sense a mitigation of the impact with the new era, since it featured familiar characters, declined along with the sensibility and the stylistic tastes of the time in order to give to the people a sense of domestic ambiance and safety. A combination of Neoclassical and Neo-Renaissance elements lied together with the masked iron construction, which was frequently connected inside the walled portion to achieve a greater stability and to reinforce the whole system[27] [28].

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[27] Ibidem, pp. 172 – 173.
[28] Kostof, S. *Historia de la Arquitectura*. Madrid: Alianza Ed., 1988, p. 1038 – 1039.

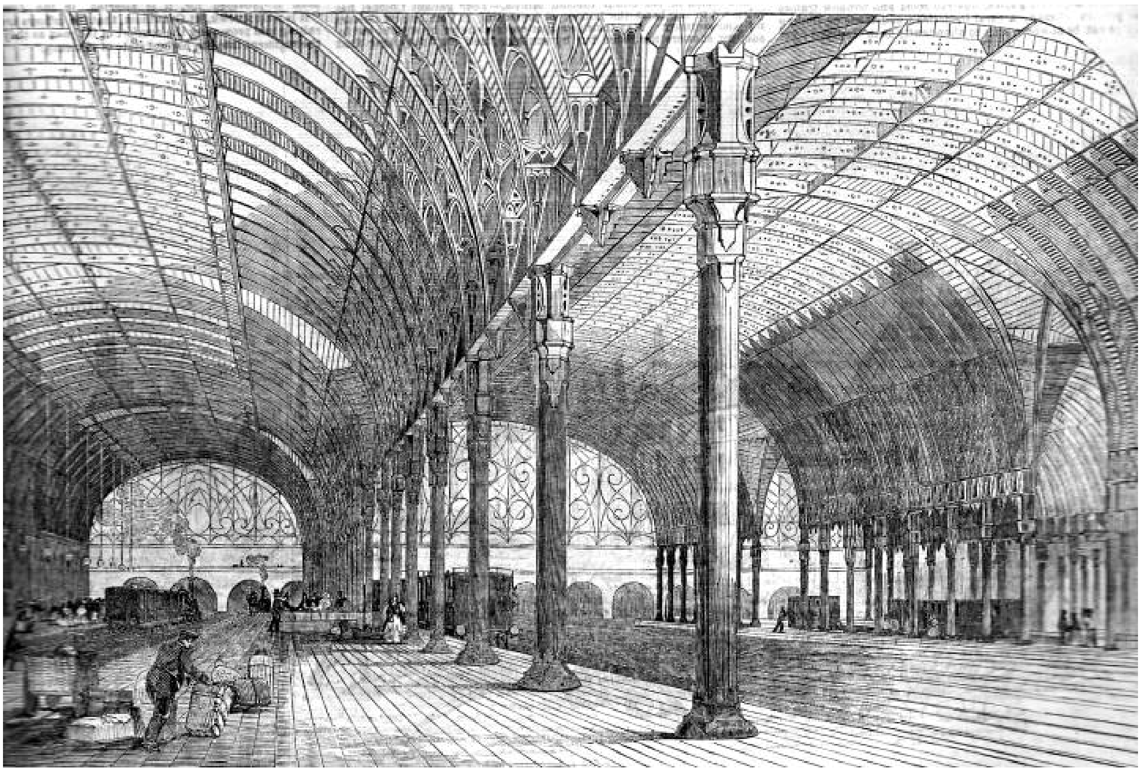


Figure 8 Paddington Station. Source: http://www.victorianweb.org/technology/railways/80.jpg

Moreover, railway stations usually featured a mixed construction, with iron and glass portions forming the roofing – generally shed shaped – and masonry sections that are not involved in structural or bearing functions but simply concealing the metal frame without searching for integration.

Sometimes the accordance between metallic frame and masonry was found in the stylistic unification, such as in Temple Meads in Bristol designed by Isambard Brunel in 1839-1840: here the medieval stylistic formulas are in fact applied to both metal and masonry components, which – unlikely from the other railway stations – feature a wooden frame in the coverage recalling the 14th century hammerbeam roof of Westminster in London[29].

[29] Hitchcock, H. R. *Architecture: Nineteenth and Twentieth Centuries*. New Heaven and London: Yale University Press, 1958, pp. 178 – 180.

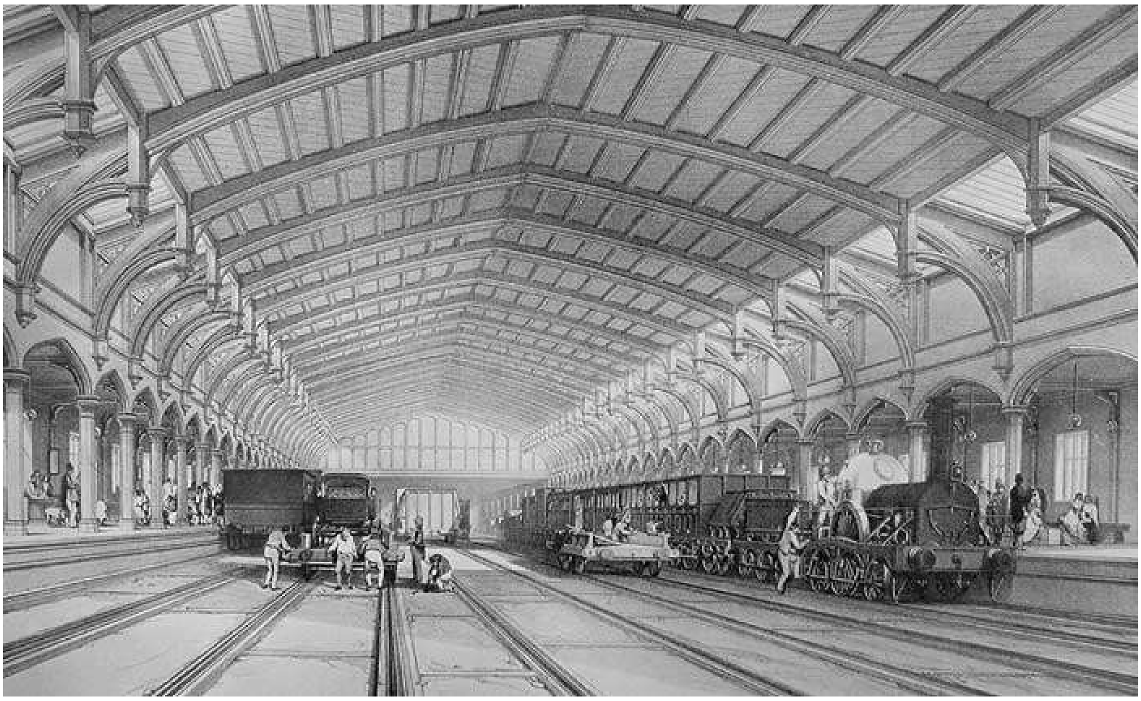


Figure 9 Temple Meads Station. Source: www.historicengland.org.uk

*The bridges*

The bridges were another ideal theme for the application of the new principles. The development of iron bridges started, however, earlier than the other transporting facilities since the fluvial trades had previously required the availability of a great number of bridges along the most practiced routes. In Great Britain the engineers found a very fertile ground to develop the issue: in 1779 we find the oldest iron bridge, designed by Abraham Darby III and T. F. Pritchard on the river Severn, near Coalbrookdale. The bridge, 30 meters long, featured a single arch, almost semicircular, consisted of five beams in melted iron and composed by only two pieces. Instead of screws, the designers assembled the pieces with holes and staples joined together. This expedient was therefore the answer to one of the most annoying issue of the design, i.e. the partition of a whole elements in single pieces in order to be transported and reassembled *in loco*.

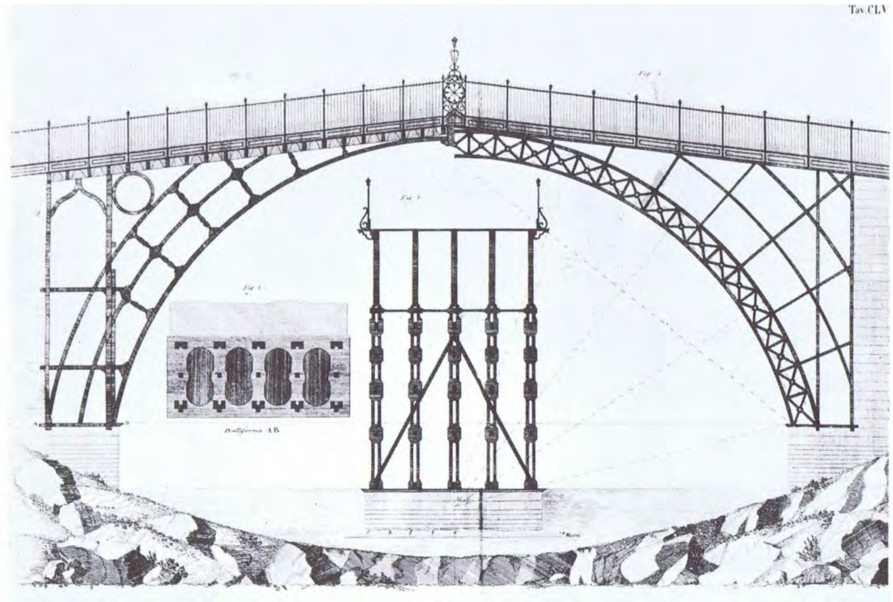


Figure 10 Details of Coalbrookdale bridge. Source: www.fantasticpixcool.com

In the Sunderland Bridge the pieces forming the single arch were built by melted iron panels which acted like the flared keystones in the masonry arches. The engineer Thomas Telford declined stylistically the theme of the iron bridges, adding a sort of "architectural sensibility" to their configuration: the masonry counterforts featured like picturesque elements combined with friezes and decorative iron elements, although keeping the primary structural function. In the Menai Bridge, in Wales, the suspended structure covers the impressive span of 177 meters: the road path is inserted among iron rods and fitted in the deepen soil at both the ends, while masonry arches anchor the metal components to the basement, enlightening the mass of the masonry and stiffening the whole system thanks to the collaboration of the chaining. The metal surfaces are preserved from corrosion thanks to linseed oil[30].

[30] Kostof, S. *Historia de la Arquitectura*. Madrid: Alianza Ed., 1988, p. 1040.

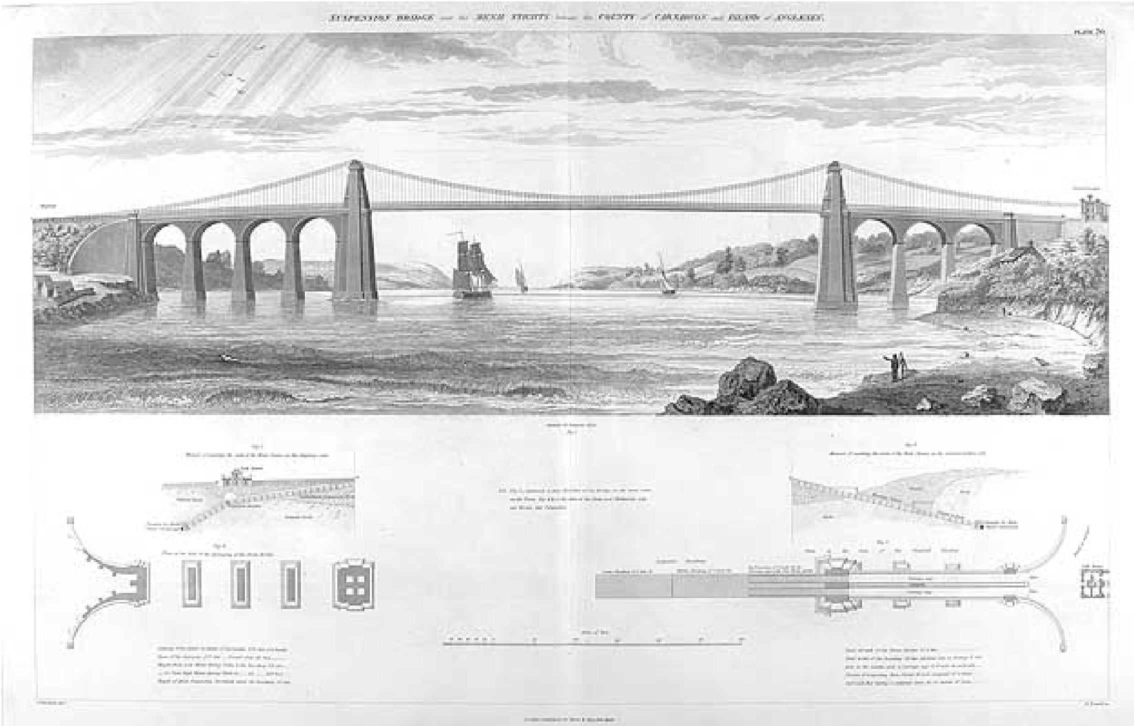


Figure 11 Telford's project for Menai Bridge. Source: www.nls.uk/news/pop_ups/menai-suspension-bridge

From the initial model with flat trusses we pass to the tubular section for the beams, used particularly for the railway bridges, and visible in the Britannia Bridge – always on Menai river – built in 1850 by Stephenson and Thompson with nailed iron bars and laminates, allowing therefore to cover great spans and evolving in different variations in France and Germany[31].

*Materials, forms and innovations*

The structural principles basing on the independent frame – featuring a variety of materials – date back to the end of the 18th century and were applied throughout the 19th. Different architectural typologies got advantage of the new building systems, which were applied both in civilian and in industrial categories of buildings. The progresses of science and technology were then combined with the innovations in the architectural styles, which preferred a renovated reminiscence of the historical languages to conceal and make more pleasant the new forms of construction, reflecting a dualism between structure and façade that merely went along with the social conflicts of the 19th century world. Regarding the factories, these were frequently designed and developed as a proper typology in order to represent the new establishment, a new social class that took its strength through the availability of great funds and budgets but that still

[31] Hitchcock, H. R. *Architecture: Nineteenth and Twentieth Centuries*. New Heaven and London: Yale University Press, 1958, p. 180.

needed a proper acceptable style: monumentality and historical reminiscence were therefore the best passport to enter in the new industrial world, where bricked façades bolstered a traditional impression and a material power of the new born industrial *bourgeoisie*. Traditional forms and new functions, new machineries and techniques led to the innovative industrial language of the first decades of the 1800s, further evolving in a depurated alchemy of independent frames, where the elements were no more concealed under the wall mass and the façades progressively abandoned the brickwork curtains.

The cast iron column was the first structural material produced through industrial methods to be used in constructions[32]. In 1780s this new element replaced the former wooden pillars to support the roofing in the textile factories in Great Britain. The iron pillars, generally, were used along with traditional masonry and concealed inside the bricked or stoned portions since they were perfectly able to support compression strains but not deflections. This resulted in the frequent substitution of masonry with iron or cast-iron columns that allowed to light in the ground floors, especially in the commercial and leisure buildings.

The long journey to the freedom of the independent frame – mainly in the industrial architecture – started in the last decades of the 18th century in Great Britain, where multi-storey factories featured a metallic skeleton that allowed an optimal spatial and volumetric distribution, especially in the textile production. In that period the energy was provided by local sources, generally located in a specific place near the building, while the main building consisted of open spaces for the machinery, natural lighting and ventilation for the employees: Lombe's mill, built in Derby in 1718-1722, reflected perfectly this typology thanks to its six-storey block, the brickwork masonry, rows of windows and timber frame inside designed by the same owners[33]. The traditional barn was in this case the referring model, but the risk of fire and disastrous events led to the search of new constructive solutions to prevent accidents in the factories: initially the structures were coated with whitewash or plasters but then these were replaced by cast-iron elements, at least in the vertical sections, keeping timber slabs. Furthermore, the renovating process was implemented and radicalized with the replacement of timber components with cast-iron ones in the whole structure: the brickwork façades were still present both because of the need of a balanced and resistant masonry and because of the permanence of familiar or

[32] Chueca Goita, F. *Historia de la Arquitectura Occidental. Tomo V (El Siglo XX: de la Revolución Industrial al Racionalismo)*. Madrid: Dossat, vol. 11, 1979, p. 17.

[33] Fitzgerald, R. The development of the cast – iron frame textile mills to 1850. *Industrial Archaeology Review*, 10, n. 2, 1988, pp. 127 – 145. Op. cit. in Sutherland, R.J.M. *Structural Iron 1750–1850*. London: Routledge, 2016.

vernacular tastes in the composition. The first episode of a whole cast-iron frame in an industrial facility comes from the Flax mill in Ditherington, designed by its owner Charles Bage in 1797: the cross-shaped cast-iron columns were in fact combined with metallic beams and bricked arches forming the slabs. This structure was then perfected in the Philip & Lee Mill in Salford thanks to the innovations by Boulton and Watt: the cast-iron columns were hollow and supported double T cast-iron beams with a variable height, and slabs consisted of the typical binomial beams and bricked arches. The *Salford Mill* is one of the first building to show and entirely metal frame: it does not features only cast-iron pillars, but also iron beams that jointly form an integral reticular frame. The beams were conceived as thick plat-bands or double T sheet iron placed on the edge in order to achieve a better moment of inertia, not yet calculated but practically guessed. Obviously the presence of the metallic frame was not left exposed, but concealed through bricked masonry that gave to the factory a reassuring character inspired to the traditional buildings with masonry structure[34] [35]. Since 1836 the factories started a full production of double T shaped metal bars and since 1845 they were produced in laminated iron. William Fairbairn, an industrial and naval builder, achieved even better results in the preservation of iron elements, using a tubular section designed in Manchester in 1846: in 1845 he had previously applied them in an eight - storey refinery where cast-iron columns were replaced by forged iron columns combined with iron beams featured as flattened arches and vaults made of bricks and thin iron girders, then covered with cement in order to achieve a better fireproof structure[36].

The metallic frame kept as a standardized element of the industrial architecture until the end of the 19th century thanks to the adaptability of the spatial solutions to the needs of the various buildings and to the various functional possibilities. The cast-iron, which was the leading element of the first buildings (both civilian and industrial), was replaced by the iron as the metallurgic industry gradually improved: the first innovation consisted of structural shear steel and then of soft-cast steel and rolled profiles, the latter coming from the Czech regions since

[34] Fitzgerald, R. The development of the cast – iron frame textile mills to 1850. *Industrial Archaeology Review*, 10, n. 2, 1988, pp. 127 – 145. Op. cit. in Sutherland, R.J.M. *Structural Iron 1750–1850.* London: Routledge, 2016.

[35] d'Alpoim Guedes, P. P. *Iron in building, 1750 - 1855: Innovation and cultural Resistance*. PhD Thesis, School of History, Philosophy, Religion & Classics, University of Queensland, December 2010, pp. 60 – 62.

[36] Castillo – Olivares, M. D. A., Alcaide, V. N., Martínez Pino, J. *El Siglo XIX: la mirada al pasado y la modernidad*. Madrid: Editorial Universitaria Ramon Areces, 2015, p. 155 – 156.

1836[37]. The spatial modifications were also due to the replacement of spinning machineries and water - powered wheels – typical of the 18th century – by larger and longer machinery and the steam engines that brought to new building layouts: the *mise au point* of the riveted assemblage of single elements allowed in fact to amplify the sections and the spans of the frames, which repeated infinitely its basic elements in order to cover huge areas developing both in largeness and in height. The aesthetic in those days was peculiarly enslaved to the stylistic embellishment and the formal combination of decorative languages that frequently enhance the lightness and the slimness of the vertical sections, increasing the spatial sense of productivity and modernity of the industrial building. The façades that initially concealed the presence of the inner frame – although declaring it through the presence of glazed portions and windows to flood in the light – are progressively conceived to underline the presence of the independent skeleton thanks to the application of Eclectic formalisms that reflect outside the structural elements[38]. The evolution of the covering systems from the initial phases until the 1850s saw the permanence of cast-iron elements that just ten years later were replaced by riveted iron beams and girders, signing their final disappearance. Furthermore new iron (and then steel) trellises made its appearance forming the bone of most industrial or expositive buildings thanks to the greater lightness, allowing to design more transparent buildings where the light could flood in from multiple directions[39].

By 1850s we find numerous variations in the design of iron buildings, showing that there were not a predetermined preference in the choice of one constructive system or another: the main reasons of this behaviour refer to the absence of a proper centralized governance of the building policies, lacking therefore of an endorsement or promotion of a specific method, and to the open field of experimentation and invention of new solutions by the engineers, the builders or the simple owners in order to captivate the building market. Combinations of wooden, cast-iron and wrought iron elements and auxiliary solutions were frequently proposed, improved and applied with a constant development in the assembly and in the technology,

[37] Šenberger T., Hořická, J. Structure impact on architectural form of multi-storey factory buildings of industrial revolution. *Structures and Architecture: Concepts, Applications and Challenges*. London: Taylor & Francis Group, 2013, pp. 1922 – 1924.

[38] Chueca Goita, F. *Historia de la Arquitectura Occidental. Tomo V (El Siglo XX: de la Revolución Industrial al Racionalismo)*. Madrid: Dossat, vol. 11, 1979, pp. 23 – 24.

[39] Fitzgerald, R. The development of the cast – iron frame textile mills to 1850. *Industrial Archaeology Review*, 10, n. 2, 1988, pp. 127 – 145. Op. cit. in Sutherland, R.J.M. *Structural Iron 1750–1850*. London: Routledge, 2016.

making the iron production expanding and increasing the investigation on new means to implement the standards.

Iron mills, warehouses and factories were of course an optimum field of experimentation, especially in Britain where textile factories featured frequently the presence of columns and iron components: until the 1840s the average design of these buildings featured a normal span of 4,27 m due to the dimensions of the machinery, but after the increasing of the standard size there was the need of greater spans resulting often in a double row of slender cast-iron columns dividing the floors and providing larger surfaces for the factories[40]. The use of iron frames is usually explained in the need of fireproofing structures, but it should be also motivated by the fact that ironworks were intended also as integral supports for the machinery parts, forming thus a sort of huge mechanical frame where structure and machinery formed an unique ensemble, surrounded just by the masonry walls containing it[41]. The integration of building and machinery was therefore a condition linked to the increase of iron sections, which allowed larger spans than the cast-iron to amplify the spatial distribution of bearing elements. In the early decades of the Nineteenth century we assist then to a proliferation of new constructive possibilities offered both by inventors and designers that had recognized the iron as an ideal material for creative designs, embellishments and building resistance: the tailor-made design proposed by the architects working for the industrial establishment was accompanied by the inventors' prerogative for the elaboration of new generalized systems applied to a wider market, where already well known solutions could be combined and adapted to suit specific requirements for the industries[42].

*Publications and Patentees*

The predominance of metallic frames in the industrial architecture of this era – jointly to the civil one – was also motivated by the political scenario that saw the levitation of the cost of the

[40] d'Alpoim Guedes, P. P. *Iron in building, 1750 - 1855: Innovation and cultural Resistance*. PhD Thesis, School of History, Philosophy, Religion & Classics, University of Queensland, December 2010, p. 62.

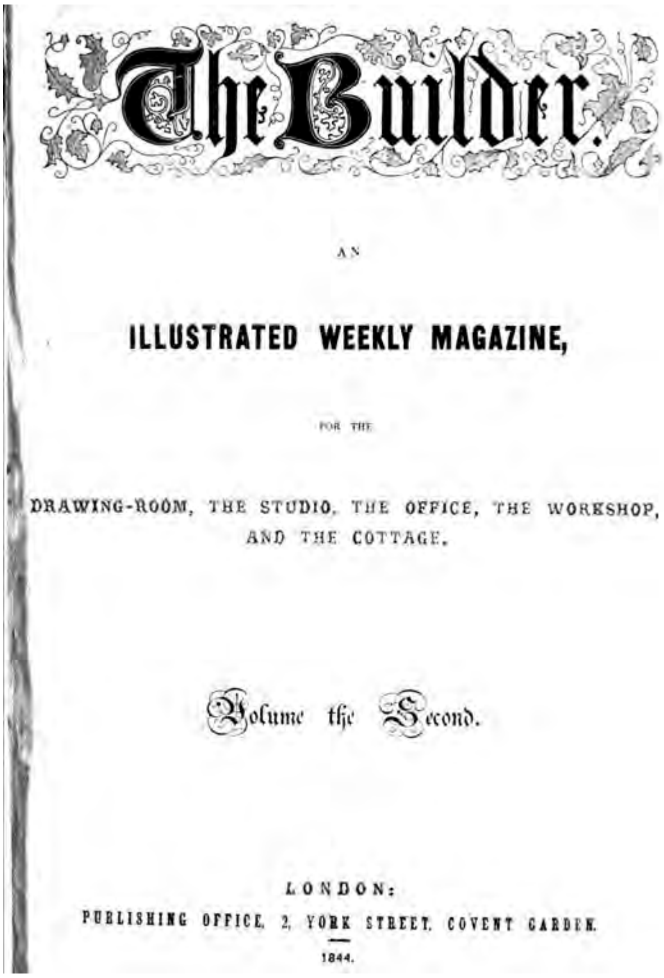
[41] During a meeting of the Institution of Civil Engineers in 1849 the engineer John Farey claimed that: "One reason which existed for constructing mills with great solidity was, that in the old wooden mills, the wear and tear of the machinery, consequent on the vibration, was twice as great as in the more modern buildings, with iron girders and columns, and brick arches." Ibidem, p. 63.

[42] Munce, J. F. *Industrial Architecture An analysis of international building practice*. New York: F. W. Dodge Corporation, 1960, pp. 2 – 3.

timber, especially from the Baltic[43]: iron was therefore more attractive than wood and could be a good alternative mainly thanks to the possibilities of replication of single elements, combination of jointed parts, availability of different sections and lengths, which were on the contrary impossible with timber components. Iron structural parts were in fact available in a variety of sizes, finishing and forms and also required a progressive expertise of specialists, architects and engineers to adapt former solutions to the new materials. The question about "how to design" the iron components and the structural elements was thus to be answered inside the same foundries and in the emerging sectors of the production, such as the mechanical industries and the scientific world of the investigation of the materials' behaviour and properties. Until the 1850s iron structures spread to a wide variety of typologies and dimensions, thanks to the adaptability and the availability of greater spans – more than 16 m – that could not have been achieved by timber structures, resulting in unprecedented examples of building expressivity. The static and the resistance of these elements was, however, a totally different issue: in the first years of application, the calculating of the size of the structural elements was still far from the expertise of architects and builders. The solution was then to be searched in the variety of technical publications, journals and magazines that spread in those years divulging the theories and the practical experiences in the iron constructions: the Architectural Magazine, the Civil Engineer and Architect's Journal were the referring sources of the 1830s, along with William Turnbulls' *Treatise on the Strength Flexure and Stiffness of Cast Iron Beams and Columns* of 1832, in which the author explained the direct observation in the foundry of *Cottam and Hallen* of the deflections and the resistance of beams and columns of various dimensions[44]. The need for architects for information on iron calculating resulted in several handbooks and formulae mainly derived from the general treatise on constructions (we must not forget that Rondelet's treatise showing building solutions and the behaviours of materials had already been published) and from the practice in building yards: from 1842[45] the publication *The Builder* became one of the most quoted in covering the aspects of experimentation, structural theories and practical architecture and since 1845 it published a series of tables and notions about the use of cast-iron beams and the calculation of the correct sizes[46] anticipating the further publications of *Civil*

[43] d'Alpoim Guedes, P. P. *Iron in building, 1750 - 1855: Innovation and cultural Resistance*. PhD Thesis, School of History, Philosophy, Religion & Classics, University of Queensland, December 2010, p. 66.
[44] Ibidem, p. 76.
[45] Ibidem, p. 77.
[46] Ibidem, p. 78.

*Engineer and Architect's Journal* and others that explained the complex mathematical formulae for the calculation.


The Builder.

AN

ILLUSTRATED WEEKLY MAGAZINE,

FOR THE

DRAWING-ROOM, THE STUDIO, THE OFFICE, THE WORKSHOP, AND THE COTTAGE.

Volume the Second.

LONDON:

PUBLISHING OFFICE, 2, YORK STREET, COVENT GARDEN.

1844.

Figure 12 Frontispiece of The Builder, 1844. Source: www.bodley.ox.ac.uk

About 1850 we see the edification of the Albert Docks in Liverpool, designed by Jesse Hartley, who avoided the use of combustible materials and introduced a new spatial concept, borrowed from Thomas Telford and Philip Hardwick' docks in London (1820s): the warehouse were in fact supported by metallic pillars built directly on the dock wall with open wharfs that entered inside the buildings; floors were sustained by inverted Y beams, which were ideal since the distribution of the material went to the lower flange and the upper part contained the springers of the bricked arches carrying the pavement[47] [48]. This type of Y beams, which had already been

[47] Kostof, S. *Historia de la Arquitectura*. Madrid: Alianza Ed., 1988, p. 1044 – 1045.

[48] Fitzgerald, R. The development of the cast – iron frame textile mills to 1850. *Industrial Archaeology Review*, 10, n. 2, 1988, pp. 127 – 145. Op. cit. in Sutherland, R.J.M. *Structural Iron 1750–1850*. London: Routledge, 2016.

experimented by Charles Dyer in London in 1842 in the project of an office building[49], were chosen by Hartley among six different projects, featuring different structures and tests to determine the resistance to sudden impacts and fire: finally the designer chose the Y beams thanks to the responding to the tests and to their cost[50]. The same testing approach was proposed also by William Fairbairn when he was commissioned to design fireproof warehouses in 1844: the report following the construction, published in *The Edinburgh New Philosophical Journal* in 1845, explained Fairbairn's recommendation to pay particular attention to the sections of bearing elements – since the increased loads to bear – and to add an extra weight due to the accidental fall of stored goods. His experience in the determination of iron resistance to the increase of temperature resulted in the expedient of introducing cold air into the hollow of the pillars through tunnels under the floors, but this was still far from the solution of the fireproofing in metal frames[51]. The first innovation in this sense was introduced by the application of insulating materials to the iron components, forming casing of fire-clay that insulate the metal parts in the event of fire. The solution consisted in fact of a layer of coarse filling and lime plugged in the ceilings and around the joints, along with mortar and finishing coat that levelled the surfaces: the metal was therefore protected by plaster, which also became an integral part of the floorings and could be used practically in every typology since it gave a more finished appearance to the whole construction. The introduction of this method gradually went on and finally became the most reliable system of fireproofing and was patented by the Fox and Barrett enterprise since 1850s. Other expedients to fireproof – and moreover waterproofing – the buildings consisted in addition of coal-tar and lime, rough plasters and layers of earth.[52]

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[49] d'Alpoim Guedes, P. P. *Iron in building, 1750 - 1855: Innovation and cultural Resistance*. PhD Thesis, School of History, Philosophy, Religion & Classics, University of Queensland, December 2010, pp. 79 – 80.

[50] Ibidem, p. 80.

[51] Coad, J. Two Early Attempts at Fire-Proofing in Royal Dockyards. *Post – Mediaeval Archaeology*, vol. 7, 1973, pp. 88-90.

[52] In Marshall's Temple Mills in Leeds, designed by James Combe in 1842, the earth stratus was sown with grass, forming a 8 cm thick layer. See: d'Alpoim Guedes, P. P. *Iron in building, 1750 - 1855: Innovation and cultural Resistance*. PhD Thesis, School of History, Philosophy, Religion & Classics, University of Queensland, December 2010, p. 106.

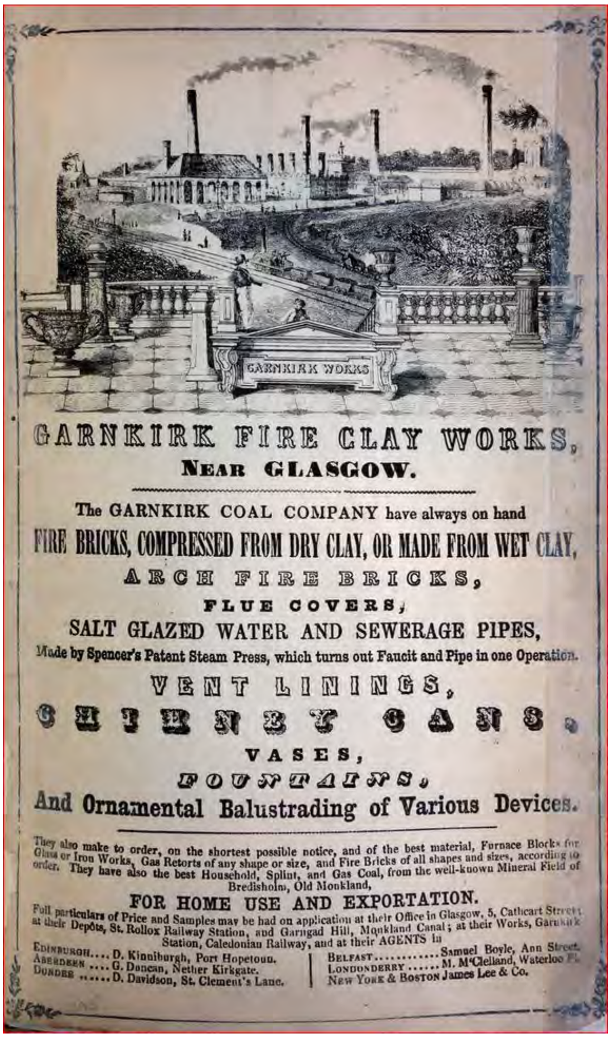


Figure 13 Garnkirk Fire Clay Works Advert 1852.

Source: www.scottishbrickhistory.co.uk/history-of-brickmaking-at-garnkirk/

The patentees are another aspect of the evolution of industrial architecture in the 1850s: since they were granted and considered responsible of the damages and the accidents that a building might suffer, the designers were finally free to dedicate themselves to the whole conception of the buildings without the risks of a structural failure. The evolution of the working processes of iron industry led furthermore to the development of new sections of wrought iron beams and girders, which became economically competitive respect to the other sections and were therefore applied in greater scales of buildings. Girders and beams were still concealed behind surfaces and ornaments but the increase in sheer size allowed the architects to build a greater variability of spaces and plans, according to the typologies and the functions to be suited. New patented flooring systems offered reliable conditions of wider spans and sections, undertaking the calculation, the upholstery and the responsibility for the built solution and, moreover, granting to the designer any appearance of finishing he preferred.

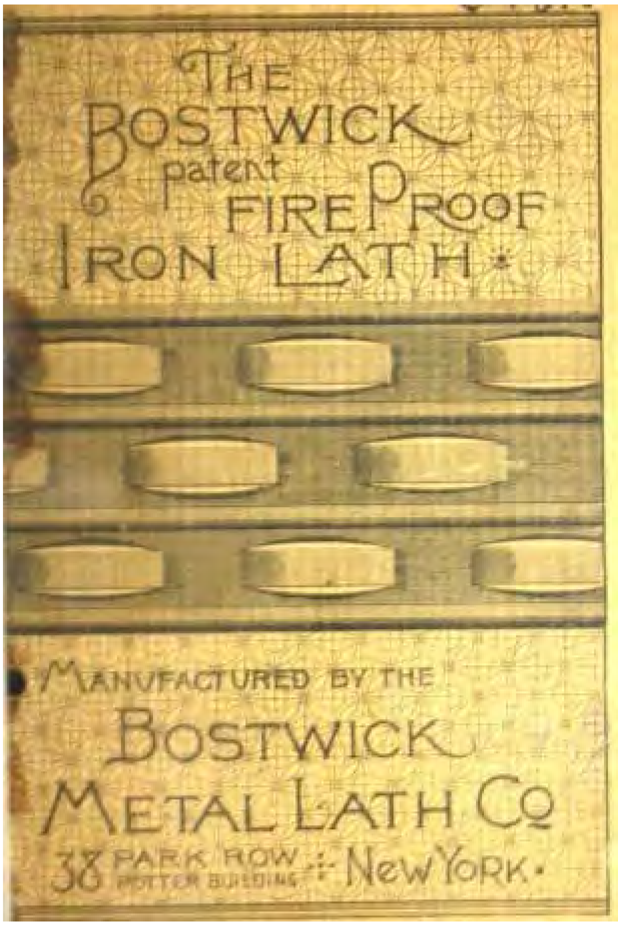


Figure 14 Bostwick Patent of Fireproof iron lath, 1890.
Source: https://archive.org/details/BostwickPatentFire-proofIronLath

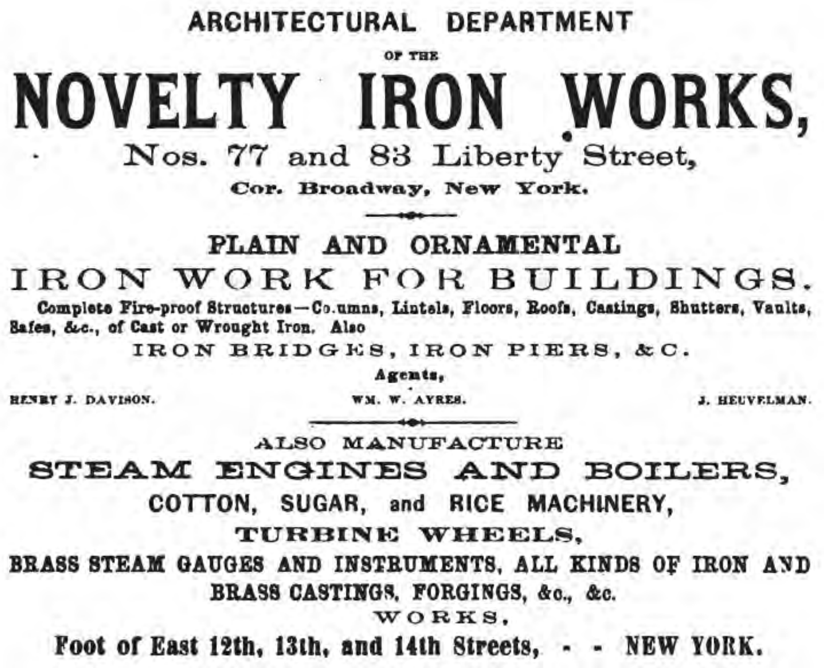


Figure 15 Advertisment of 1862 promoting novelty iron works. Source: upload.wikimedia.org

The initial application of these expedients was, however, deemed of architectural poorness due to the traditional familiarity with the proportions of timber and masonry elements, which were challenged by the new sections and the slender figures of iron components. The challenge to the past and the ancient solutions, proper of the most aulic edifications of the British and French Neoclassicism, was accepted by the architects who saw an exciting opportunity to develop a new architectural language: large open spaces, free visibility, absence of masonry obstructions and slender elements became then the main components of a new spatial experience. The combination with glass resulting in skylights and big windows was an additional element that contributed to achieve a level of natural lighting and ventilation without precedents. The variation presented by single naved factories was, in addition, a new version of the same thematic: the buildings consisted in fact of huge volumes, occupied only by the bearing structure and left completely visible and accessible by machines, with favourable ventilation and illumination; the halls were therefore climatically uniform, featured a great flexibility of space and movements and moreover were better protected from fires thanks to the absence of intermediate floors. These buildings came finally a recurrent typology for commercial facilities and warehouses, factories and mills and developed frequently as masonry shells with open spaces and columns. In the last quarter of the Nineteenth century there is a further evolution of this model, especially in commercial buildings, bringing the light into the centre of the volume to the atria and floors supported only by columns and external walls[53].

*Roofing*

The design of metallic roofs kept being a central question in the architecture of the 19th century. The first precedent of iron roof dated back to Jacques-Germain Soufflot and his roof covering the staircase in the Louvre in Paris: the spans were however modest and the main structure consisted of wrought iron frames supporting a skylight; it was followed in 1789 by the roof of the *Théâtre Français* in the Royal Palace by Victor Louis, who reached a span of 23,4 m combining iron framework and hollow clay-pot vaults to achieve a fireproof structure and by Renard's iron roof for the *salon d'exposition des tableaux* in the Louvre in the same year[54].

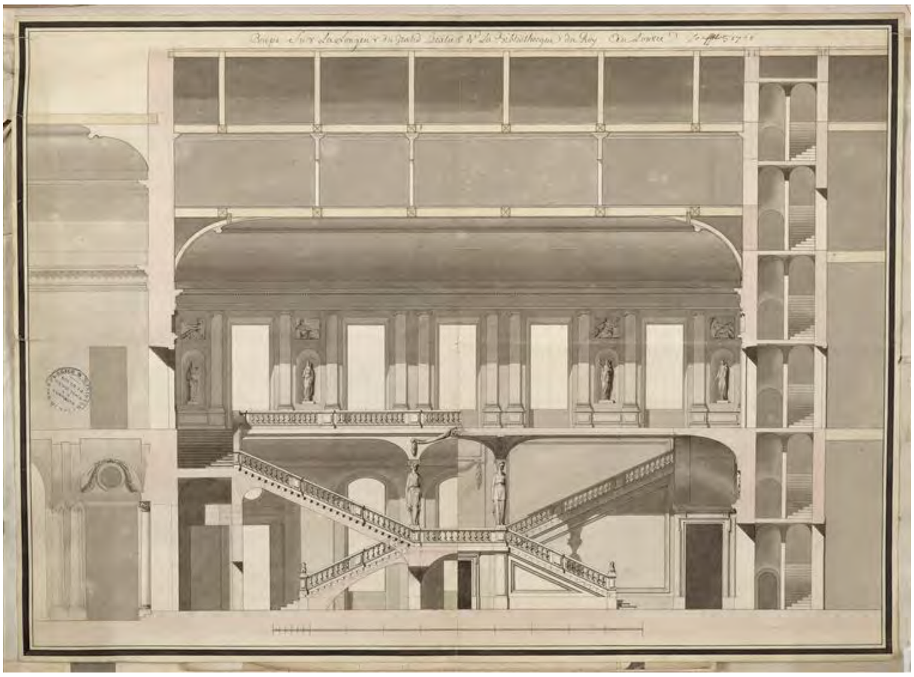

Figure 16 Section of Soufflot's staircase in Louvre. Source: www.photo.rmn.fr

[53] Hitchcock, H. R. *Architecture: Nineteenth and Twentieth Centuries*. New Heaven and London: Yale University Press, 1958, p. 184 – 186.

[54] d'Alpoim Guedes, P. P. *Iron in building, 1750 - 1855: Innovation and cultural Resistance*. PhD Thesis, School of History, Philosophy, Religion & Classics, University of Queensland, December 2010, p. 108.

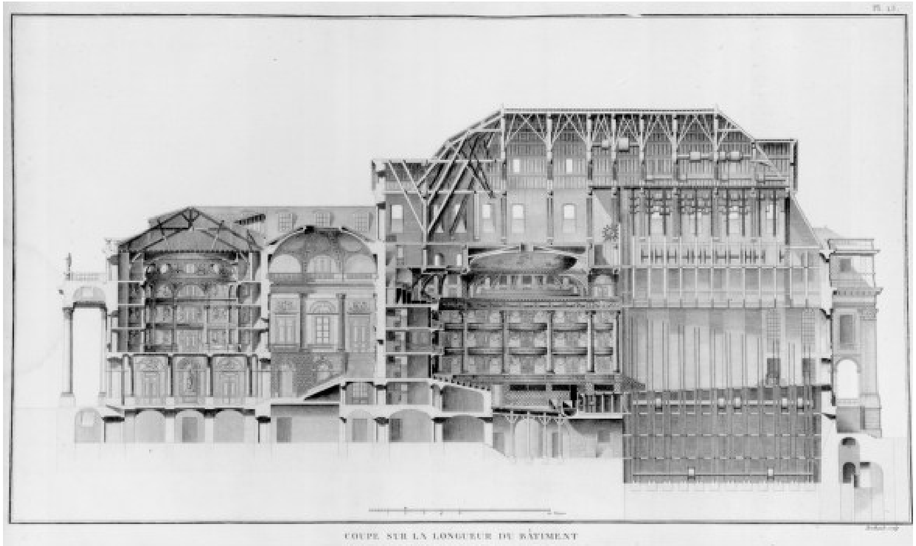


Figure 17 Section of the *Théâtre Français* by Victor Louis Source: www.act.art.queensu.ca

The peculiarities of these buildings were, of course, the zenithal light coming from above, leaving the walls free of windows and dedicated to the expositions and these features claimed, obviously, the attention of the second great Country investigating in new building technologies. British engineers and architects dedicated their efforts to study the building of iron roofing and until 1850s their design consisted mainly in a combination of wrought iron and cast iron elements that had been perfected along the years. In the first phase iron roofs were employed along with iron frames – particularly in industrial buildings – and fireproofed in every part: one solution saw the extension of the iron columns to support the frames of the roofing, borrowing the principles of floors supporting. This technology was already employed in Bage's Ditherington Mill in Shrewsbury in 1796 and in several mills of the first decades of the 19$^{th}$ century where the iron columns were intended as props for the sloping rafters that formed a sort of a loft under the roof.

Figure 18 Ditherington Flax Mill. Source: /www.gooseygoo.co.uk

The second solution saw the extension of iron frames up to greater spans in order to cover the whole width of the buildings to achieve a free inner space to place the looms and machinery: the greatest effort was, however, to build a structure that would not thrust laterally against the walls and therefore it was frequently designed as arches acting as rigid beams or tied at the level of the springers by iron rods.[55] [56]

[55] Fitzgerald, R. The development of the cast – iron frame textile mills to 1850. *Industrial Archaeology Review*, 10, n. 2, 1988, pp. 127 – 145. Op. cit. in Sutherland, R.J.M. *Structural Iron 1750–1850.* London: Routledge, 2016.

[56] d'Alpoim Guedes, P. P. *Iron in building, 1750 - 1855: Innovation and cultural Resistance*. PhD Thesis, School of History, Philosophy, Religion & Classics, University of Queensland, December 2010, pp. 105 – 106.

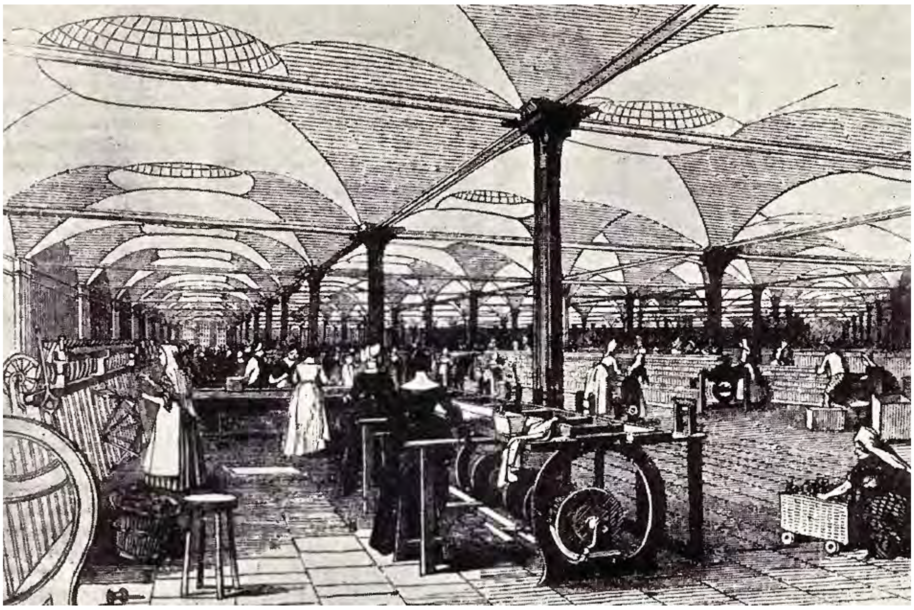

Figure 19 Interior view of Marshall's flax mill in Leeds. Source: www.tishfarrell.files.wordpress.com

Sheds were a solution mainly applied in industrial buildings and storage rooms, since iron offered more vantages over timber thanks to the fireproofing and the lower aging: the sheds mainly consisted of large castings joined with sloping rafters and arched lower elements, with angular and vertical parts connecting and tying the ensemble in a King-post frame. The shed was then linked to the columns by wrought iron ties, keeping the whole frame joined and fastened together[57].

The further evolution in metallic roofing involves the design of the trusses: timber trusses have been a sort of a canopy for the design of metallic trusses, which emulated the timber King-Post or Queen-Post types. Initially the development of these structures started inside the foundries along with builders, since they had a sufficient knowledge of the properties of cast-iron and iron and were able to elaborate solutions borrowed from the evolving metallurgic industry. The design was obviously intuitive and based on the practical observation of the behaviour of the parts, since a proper scientific investigation on the science of construction would only come later. Statically the castings were charged of compression strains and wrought iron coped with the tensile forces where the framing parts bent: the principle was thus the same of the King-post truss and became very frequent in British industrial architecture since it gained the general approval for covering wider spans than the timber solution. Secondary elements such as purlins and boards were fixed to the main structure and progressively the whole system achieved an

[57] Ibidem, pp. 116 – 118.

easy and intuitive assembling resulting in light structures, where rigid elements such as double T and angular sections were placed[58].

One of the typical field of application of this technology was the emerging railway industry: in 1837, for instance, the Euston station featured an iron roof made of T and L sections coping with compression and wrought iron rods tying the whole system. The geometry of the truss recalled the classic king post truss with a larger span and a lighter and easily transportable elements than the cast-iron rafters and struts, thanks to the mechanically produced elements; a further variation of the King-Post consisted in the total replacement of the cast-iron components with wrought iron, whose sizes were empirically determined and experimented until the availability of a proper method for calculating the stresses and the resistance of the parts. A process of standardization of joints and sections took place allowing a rapid and modernized diffusion and employ of metal trusses, even thanks to the mechanization of the productive process emulating the already known technologies of naval and engine industry: the mechanization of riveting and turning evolved and became part of the whole process of building, while forging and cutting became so advanced that could grant precision and easiness of execution.


Figure 20 Euston Station in London. Source: http://lowres-picturecabinet.com.

[58] Ibidem, pp. 118 – 120.

Another typology of metallic truss was the one invented and patented by the French engineer Camille Polonceau in 1839, who aimed to make all the elements of the truss working at their best: the gable roof consisted of two inclined beams and a central tie, which underwent to tension[59] [60]. The result was a simple but efficient solution, inexpensive if compared to material costs[61] and easy to calculate thanks to the graphic statics. The application of this truss spread rapidly and it was frequently used in a great variety of buildings until the advent of the concrete, although it was deemed by the architectural world to be unaesthetic and proof of expressivity, which led to the development of variations and addition of new forms: one of the most famous was the addition of arched elements that formed a sort of curved truss, which however presented the issue of contrasting the lateral thrusts through ties undergoing the tensions. To solve the problem the French engineer Paul Joseph Ardant elaborated variants of the arched truss analyzing the exerted tensions: his conclusion was that the semi-circular arch theoretically should not expose the ensemble horizontal thrusts on the walls, while the other arched forms did. He therefore proposed to stiffen the semi-circular type with a spandrel arch, tangent to the semi-circumference and framed to the rafters of the gable. The achievement of a more elegant and apparently lighter structure made Ardant's truss to be used in public buildings and prestigious locations, such as marketplaces, department stores and educational buildings, while the *Polonceau* was mainly relegated to industrial and commercial facilities[62].

[59] Nieuwmeijer, G., Polonceau-spanten. *Monumenten*, n. 11, pp. 20-23, 2001. Op. cit. de Bouw, M, Wouters, I. Polonceau versus Ardant: efficiency versus aesthetics? In Brebbia, C. A., Binda, L. (eds.). *STREMAH Structural Repairs and Maintenance of Heritage Architecture*. Ashurst Lodge, Ashurst, Southampton: WIT Press, vol. XII, 2011, p. 321.

[60] Holzer, S., The Polonceau Roof and its Analysis. *International Journal for the history of Engineering and Technology*, 80 (1), pp. 22–54, 2010. Op. cit. in de Bouw, M, Wouters, I. Polonceau versus Ardant: efficiency versus aesthetics? In Brebbia, C. A., Binda, L. (eds.). *STREMAH Structural Repairs and Maintenance of Heritage Architecture*. Ashurst Lodge, Ashurst, Southampton: WIT Press, vol. XII, 2011, p. 321.

[61] See:

Dechamps, H., *Les principes de la construction de charpentes métalliques*, Imprimerie H. Vaillant-Carmanne: Liège, 1888.

Vierendeel, A., *La construction architecturale en fonte, fer et acier*, Bruxelles-Louvain-Paris, 1902. Op. cit. in de Bouw, M, Wouters, I. Polonceau versus Ardant: efficiency versus aesthetics? In Brebbia, C. A., Binda, L. (eds.). *STREMAH Structural Repairs and Maintenance of Heritage Architecture*. Ashurst Lodge, Ashurst, Southampton: WIT Press, vol. XII, 2011, p. 321.

[62] Ibidem, p. 322.

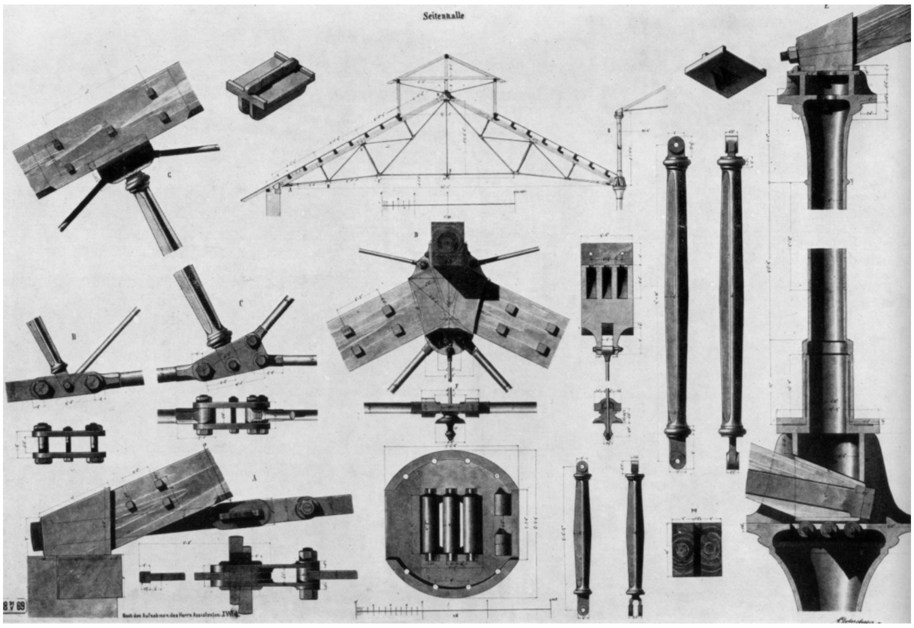

Figure 21 Assembling details of Polonceau truss. Source: https://i.pinimg.com

The cost of iron components was determined through the amount of iron – and then steel – needed, calculated confronting the weight and the span[63]: the ratio was then one of the most captivating reason to chose one solution instead of another and this is perfectly appreciable in Polonceau's description of his truss in the *Revue Générale de l'Architecture et des Travaux Publics* where he claimed a limited need of iron resulting in a light and cheap solution. Although the confrontation of the two trusses – the straight and the arched – proved that they were both ideal to roofing since they showed very similar weight-to-surface ratio in similar working conditions, the *Polonceau* trusses presented a static advantage in confront to the *Ardants* since they had been conceived to work in optimal conditions for their element, i.e. compression and tension. The explication of why they were equally efficient and frequently used in the architecture of the 1850s must be searched in the interaction between the stylistic approach, the standardization and the calculation of the stresses: the Polonceau, as we said previously, suffered from the lack of a beautiful or "architecturally" acceptable physiognomy but it was still employed thanks to the efficiency (weight / span) and the graphic calculation that allowed a simple design of the triangulated elements, though loosing free space[64]. The arched solution, instead, was perceived as a more aesthetic and useful solution to gain volume, but it was not so simple to calculate as the other: this resulted in a frequent application of imitating motifs,

[63] Ibidem, p. 323.

[64] de Bouw, M, Wouters, I. Polonceau versus Ardant: efficiency versus aesthetics? In Brebbia, C. A., Binda, L. (eds.). *STREMAH Structural Repairs and Maintenance of Heritage Architecture*. Ashurst Lodge, Ashurst, Southampton: WIT Press, vol. XII, 2011, p. 324.

decorated spandrels at the springers and curved elements that offered a suitable alternative to the simple design of the industrial Polonceau truss. This is evident, for example, in the design of the Budapest railway station (1877) where the triangulated trusses are combined with arched frames and spirals[65]. Moreover, with the development of standardization since the 1880s there was also an increase of the availability of standardized sections, which started to be illustrated in proper catalogues proposed by the forgeries themselves: the main implication was that the cost of the single product depended not by the amount of the material but by the required labour and workmanship to produce it. The production of standardized trusses prevailed therefore over the special pieces, such as specific joints to assembly all the Polonceau components together, with a favourable appreciation of the standard iron sections of the *Ardant* typology, which required flat and simpler elements[66]. The standardization involved ready-to-use trussed roofs, prefabricated in standard patterns and sizes, which could be mounted and dismantled to be reuse elsewhere in case of dismissal of the former building. One of the most famous fabricator of prefabricated roofs was the Fox, Henderson & Company, which played an important role in the development of assembling details and schemes, resulting in an export to worldwide markets since the 1830s.
Despite the high popularity of *Polonceau*'s solution for roofs with straight rafters in France, it was not very common in British architecture since the designers still preferred the king-post technology since it was more familiar with the vernacular shapes of roofs, e.g. the hip roofs, than full gables.

In 1853 a new version of the triangulated truss was proposed by Robert Henry Bow, who assembled the traditional king-post with rafters and a lower cord, undergoing tension: this solution claimed a saving in material, especially in very large trusses that could be calculated graphically to determine the allowed loads along with diagrams. The graphical approach, evolved through the practical knowledge and the correction of errors, provided therefore a direct visibility of the design and more readable projects for the roofing and the interactions between the elements: this was obviously a vantage in the architectural practice, especially in those buildings which could be designed using standardized and already tested trusses, e.g. the industrial naves and warehouses that could be replicated with slightly variations[67].

[65] Ibidem, p. 325.
[66] Ibidem, p. 325.
[67] d'Alpoim Guedes, P. P. *Iron in building, 1750 - 1855: Innovation and cultural Resistance*. PhD Thesis, School of History, Philosophy, Religion & Classics, University of Queensland, December 2010, p. 123.

In Britain arched roofs also spread in many temporary buildings and in the majority of railway terminals: the exportation of this solution reached the Americas, Australia and South Africa and was promoted despite the costs as the most reassuring and elegant elements to cover the spaces, becoming soon a symbol of technical and economical progress thanks mainly to the visibility and the sinuosity of the riveted curved girders and the transparency of frames and lattices used to cover huge spans. Since their employment, the peculiarity of such great structures slightly transferred the pertinence of their design from architects to engineers, *de facto* remarking the separation between the two great branches of the construction[68].

Since 1830s we see that iron became widely used in the construction of civil and industrial buildings even thanks to the development of ideas and improvements that took advantage of the properties and the availability of the material. One of the most important invention that in a certain way signed the abandon of cast-iron was the wrought iron girder: it consisted of wrought iron angles and plate riveted together to form an unique element able to resist to stress and strains. The riveted beams composed by top and bottom flanges of iron proved to be less expensive than cast-iron solutions and they were more suitable for industrial buildings such as mills, factories, storage rooms, bridges and docks since they could cover significant spans and at the same time be fireproofed by paints and retarding materials before or after the assembling; another point was the ability to support masonry even with thick sections[69].

*Industrial architecture: functionalism and prefabrication*

Nineteenth century could be considered as the promoter of the age of the machine and as the field of first introduction of the concept of functionality: the architecture aimed to realize building responding to the new needs and purposes of the newborn industrial society, through a multiplicity of typologies and technologies. The factories and the places of production featured different structures, physiognomies and technologies than the public buildings, the exhibition palaces, the stores and libraries mainly because they responded differently to the requirements proper of a specific theme.

The industrial architecture offered a new and recent field of application of the new techniques and materials, more than the monumental one that – as we said – preferred the familiarity of the traditional composition. The criteria guiding the industrial projects were therefore more referring

[68] Ibidem, p. 127.
[69] Ibidem, p. 252.

to the scientific innovations and progress, e.g. the technique, the production, the organization and the time of execution. An industrial building was intended to exercise a specific function in the best possible time and productivity and therefore its concept was to respond to the most favourable criteria to perform its functions, to house the machinery and to achieve the highest productivity. The mechanization also needed new forms and volumes to which the architectural project should provide correct solutions and the best materials. One of the first modern approach to these issues was the prefabrication, intended as the result of the development of the principles of functionality, cycles of production, predominance of machinery and fastness and precision of execution proper of the industrial revolution: the economic purpose therefore entered promptly inside the conceive of the architectural topics , reflecting the urgency of new forms and buildings where pieces, machinery, engines and goods could be serially produced. This phase of the industrialization and the architecture for the industry signs in this moment the start of the uniformity: one of the first examples of this approach was the American, prefabricated, wooden structure called "Ballon Frame", which was defined by Leonardo Benevolo[70] as a structure composed of main and secondary elements, assembled and dimensionally various, placed at fixed distances and nailed. The idea of this ensemble was the use of a standard modulus that could be applied in the whole composition, with different components to resist to climatic and strain actions, resulting in a sort of a motto claiming that everyone could built his own house without much effort. The diffusion of this expedient spread in the first three decades of the 19th century mainly during the occupation of new lands and territories in the pioneer era of the United States. The aim to focus on modules to be replicated and applied in different situations finally resulted as a declination of standard typologies, applicable to various buildings, that satisfied the main criteria of the industrial production and also the tastes of the clients.

[70] Benevolo, L. *Historia de la arquitectura moderna*. Barcelona: Gustavo Gili S A, 1974, pp.256-257. Op. Cit. Civara, I. A. *Arquitectura industrial: concepto, método y fuentes*. Valencia: Museu d'Etnologia, 1998, p. 108.

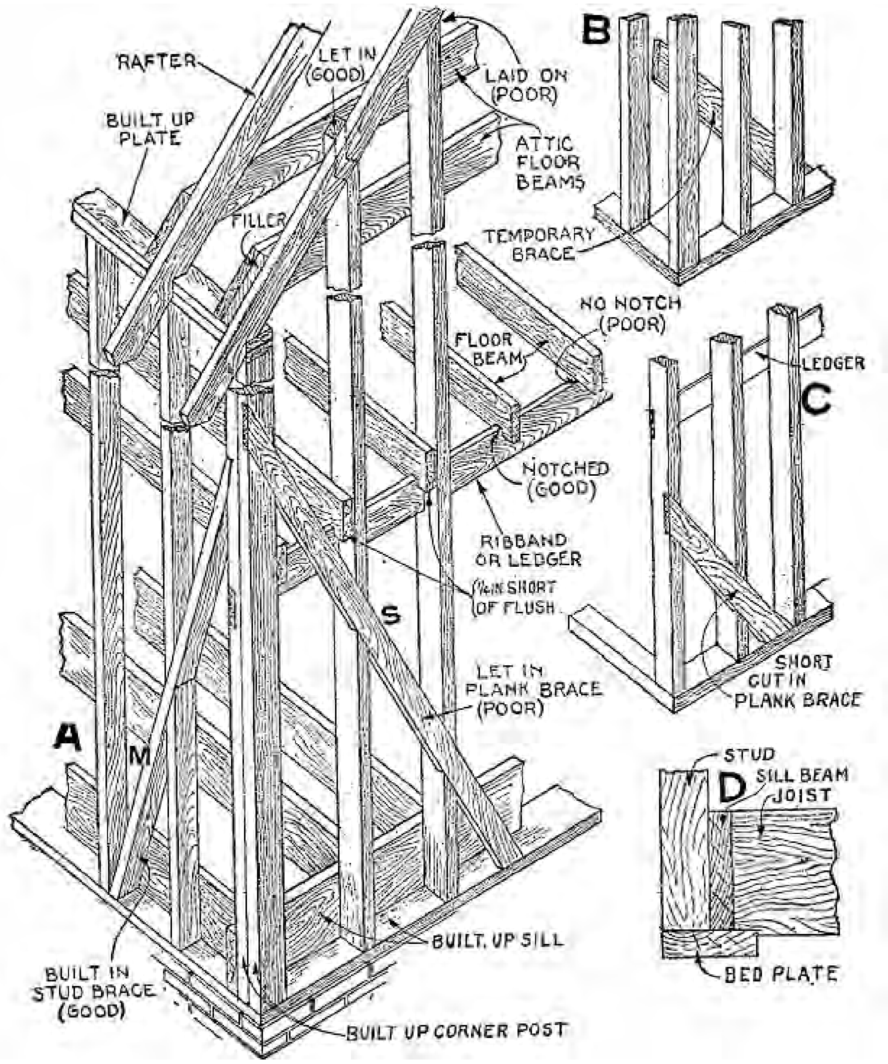


Figure 22 Assembling scheme of a Balloon Frame. Source: T. Audel, *Audel's Carpenter's and Builder's Guide*, 1923.

The "Ballon Frame" module was of course not suitable for a great serial production for the industrial sector, since it was intended more as a practical expedient to build wooden houses and would present serious risks of fires and collapses in case of an industrial application: wood and timber therefore were not the right materials for the development of the industry and soon they were integrated – and finally replaced – by iron, which was of course the best suitable element for the accelerated industrial production. The scientific technology melted with the architectural theories and resulted in a fast development of ready-to-use finished elements: between 1830 and 1840 in the majority of the European foundries, especially in Great Britain and in Germany[71], the serial production of iron beams, lamination, profiled girders became a common practice which were inserted in catalogues showing the assembling schemes of

[71] Civara, I. A. *Arquitectura industrial: concepto, método y fuentes*. Valencia: Museu d'Etnologia, 1998, p. 109.

standardized and always available items. From the linguistic point of view the advent of prefabrication on one side did not interfere with the architectural expressivity and potential, since it allowed a versatility and adaptability of the single prefabricated elements to the forms and concepts proposed by architects and engineers; on the other it however signed a break with the Classic proportions and physiognomies of the past, opening the field of the stylistic experimentation and the coexistence of different languages, borrowed from the theories promoted by the fans of the Gothic-revival, the Neo-Renaissance and the Neo-Classicism that developed independently under the name of Eclecticism. Decorative elements, staircases, beams and columns could be thus moulded and proposed in a huge variety of solutions, each adaptable to the linguistic and formal variations of each project. The rapidity of the assemblage, which we may call the "constructive kit", also allowed the building or the facility to be dismantled and transferred elsewhere without losing its components and to be adapted to new functions or added to other compounds.

*Conclusions*

The architecture of the factories must be intended as a multiplicity of contributions that joined the formulas and the criteria of the new buildings and materials with the architects' sensibility for the new typologies to accomplish the industrial purposes: the utilitarian approach to the solution of the factory should however not be seen as a lack of the architectural presence, but as the way through which the industry came part of the landscapes and the ordinary aspects of the urban and rural lives, since it replaced or melted with the pre-existent communities and facilities in a such fast manner that the fastness of execution actualized and appropriated the traditional characters with new significances and purposes. The permanence of vernacular or traditional building schemes is in fact a characteristic that permeated the industrial activities and architecture for almost the whole 19$^{th}$ century since it kept elements such as the bearing masonry along with innovative features such as the iron structures, the glazed surfaces and the engines. The passage from the industrial buildings of the last decades of the 18$^{th}$ century and the firsts of the 19$^{th}$ to those of the second half of that century is evident when we consider that the technological progress and the scientific innovations were a fundamental element involved in the architectural features of the factories: the unique engine that replaced the steam machine and the hydraulic wheel required in fact a complex cycle of horizontal and vertical connections to transfer the movements to the whole machinery and therefore it transformed the volumes of the factories into a huge engine. The textile mills and factories were the first examples of modernization of the architecture: the high and narrow volumes became the typical configuration, with numerous floors containing the machineries propelled by the unique engines, placed along a vertical axe that connected the whole elements by horizontal transmission. The result is the multi-storey factory as typical model of the 19$^{th}$ century industrial architecture, based on the iron frames with trusses, skylights and windows placed in the outer walls. The freedom from the masonry was one of the most important innovations of those years and it further developed in the replacement of portions of the external walls with metallic pillars integrated or visible in the masonry: this is, for instance, the case of the *Harper & Bros* Building in New York designed in 1848 by James Bogardus, who connected the iron frame to the iron parapets in order to create a rigid frame repeated in each level.

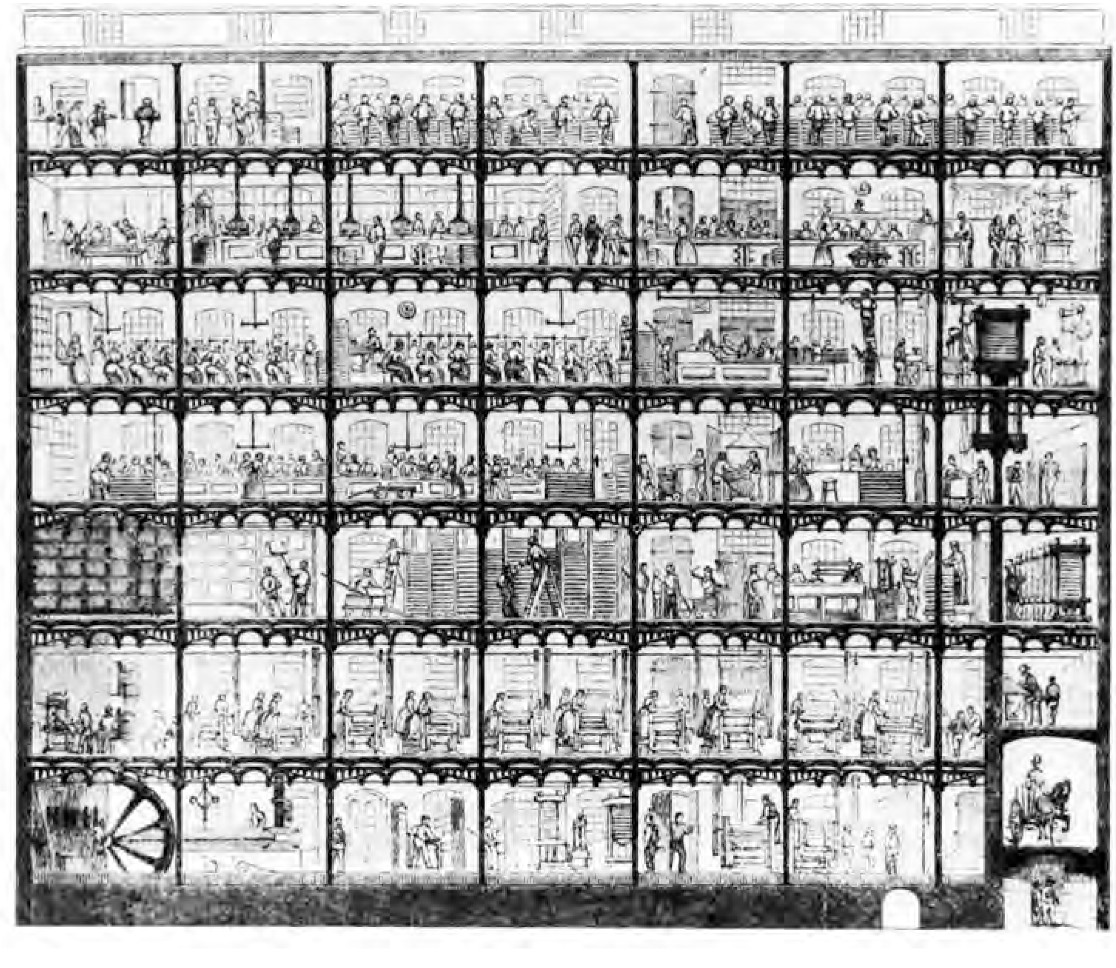

Figure 23 James Bogardus, Section of the Harper Brothers Building, 1854. Source: https://i.pinimg.com

Another interesting example of the enhancement of the iron frame is the chocolate factory Menier in Noisiel, designed by Jules Saulnier in 1871-1872, featuring a whole metallic frame made of visible reticular beams like trellises, diagonally crossed, bricked masonry intended not as a bearing support but as fillings[72]. Externally the metallic frame with the rhomboidal elements is appreciable and remanding to the wooden structures of the central European buildings, which frequently showed a timber frame in the main façades, emerging from the walls to declare their bearing function[73].

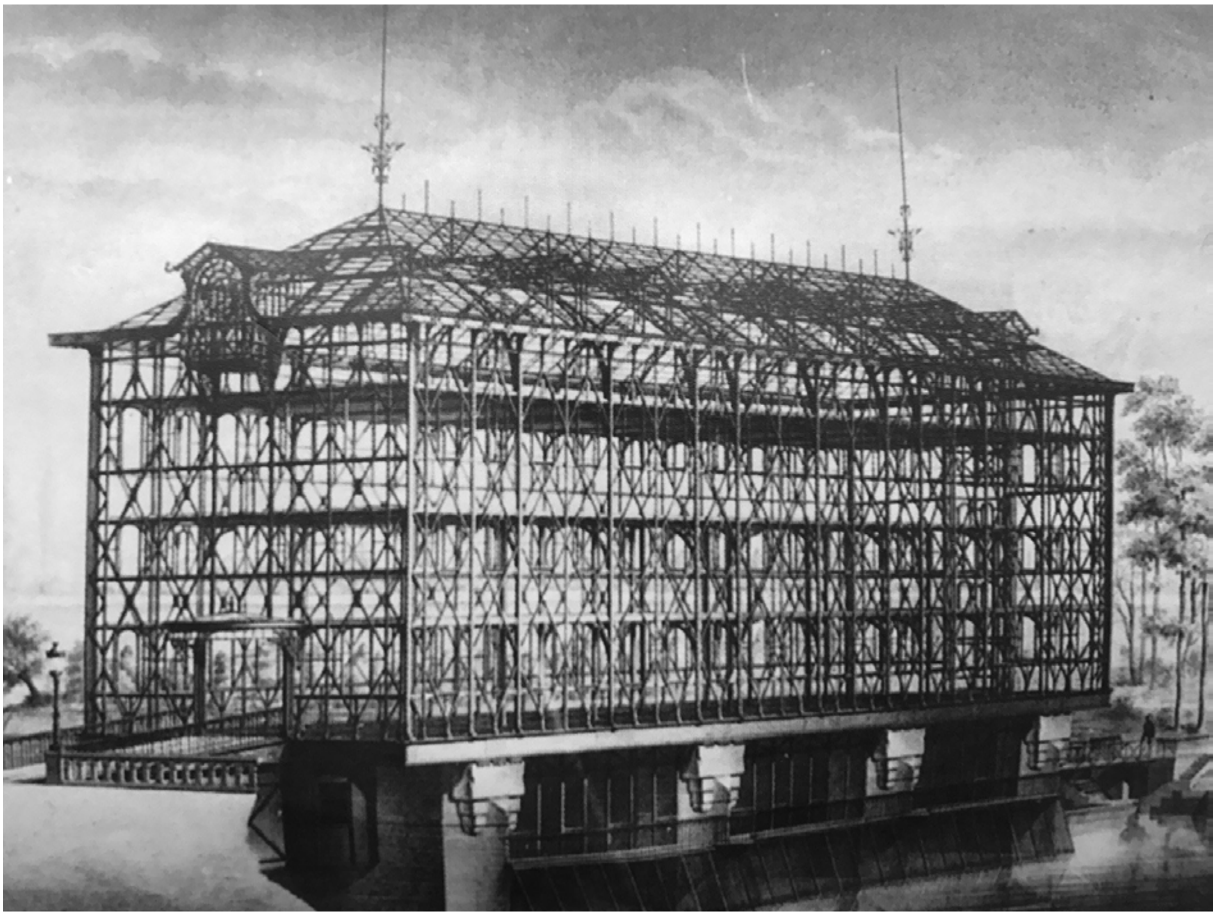

Figure 24 The iron frame of the *Menier* factory. Source: twitter.com/CarverHaggard/status/802817789056557061

Another frequent typology in the spatial configuration of the 19th century factory was the single-naved building: the single-storey volumes were usually dimensionally determined (between 10 and 16 m wide) with the possibility to be "infinitely" extended and thus introducing a new formal concept: the flexibility. This was in fact one of the most important innovation in the conceive of the factories, since they allowed the integration or the replacement of former parts with new ones without affecting the whole composition, since the bearing parts could be added and linked to the formers. The naves presented moreover the opportunity to study the evolution of

[72] Ibidem, pp. 177 – 178.

[73] Castillo – Olivares, M. D. A., Alcaide, V. N., Martínez Pino, J. *El Siglo XIX: la mirada al pasado y la modernidad*. Madrid: Editorial Universitaria Ramon Areces, 2015, p. 161.

the covering systems of riveted girders, triangular trusses, integration with skylights, mixed structures and metallic trellises: starting from the combination timber-iron we see the gradual passage to the whole iron covering, where the definition of the structural roles of each part is strongly evident and determined and suggests a sense of lightness, aerial and independence. The flexibility of the new systems also allowed the extension of the single volume and the addition of parts that did not suffer from the insertion of new walls since the independent iron frame could replace the masonry, resulting in lighter and visibly permeable industrial spaces. In the last decades of the century there was the introduction of the shed system that granted both a transversal illumination and the extendibility of the single module made of pillars and trellises: this last solution may be intended as the natural evolution of the single naved factory, since it did not preferred a specific direction in the spatial development and allowed the use of large glazed panels to flood in the light zenithally[74].

Finally, the industrial theme was therefore a field of experimentation of the new technologies and to test the performance of materials and structures, allowing engineers, scientists and technicians to evaluate and claim their theories, examples and inventions combining different solutions, experimenting new ways to assembly the components and to empirically determine the calculation of the strains and resistances when a proper knowledge of the science of construction was not yet available or divulgated.
This is, for instance, the case of another element which revolved the industrial architecture and furthermore the whole building sector since the beginnings of the 20th century: the concrete.

[74] Civara, I. A. *Arquitectura industrial: concepto, método y fuentes*. Valencia: Museu d'Etnologia, 1998, pp. 178 – 179.

## From the empirical practice of architecture to the standardization of best practices

The historic and evolutional route that has marked the mining history of Sardinia and in particular Monteponi follows and intersects the one that has characterized the constructive cultures and the training of architects and engineers in the epochal passage through the Enlightenment of the Eighteenth century to the Nineteenth-century Eclecticism.

It is in the time lapse running from the Eighteenth to the Nineteenth century that there is a strong scientific revolution of the academic, ideological and technological knowledge and its transmission, which will lead to a new course of building production so relevant to set the basis for the whole Modern era[1].

Whether it is universally recognized as starting point of the rationalist breakthrough the translation of Vitruvius by Claude Perrault, which established the proportions and the aesthetic paradigms related to the use of orders based on a single module, Michel de Fremin's work[2] emphasizes the importance of environmental constraints, the quality of materials and needs of the client in front of the architectural practice, while sharing some Perrault's thesis.

But it is the reinterpretation of the Gothic tradition that reinforces the Nineteenth-century architectural theorist seam, through the publications of Rondelet and Viollet-le-Duc de Cordemoy, where the technical-structural aspects of the art of building were brought to light. The gothic architecture in fact presents a rational response[3] to issues relating to the stresses and the use of available materials such as stone, combined into arcs, ribs and concave vaults. However, these dissertations are merely discursive or ideological, but far from informative purposes and supportive of the later works.

Surely, the key building of the ideological - rationalist debate ideally incorporates the design of the Church of Sainte Genevieve by Jacques - Germain Soufflot, now the Pantheon, which is proposed as a synthesis of the composed severity of the Greek architecture and the structural lightness of the Gothic: the prior aspects to which Soufflot inspires are the Chapel of the Holy Shroud by Guarino Guarini and *Santa Maria della Salute* in Venice. With this building it opens the debate among the intellectuals of the epoch on the determination of mathematical calculation related to the building issues, which will pave the way to the next constructive science: Soufflot aims to reduce the useful sections to the minimum necessary to support the vaults, by studying in the laboratory the strength and elasticity of the stone by means of a machine, which is then perfected by Rondelet to repair cracks in the pillars. In those same years Belidor devised his theories on the static behaviours and the introduction of descriptive geometry of stereotomy improved the static analysis up to a final systematization. In Italy the proposition of rationalist argument about the stability of the buildings belongs among others to the monk Carlo

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[1] Guenzi, C. (Ed.). L'Arte edificare. Manuali in Italia 1750 – 1950. Milan: Be – Ma Editrice, 1993, p. 16.

[2] Memoires critiques d'architecture. Op. Cit. in: Guenzi, C. (Ed.). L'Arte edificare. Manuali in Italia 1750 – 1950. Milan: Be – Ma Editrice, 1993, p. 16.

[3] Guenzi, C. (Ed.). L'Arte edificare. Manuali in Italia 1750 – 1950. Milan: Be – Ma Editrice, 1993, p. 16.

Lodoli, who is opposed to the uncertainty of Vitruvian proportions to be taken when dimensioning and affirms the need for a correspondence between form and function.

The ideological debate settles in the European academic world of the late Eighteenth century and sees the confrontation between the engineers as advocates of "the science" as the basis of the construction and the Academics of the School of Fine Arts, who propagate "art and beauty" in the role of the guides for the design .

It can be reasonably stated that the constructive knowledge has gradually evolved towards more and more accentuated forms of normalization, i.e. towards a rationalization of the principles of architecture and the art of making, which have seen the weakening of purely empirical practices in favour of a better defined *corpus* of constructive procedures and standardized languages. A more precise identification of the technical and professional figures of architects and engineers – and the related Schools – has brought to unitary visions of the problems linked to the building practice and of the best approaches for their resolution. From Vitruvius onward the transmission of the constructive knowledge was increasingly subject to royalties, whose principles and objectives – although empirically determined – have formed the ratio with which to exercise the art of building: the transmission of this knowledge, therefore necessarily subject of Treaties and handbooks (also with a popular nature), has inevitably led to sum up in some more or less organic way the scientific, cultural, philosophical and technology principles that make up the architectural projects. In the architectural literature of the Seventeenth and Eighteenth centuries on one hand there are the most original expressions, rich contributions of the ancient world, reworked through experimental and visionary thinking of authors such as Ledoux and Boullée, on the other we find the concept of best practice as a unique resolution within at specific cultural moment. In this evolutionary transition it is thus performed the will to integrate the rules of construction – recognized and recognizable – with the superior craftsmanship of architectural factory, to mediate between technology and art.[4]

Even the scientific organization of humanistic and scientific knowledge, which very often mingles with the architecture of the Eighteenth century, reflects the need and willingness to normalize: in 1750 appears the *Encyclopaedia,* or the *Reasoned Dictionary of sciences, arts and crafts*, a collaboration between André Le Breton and Denis Diderot in the role of translator of the *Cyclopaedia, or Universal dictionary of arts and sciences,* published by the Englishman Ephraim Chambers in 1728. This book was in fact considered at the time to point of reference for the dissemination of knowledge and its translation reveals itself as one of the greatest cultural revolutions in Europe in literary and scientific matters, with a practical and experimental approach as opposed to the mere erudition.

Therefore in this atmosphere we can identify the quick spreading of handbooks in the constructive field, written by characters from the worlds of mathematics, chemistry, the Royal Army, engineering and architecture. In Italy, apart from the dissemination of works from across

[4] Tatano, V. L'evoluzione dell'informazione tecnica: dalla manualistica ottocentesca al Dizionario dei nuovi materiali di Enrico Griffini. In Sinopoli, N. *Dal manuale al web. Cultura tecnica, informazione tecnica e produzione edilizia per il progetto di architettura*. Rome: officina edizioni, 2007, pp. 15-16.

the Alps in scientific circles, academies and technical schools, it was not until the early decades of the Nineteenth century that we assist to the birth and the proliferation of a practical literature on building. The names of these works still evoke the concept of perfection that always has had dictated the *raison d'être*, or the art of construction, under generally accepted and shared principles within the scientific and academic community. Equally you can say that for the theoretical – practical treaties that joined to the enunciation of the theoretic principles and govern the static of the building, the applicative drawings, assembly diagrams, dimensions and types of the individual components as like as these were presented by their inventors in magazines of military engineering, in periodic chronicles and in books for the application of civil engineering.

It should be noted that a great role in the formation of disciplinary specialization and corresponding professional categories of the Nineteenth century is due to the desire to direct the education of engineering students to specific branches of the technique, as Colbert did with the creation of a field devoted entirely to the study of bridges and roads[5].

Until the Eighteenth century there was no clear distinction between "engineers" and "architects" and the formation of the firsts, engaged in military facilities, was done through apprenticeship. It was the creation in France in 1679 by Colbert of a field of study devoted to bridges and roads – to which followed quickly the emergence of more and more specialized academic institutions, such as the *École des Ponts et Chausséesin* 1747, followed by *Ecole du Genie at Mezieres* in 1748, and the *Ecole des Mines* in Paris in 1783 and finally the *École Centrale des Travaux Publics* that later became the first Polytechnic – that revolutionized the training of all the engineers, civil or military, with a simultaneously theoretical and practical footprint. Along the lines of the *Ecole Polytechnique* they spread quickly through the various schools that attracted the French model, first of all the Schools of Engineering in Naples (1811) and Rome (1817). In the Bourbon Kingdom was established in the same year the School of Bridges and Roads Application, while the Papal States arose the Corps of engineers of waters and roads.

The Kingdom of Sardinia proved forefront at this juncture since in 1816 it established the Royal Habilitating Patents with an Engineers Corps that in 1825 became the Royal Corps of Civil Engineers.

A further contribution to the dissemination of literary and technical - scientific cultures up to Carlo Cattaneo, who launched in 1835 the magazine The Polytechnic in order to offer a monthly repertory of studies applied to prosperity and social cultures (*Repertorio mensile di studj applicati alla prosperità e coltura sociale*)[6].

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[5] The creation in France from 1679 onwards of a service charged of bridges and roads by Colbert, followed by the *Corp des Ponts et Chaussées* in 1713, marks a turning point in the exercise of the engineering profession as a separate practice. In front of the Academy that controls the craft and knowledge of the architects, the *Corp* can affirm its autonomy of action and opinion. See: Crippa, M. A., Gavinelli, C., Loik M. Architettura del XX secolo. Milan: Jaca Book ed., 1993, pp. 65-67.

[6] So reads the full title: *Il Politecnico. Repertorio mensile di studj applicati alla prosperità e coltura sociale*. Milan: Luigi Giacomo Pirola.

## *The Polytechnic Schools and Academies*

In the Italy of the early decades of the Nineteenth century, simultaneously with the revolutionary aspirations and the desire to unify the Country under a single State, it develops a growing interest in technical - scientific updating and training, especially with regard to applications, technological practices and scientific knowledge.
In the Kingdom of Sardinia the first crucial moment for the development of a new technical and scientific intelligentsia refers to the promulgation of the *Casati* Law – followed by the establishment by Carlo Alberto's Government of the Ministry of Education and by the *Boncompagni* Law of 1848, which encompassed all the schools and educational institutions under its jurisdiction – whose application formally established the School for engineers, basing on the French *Écoles polytechniques* model where the scientific and philosophical disciplines were not subject to a clear academic demarcation.
The *Casati* Law in fact provided for education of elite, with large secondary and tertiary education space at the expense of primary, with a clear separation between technical training and classical-humanistic disciplines and emphasized the importance of directing the education of primary schools to the public and private careers that required further scientific or literary cultures through "*accurate special studies*".[7]

The first Application School for Engineers was opened in 1860 in Turin, capital of the Kingdom of Sardinia in 1860 as a branch of the Royal Technical Institute, which was an entity arising of a merger of the existing Mechanic and Chemistry Schools applied to the arts with Agrochemical schools, agricultural and forestry courses with the addition of the geometry applied to the arts, descriptive geometry and geometric design.

In Milan, the opening of a school for high-level technical training was in the air for some time, with the right climate also created by Carlo Cattaneo and his magazine *The Polytechnic*.
In 1838, on the initiative of industrialists and businessmen, the Society of encouragement of arts and crafts was created and ten years later the Lombard Institute promoted a project to reform the school system, including the engineer's training, with Cattaneo as a teacher. In 1850 Francesco Brioschi founded the Royal Higher Technical College with a course of three years; to access it students should have attended two years of mathematics at the University of Pavia or any other university in the Kingdom of Italy. In 1865 it was established the section for architects in collaboration with the Academy of Brera and in 1873 one for mechanical engineers. In 1875 the Royal Institute opened a preparatory school and became independent from the university.

In Naples, where already existed since 1811 the Application School of bridges and roads for engineers founded by Gioacchino Murat, followed by the creation – thanks to the will of the same founder – the Corp of Engineers of roads and bridges on the model of French *École des Ponts et Chaussées*, from which it was possible to get a degree in civil architecture, demonstrating the subordinate role to which were relegated the universities of the time.

[7] See: D. Capecchi, Ruta G. *La scienza delle costruzioni in Italia nell'Ottocento*. Milan: Springer Verlag, 2011, pp. 171-173.

In 1863 the School, evolved into the School of Application for Civil Engineers, passed under the Ministry of Education and assumed the name of the Royal School of Application for Engineers and absorbed the settlement of that of Turin, which reserved the admission to graduate in mathematics and for the period of study of two years. At the end of the century, the statutes of the Royal Application Schools for engineers in Italy were unified and in Naples too the School's courses lasted three years, after two years of physical and mathematical studies, leading to the attainment of the title of civil engineer or architect.

On October 23rd 1817 in Rome the School of Engineering arose by Pope Pius VII's initiative. This new pontifical school was established for the need to acquire knowledge with a local engineering training[8]: the three-year training consisted of descriptive geometry teachings, static architecture, construction, hydraulic, hydrometric, topography and physics. The study ended with a general examination for issuance of civil engineering diploma, with which one could enter the Papal Corps of Engineers but also, for the first time in Italy, access to professional services. After the reunification of Rome to Italy, with a decree in 1872 the *Casati* Law was applied here too and on October 9th 1873 was issued the decree of establishment of the Application School for Engineers in Rome.
For nearly fifty years the School, while intended to train civil engineers, did not fail to carry out experiments and research to offer a wider and complete preparation of their students, until a new regulation will not foresee two sections, one civil and the other one industrial; these were added to the teachings of Geodesy, applied geometry, technical physics, chemistry applied to building materials, applied geology; it introduced in 1886 the electrotechnical and finally in 1892 the valuation, the agricultural economy and the applied hygiene.

### *The Nineteenth century handbooks as a tool of building knowledge*

The technical development in the construction industry, which as we have seen accelerated in a clear manner from the first decades of the Nineteenth century, makes essential to ongoing training and dissemination of ideas, patents and structural solutions on a large scale beyond the boundaries of individual States. This contribution, mainly aimed at designers, students and builders, required the preparation of appropriate handbooks – given the poor circulation of magazines – frequently updated and prepared by the same inventors of the constructive methods or by the teachers of the Universities and academic courses of the moment. Very often the editions of the handbooks were updated and re-edited into service of new examples or new discoveries, theories on the performances of materials and stress or challenges for the design.

The handbooks also allowed the dissemination of ideas not only within the regional borders but in reality of the pre-unified Italy and across States' boundaries, collecting contributions from the most famous characters in the French, English and German scientific worlds. The Universal Exhibitions, which took place in the middle of the Nineteenth century, are the first carrier of the development of innovations and the time of inventions, introducing new definitions of the relationship between function and type, again suggesting the differentiation among the

[8] Ibidem, p. 177.

protagonists of building practice that wants on one side the architects associated to the sphere of arts and Academies, hardly approachable to the scientific world and the static calculation of the proportion; on the other the trained and qualified engineers according first to the French models and then to the German ones.[9]

In this period the treatise is still unrelated to empirical practice of construction and appeals to connoisseurs and amateurs of the disciplines, however taking important conclusions and technical developments from the realizations and the experiences that we find in France as the architecture of bridges, roads and public works, at the base of which several experiments are conducted; in England it is instead the technical entrepreneur that forms himself on the thrust of the practical experience to obtain a scientific and theoretical feedback, as in the case of Joseph Paxton. In Italy and France also, we are witnessing the gradual disappearance of the guilds, which give way to the professional class for solving computational problems concerning primarily public works such as railways and bridges, demonstrating the impact of theory and innovation prevailing on the practice and on the reiteration of past models.

*Nicola Cavalieri di San Bertolo: Institutions of Static Architecture and Hydraulics*

Among the first and most important modern handbook repertoire there is the work of Nicola Cavalieri di San Bertolo, entitled *Institutions of static and hydraulic architecture*[10]. The novelty presented by this text is the intent not so much theoretical as practical, as an aid to architects and engineers. In this book, as in most of the contemporary publications, it does not hardly ever reference to the aesthetics of buildings, preferring purely structural constructive details, as befitted the mentality of the time towards the industrial production of increasingly larger scales – although in Italy the effects of this production are experienced in a substantially slower and more backward manner than in the rest of Europe – even in the building field, finishing then to put aside the question of aesthetics to the advantage of rapidity of assembly the structural components[11].

The didactic interest is declared by the same author who wants to present his work in a mediation between the theoretical principles, widely practiced building traditions and exceptional embodiments, which are presented as codes to be replicated in front of particularly complex cases by the static and hydraulic point of view such as bridges, floors, arches and machines[12]. Even in the explication of the positivity of widely proposed scientific cultures in the Polytechnics of his time, Cavalieri di San Bertolo expresses his preference for the constructive types more than for the building ones, in contrast therefore with the academic practices of separating the cultural, artistic and technical formation inside their own schools. In Cavalieri's work we cannot in any case read any note of controversy against the academic trends since his treatise is enhanced through scientific contributions already published at the time, in a

[9] Guenzi, C. (Ed.). L'Arte edificare. Manuali in Italia 1750 – 1950. Milan: Be – Ma Editrice, 1993, p. 28.
[10] Cavalieri di San Bertolo, N. *Istituzioni di Architettura, statica e idraulica*. Mantua: Fratelli Negretti, 1831.
[11] See: Trivellin, E. Storia della tecnica edilizia in Italia: dall'unità ad oggi. Florence: Alinea, 1998, pp. 49-51.
[12] Guenzi, C. (Ed.). L'Arte edificare. Manuali in Italia 1750 – 1950. Milan: Be – Ma Editrice, 1993, p. 32.

bibliography that can be defined modern and updated[13] for his time and even anticipates the scientific - technical disclosure fielded by Rondelet, Navier, Belidor, which will occur even after the publication of his work.

One aspect that this work has in common with its similar examples across the Alps is certainly the presentation of innovative construction systems, which also cover the equipment and the tools of the building site, the cast iron bridges, railways, etc. ... thus demonstrating the rising interest in the progress in sciences and in techniques along the period of the industrial revolution, even in the Italian context which – we may say, played a more marginal role.

*Giovanni Rondelet: Theoretical Practical Treaty of the Art of Edifying*

Most Italian handbooks still clearly show a transalpine imprint: in the volume by Cavalieri di San Bertolo we cannot longer ignore the mould of an author who had previously drawn up a series of volumes entitled *Theoretical Practical Treaties about the Art of edifying*, i.e. Giovanni Rondelet. The first Italian drafting of his work is in fact contemporary to that of the *Institutions of Architecture* and it resumes the setting divided by volumes that treat well divided arguments for the use not only of the Architecture Institutions Course[14] but also of the professional practice of engineers and architects. The volumes deal precisely with earthworks, the works in wood and iron, masonry, machine and finally estimates. Even with such a large structure is evident that the treaty was affected by the poor implementation of certain techniques in the Italian constructive reality, as it happens in the case of iron constructions that – unlike in Italy – had already been extensively studied in France and Germany.

The comparison with the work of Rondelet also suggests another consideration, valid not only for the work of Cavalieri di San Bertolo, but in general for all the handbooks that followed: the French handbook has in fact the merit of introducing two fundamental components for the practice Treatises, i.e. the use of stereometry according to functional geometric designs of Gaspard Monge[15] and the mathematical calculation of the beams, based on Navier's, Belidor's and Gauthey's contributions. The first point in fact introduced the possibility to prefabricate the individual constructive piece, by virtue of the design of complex parts, the mechanical couplings between different materials and perfect joints between the different parts, especially in those extremely complex works such as arched bridges, lighthouses, stairs etc. Therefore Rondelet sets his point of view on the junction between the performance of the material and the physical laws that must guide the design. Even for the performance of materials and the study of their resistance Rondelet was concerned to provide for a scientific paper, although thanks to the use of machinery designed and tested by himself, living real examples as in the disposition of the stone courses in the pronaos of Sainte Geneviéve through a connecting iron reinforcement that follows the behaviour of the strains, anticipating therefore with the use of the stone what will

[13] Guenzi, C. (Ed.). L'Arte edificare. Manuali in Italia 1750 – 1950. Milan: Be – Ma Editrice, 1993, p. 37.

[14] For the Archiginnasio School for engineers of the University of Rome "La Sapienza". See: Trivellin, E. Storia della tecnica edilizia in Italia: dall'unità ad oggi. Florence: Alinea, 1998, p. 51.

[15] Ibidem, p. 51.

happen with the reinforced concrete[16]. The work of Rondelet thus proves a treaty constantly illuminated by rational scientific research and technical precision, which does not neglect nor the static aspects of the performance and design of the building, nor those of the practical organization of the construction site, the quality of the materials, the need for testing and inspections along the time. Rondelet is therefore aware of the historical experiences and consolidated cases to present his enlarged vision, thorough and complete regarding the constructive problems.

On the vast work of Rondelet we shall not dwell on if not brief references to the constructive techniques that are closest to the situations encountered in the case studies, such as the wooden shell, iron, the floors and walls. In a tome dedicated to wood construction, particularly the armour of roofs, Rondelet says:

*The lowered roof armours*

*When the timber armours do not have much length can be made with only three pieces, two of which* a *are called slanted struts and the third* b*, horizontal rod or tie beam where the other two are connected so that they form an isosceles triangle. In Italy we see a lot of armour that are made in this way.*

*The struts of these armatures are connected inferiorly into the ends of the tie beam with teeth and sores to iron straps placed perpendicularly to the inclination of the struts that secure them in invariable manner. Above these struts come together to form the tip of the roof, to fit a vertical commissure and are hoisted by a kind of expulsion key in two pieces and pinned as shown in figure 8. Sometimes aren't gathered by indentations in half stops with a* cavicchia (a wooden pin).

*When these armatures have a certain magnitude, they are internally fortified with another composed element of three pieces* f, g, f *two of which double the struts up to approximately two-thirds and the other in the form of tie beam for counterthrust them as seen from the figures.*[17]

[16] Guenzi, C. (Ed.). L'Arte edificare. Manuali in Italia 1750 – 1950. Milan: Be – Ma Editrice, 1993, p. 42.

[17] Soresina, B. (ed.), Rondelet, G. *Trattato teorico e pratico dell'Arte di Edificare*. Naples: Tipografia del Gallo, 1839, p. 110.

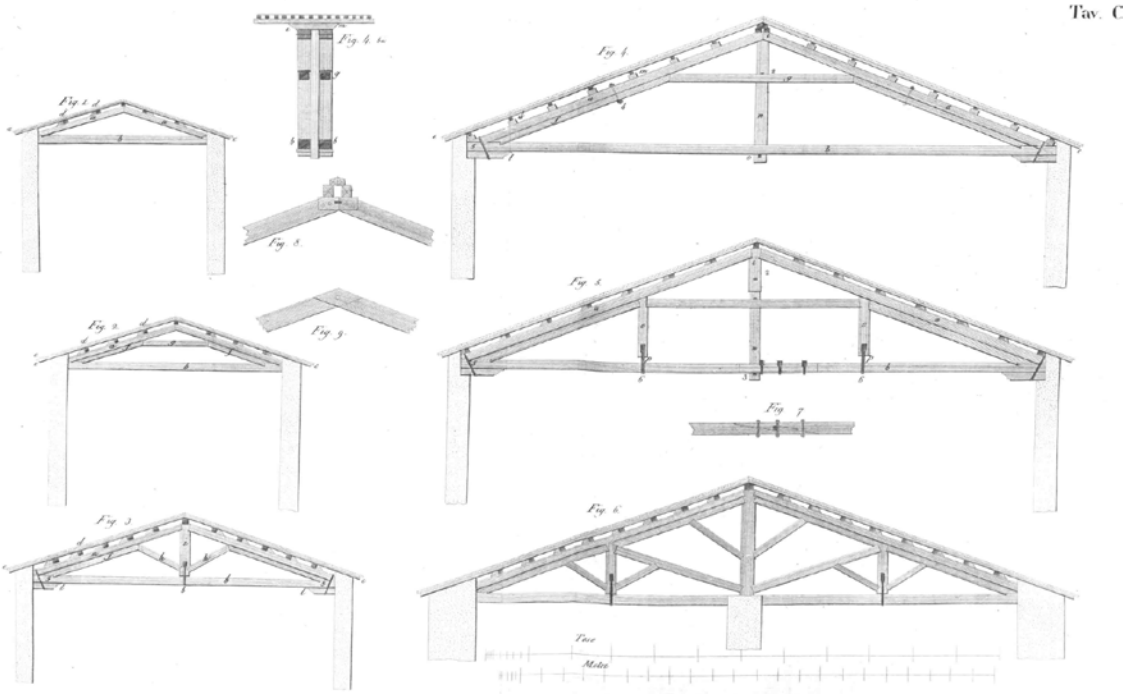



Figure 1. Rondelet TABLE CV: the lowered roof fittings.

*Armour of the raised roof*

*The figure I of the CVI Table is one of the main plates of a raised roof, the length of which between the walls is 27 feet. The struts rest at the bottom above a heavy bottom cord* b *of a single piece, which forms the entire length of the building, including the thickness of the walls, and goes to be committed to a king post which rest on the pieces forming the ridge board* f.

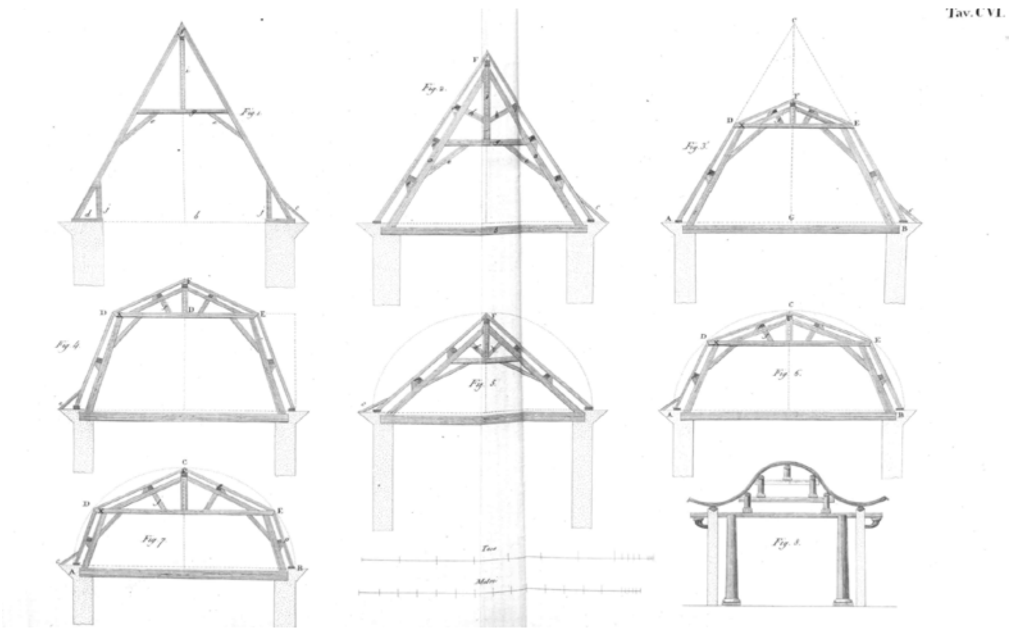



Figure 2. Rondelet Table CVI: armour of the raised roof

*In general, the armour of roofs may be considered as the main beams of the floors, the paradoxes as the nailed beams and the rafters as those filling. We did see, speaking of the* *beams, that when these are too weak they can be fortified with species of struts to which these beams serve as the basis. It is evident that the longer these struts are elevated above the rafters, the more they have the force to support them, whence it appears that timber an armour composed of a tie beam and two struts has much more of a beam strength to support the parts that correspond. Nevertheless, when the struts do not have a thickness in proportion to their length, the weight of the paradoxes can make them bend in the middle. In this case, the easiest way to prevent this effect is counter – throw them with a horizontal piece of wood called false or false cord. In the reinforcements which have a king post as support the middle of the struts with two struts* h *connected in the king post.*[18]

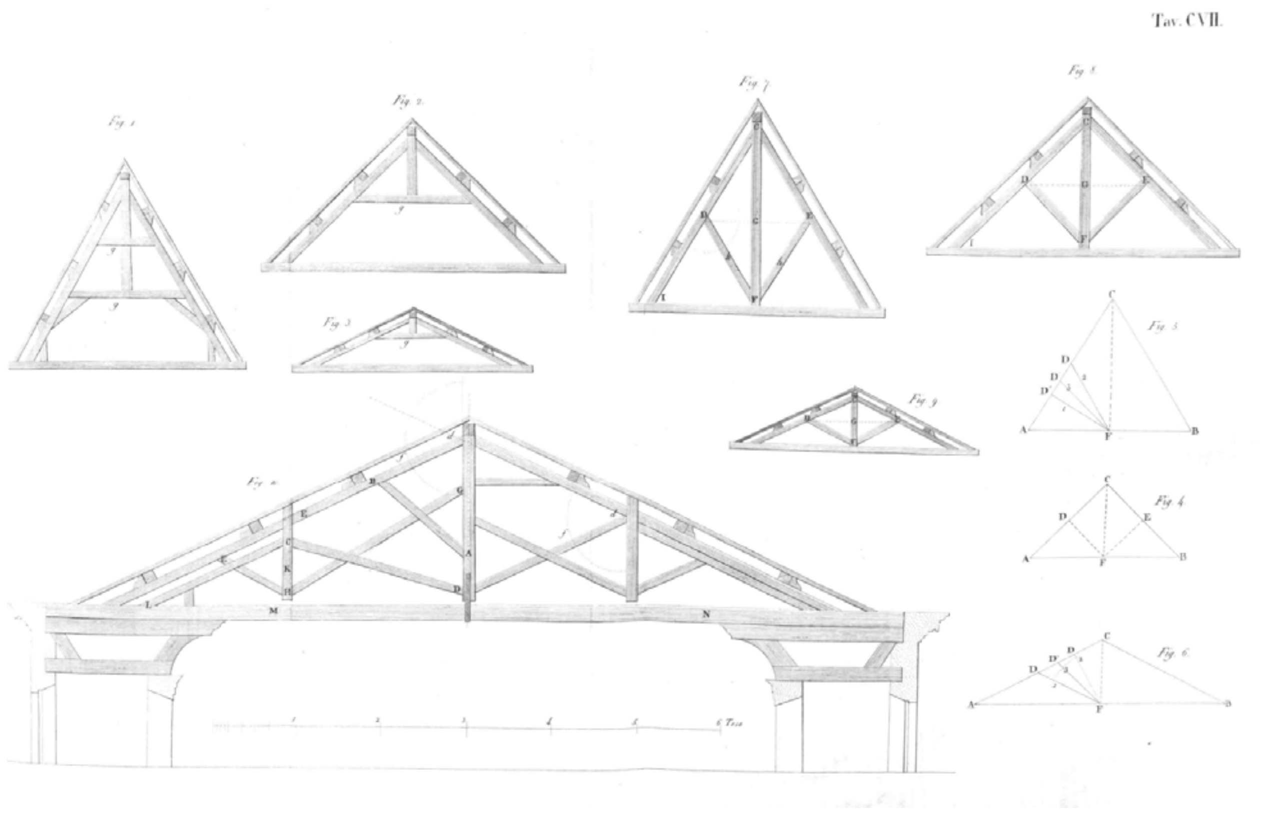



Figure 3. Rondelet Table CVII: Disposition of the elements of the reinforcement according to Functional principles.

Following Rondelet and his followers' examples, the question of style and typological and formal aspects of the construction ended then to be discarded by technical handbooks and delegated to those who came from the world of the Academies and the *Ecoles des Beaux Arts*, then tracing a net groove between the practices and the training of engineers – constantly evolving and updated on scientific objectivity – and the reality of the architects. These found themselves in fact devoid of the contact elements with the technical field that sought rather precise solutions to specific building types, and they had to contact those consolidated and traditional formal languages of the historical archive, using a series of parameters that allow them to choose a style rather than another.[19].

[18] Ibidem, p. 119.

[19] Trivellin, E. Storia della tecnica edilizia in Italia: dall'unità ad oggi. Florence: Alinea, 1998, p. 52.

In addition to the above works it deserves a place also for another work, decidedly on technical branch and specifically addressed to the world of engineering: it is Belidor's *The Science of Engineers*, translated into an Italian version in 1834 by Luigi Masieri. This work is characterized as a very technical and scientific compendium, interested in the mechanical part of the discipline, as evidenced by the titles of the various chapters devoted precisely to the mechanics of vaults, arches and walls aimed at civil and military works; always in Belidor's, particular attention is paid to both the method of packaging and processing of the materials and to the recent studies on the Science of Construction, reported in a tome apart[20] [21]and cited as *Notes of Mr. Navier to Mr. Belidor's Science of Engineering*. The final part of the work are the accompanying drawings, describing those related to the cases of fortification and classic building – with capitals, bases, etc. buildings from the Classical era – contained in the first volume of text only.

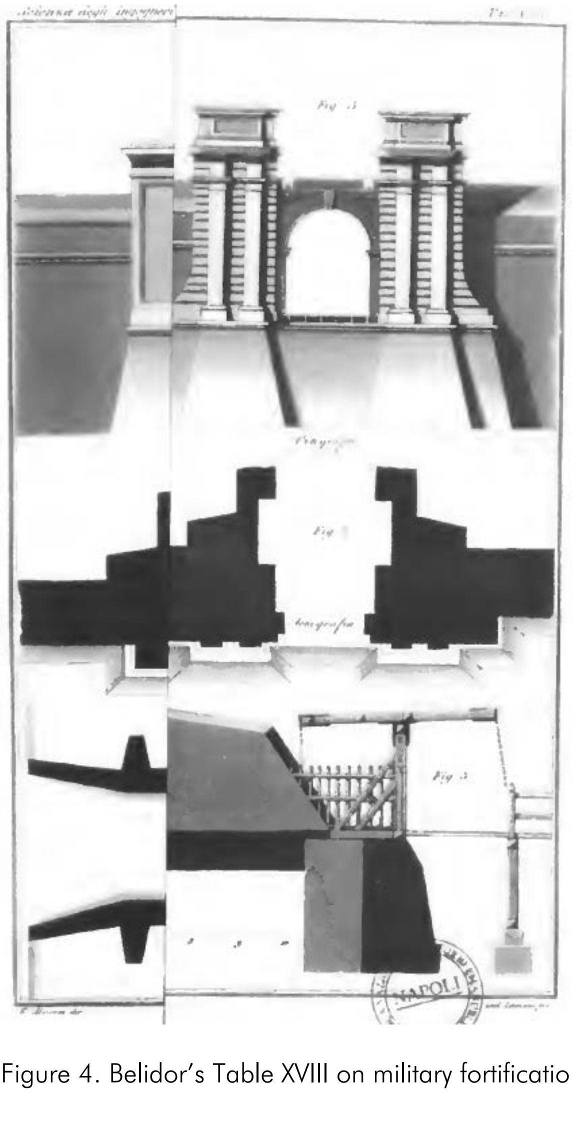


Figure 4. Belidor's Table XVIII on military fortification

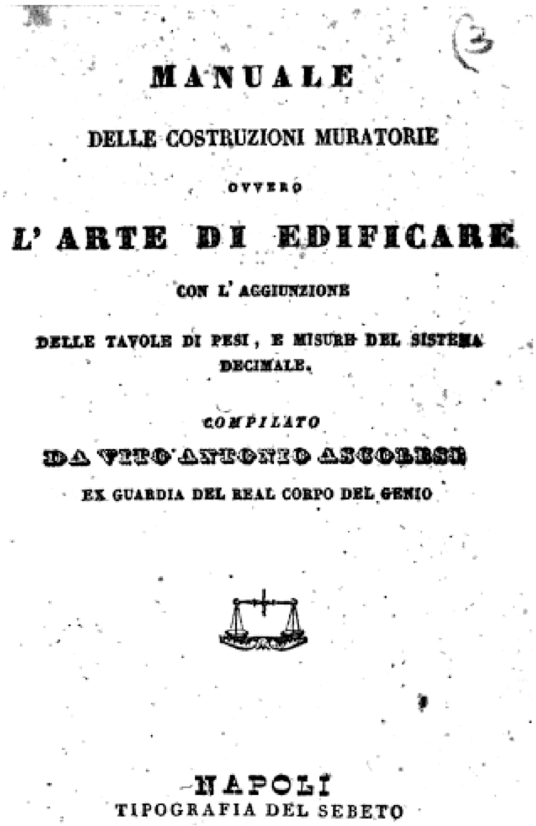
[20] Masieri, L. *La Scienza degli ingegneri nella direzione delle opere di fortificazione e d'architettura civile di Belidor con note del Signor Navier*. Livorno: Giulio Sardi, 1834.

[21] Masieri, L. *La Scienza degli ingegneri nella direzione delle opere di fortificazione e d'architettura civile di Belidor con note del Signor Navier. Tavole*. Mantua: Fratelli Negretti, 1832.

Mattia Giuseppe Sganzin: *New Complete Course of Public Construction*

The most obvious advantage of Sganzin's work, formed in the period of transition from the *Ancien Régime* to the Restoration in the middle of the Age of Enlightenment, is to present a systematic and divided repertoire of the most important achievements that occurred in those years, thus presenting itself as an atlas full of engravings, author's notes, sections and subsections. Sganzin then provides a variety of situations both in Europe and in the United States where there are recent and innovative solutions, such as infrastructure of armour systems, ports, roads, bridges, arsenals, particularly in the French camp. It is to the French world that the author will connect most of his references, bearing witness to the period of evolution of French public institutions, in the transition from Monarchy to Republic.

Of the pre – Unification period is also the tome by Vito Antonio Ascolese, the *Handbook of Construction*[22] that, contrary to what was promised in the title, provides a listing of the weights and measures and the preparation mode, works management and delivery by the various protagonists of the construction, i.e. the architect, the builder, the carpenter, etc. It captures also intent so to speak in a precautionary or advisory way facing the unexpected and the worksite accidents that can harm the building factory and intervention measures that belong to each of the characters mentioned by the author.



MANUALE

DELLE COSTRUZIONI MURATORIE

OVVERO

L' ARTE DI EDIFICARE

CON L' AGGIUNZIONE

DELLE TAVOLE DI PESI, E MISURE DEL SISTEMA DECIMALE.

COMPILATO

DA VITO ANTONIO ASCOLESE

EX GUARDIA DEL REAL CORPO DEL GENIO

NAPOLI

TIPOGRAFIA DEL SEBETO

Figure 5. Frontispiece of the Construction Handbook by Vito Antonio Ascolese.

[22] Ascolese, V. A. *Manuale di costruzioni muratorie ovvero l'arte di edificare*. Naples: Tipografia del Sebeto, 1840.

## The post – Unit era

After the National Unity, in Italy arose a period of growth that include both the economic production and the infrastructure, in the wake of the transaction from the pre-industrial phase of Italian manufacturing sectors to the industrial production: the building industry and the constructions live at this time a new stage, motivated by the growing need for urban answers, new patterns of the soil exploitation, the land reclamation and improvement of housing conditions of the working classes. The availability of new materials and advanced techniques for the time goes as close as possible with the specialized training of the engineer, which is increasingly specialized, and it ensures the progress of building production; architecture by contrast remains an open field of ideological and academic debate than of a practical activity[23].
As for the technical treatises and publications in the construction industry of the mid-Nineteenth century – when the fundamental historic and cultural moment shifts in the Italian professional and social reality – classic publications are reissued and at the same time new periodicals, textbooks and especially a new kind of practical and popular handbooks assert themselves: it is the updated edition of foreign works that are handled by Italian technicians and professors with combinations of foreign cases to the reality of national construction.
In these years then handbooks, illustrated tables, handbooks with the drawings which exemplify and dissect technical problems, design solutions, etc. traditional systems proliferate. Recipients are not only the architecture and construction experts, but they are enriched by a wider audience coming from the lower levels of the construction industry, and assimilating those romantic Nineteenth century Enlightenment principles that want the culture and the knowledge addressed to the workers and not to the elites of the medium-high industrial bourgeoisie.
The mechanization of production opens the door to new materials and new tools and equipment to exploit in all kinds of construction work, from residential to those of wider mechanical and technical capacity such as bridges, railways, ports, reclamation and networks of infrastructure works, plant engineering and lighting; everything that was first speculated on paper and brought back to work in a smaller and almost experimental form, now propagates in all the areas of construction, applying to numerous building types ranging alongside the dwelling. Due to these considerations mid-Nineteenth century handbooks became even more sectorial, both in small publications of great size, devoting specific chapters or volumes to specific items (walls, wood construction, iron and stone finishes and decorations, plants, vaults and roofs etc …) and materials (bricks, iron slabs, reinforced concrete). The health emergencies light up a warning sign on the toilet issue of housing, promoting the installation and the study of hygienic equipments as an integrative part of the urban renovation, especially in the old towns and in the social housing, even looking at the examples from Belgium, France and Great Britain where there was the adoption of a Hygienic Record for the Housing[24]. The theme of the working housings was faced and felt to a collective level in the building secor, also stimulating international initiatives in the Expositions of workers' houses in Amsterdam (1862), Vienna (1873), Paris (1878), London (1885) etc.

[23] Guenzi, C. (Ed.). L'Arte edificare. Manuali in Italia 1750 – 1950. Milan: Be – Ma Editrice, 1993, p. 68.
[24] Ibidem, p. 70.

The question of the style takes on new meanings and contributions: in Europe in the Nineteenth century in fact, until the end of the century, there were consciously elements belonging to the remotest periods or disconnected from the architectural culture of the place, reassembled in an almost redundant way according to stylistic criteria distinguished by type (religious buildings, railway, industrial etc ...) or even totally arbitrary, according to Piranesi or bizarre visions: one example among all at European level is represented by the volume *Handbuch der Architektur*[25], literally a handbook of considerable size which collects numerous tables dedicated to the architectural composition, to the architectural style and to the types of emblematic buildings made from ancient times in which they highlight and analyze the styles of distant epochs.

In this literary genre ranks the work of Francesco De Cesare published in 1855. Unlike other types of handbook, *The Science of Architecture Applied to the Construction Distribution and decoration of Civil Buildings* (*La Scienza dell'architettura Applicata alla Costruzione Distribuzione e Decorazione degli Edifici Civili*) identifies more as a treaty that investigates the convenience of architect chosen the time of design as well as technical safety in construction. Even in the first volume, dedicated to the construction of architecture, De Cesare explains the properties of the materials to be used in construction, defines the resistances and performances but omits somehow entering into the detail of the assemblies, components and structural mechanisms of the building parties; in the explanation of the walls, for example, he refers to ancient authors such as Leon Battista Alberti[26] and even to the far more remote Roman walls; he lists the names and old equipment of masonry but to provide instructions for the rating of the parties he explicitly addresses to the work of the "sagacious" Rondelet[27] who "*knowing that only by taking experience could be the true standards to determine the limits of thickness of a wall, and wanting to establish rules based on well-proven facts by the example of buildings, which gave wise of their solid construction, coordinating the safety with the economy, he applied these useful research; and he examined brick and stone walls: his travails and knowledge premise is not difficult to adjust in the variety of' materials.* "

[25] Ibidem, p. 82.

[26] Alberti, L. B. *De re aedificatoria. I dieci libri de l'Architettura*. Vinegia (Venice): Vincenzo Vaugris, 1546, Lib. 3, cap. IX.Vol 1. Op Cit. in De Cesare, F. *La Scienza dell'architettura Applicata alla Costruzione Distribuzione e Decorazione degli Edifici Civili*. Naples: Giovanni Pellizzone, p 137.

[27] De Cesare, F. *La Scienza dell'architettura Applicata alla Costruzione Distribuzione e Decorazione degli Edifici Civili*. Naples: Giovanni Pellizzone, 1855, p 146.


LA SCIENZA

DELL'ARCHITETTURA

APPLICATA

ALLA COSTRUZIONE, ALLA DISTRIBUZIONE, ALLA DECORAZIONE

DEGLI EDIFICI CIVILI

PER

FRANCESCO DE CESARE

ARCHITETTO

SECONDA EDIZIONE

DIVERSAMENTE ORDINATA, E CORREDATA DI NUOVE DOTTRINE

Architectura, Scientia pluribus disciplinis, et variis eruditionibus ornata.
Vitruvio, Lib. I.



VOLUME II.

NAPOLI
1856

Figure 6. Frontispiece of De Cesare's The Science of Architecture.

In 1856 appeared in Italy the volume of Armand Rose Emy titled in the Italian translation[28] *Treaty of the Carpenter art*: the complexity of this discussion is clear since only observing the illustrated Atlas, in which it seems the succession of all the possible conditions of application of the wooden carpentry, with a huge and complex review of frames, joints, roofing groundwater, beams, arches and ribs and so forth. The work is thus presented more like a job dedicated to the designing engineer that to the carpenter, being devoid of the intuitiveness and technical practicality that will characterize the handbooks of the last part of the century, often dedicated to the workers responsible for the realization of the building more than the engineer or the architect.

Four years after De Cesare's handbook, was published in Naples the volume *Principles of Architecture*, written by Luigi Ragucci, which however distances itself from technical papers par excellence like the Cavaliere di San Bertolo's or Rondelet's megalithic work. This volume can in fact be reasonably associated with that strand of handbooks that takes into consideration the costs and the definitions of building materials and finishing of buildings, rather than their correct application and combination during the phases of construction. Not by chance often this type of handbooks is characterized by "regionalistic" tints, which take account of changes in cost of labour and the production of products for the building industry, the result of local variations, the different names and forms by which the indigenous culture of production affects the finished products. In this sense it is located, in addition to the work of Ragucci, also Curioni's *Treaty* dedicated to construction materials albeit facing in a more specific way their characteristics and properties.

[28] Emy, A. R., Romano G. A. (ed.). 1856. *Trattato dell'arte del Carpentiere*. Venice: Antonelli, 1856.

Giovanni Curioni: *The Art of Manufacturing*

The first text of united Italy's technical architecture is *The Art of Manufacturing*, written by Giovanni Curioni and published in Turin in 1865. Like its predecessors, this one presents itself as divided into volumes and certainly it is important to reflect on the presence of a tome fully dedicated to the resistance and to the performance of the materials, the result of recent studies on the science of constructions in the Academies and Italian University with the latest theories on the strength of the construction elements. Just Curioni deserves the merit of having introduced in Turin's School in 1877 the course of Structural Mechanics, revisiting the previous Mechanics of buildings.[29]In his volume in truth the part entitled *Resistance of materials and stability of the construction* treats briefly the resistance without officially introducing the strain (as the same Navier in his *Résumé des leçons*) and it arrives to the resistance of beams studying tensile stresses, compression, torsion, shear and bending and with a nod to the reticular trusses, although in a simplified manner, on the model then of the treatises of his time.

The handbook is divided into six volumes, containing within it the author's studies and researches, the results of his academic experience and then it responds to the need for a constant technological research in addressing the challenges facing the growing industrial construction. As a whole, it can therefore be defined as an open work, hardly finally ended in its goal because it leaves open the possibility that the professional is ongoing update and enrich his knowledge of materials with new contributions, testing new theories and putting into practice the advances in *ars edificatoria*. The mission of the text is therefore to provide expertise in all the fields of construction, contributing at the same time to form the builder with the most recent technical and scientific knowledge[30], while the third volume is dedicated to the work of civil, road and hydraulic architecture after minutely deepening the building materials, the characteristics and the costs in the immediately preceding Volume. For Curioni a 360 – degree knowledge of the performance of each component of the building is critical and this awareness stems certainly from his training and academic activities, where he sought, studied and experimented continuously. Not satisfied by the completion of the work in 1870, this is followed only three years later by the entire apparatus of the Appendices, motivated by the need for constant and never completely insatiable need to learn about the modern art of building: although it is not systematically presented as in his major work, Curioni faces here the specific geometry problems, achievements and contingencies of the yard, miscellanea, science of construction combined with examples of transport infrastructure planning. He concludes this second publication with a volume dedicated to the results of experiments on materials and deformations, presenting then as the result of an intense and long program of research and experimentation rather than as a practical constructive Treaty, thus mediating between the engineer's figure as a scholar of mathematics and statics of bodies and that of the specialized designer from the concurrent application Schools[31].

[29] Capecchi D. G., Ruta G. *La scienza delle costruzioni in Italia nell'Ottocento*. Milan: Springer Verlag, 2011, p. 181.

[30] Guenzi, C. (Ed.). L'Arte edificare. Manuali in Italia 1750 – 1950. Milan: Be – Ma Editrice, 1993, p. 92.

[31] Ibidem, 92.

In Curioni's *Opera omnia* there is an interesting dissertation entitled *Parts components the backbone of a civil construction above the underground*, in which is provided an eloquent explanation accompanied by mathematical formulas for the calculation of the stability of the masonries, the bearing parts in wood and cast iron such as arches, pillars and columns, piers with the relevant verifications based on the most varied series of deformation and of the causes of breaking:

*Thickness of the walls of factories numbering different levels with vaults. -*

*A wall that bears a vault is subjected to vertical and horizontal actions stresses: the first tend to crush materials which are found to the lowly speak of the wall; the latter tend to slide or topple whole or in part. The horizontal forces, said thrusts, are generally the most influential: they depend on the shape, the size and construction of vaults system; and the thickness from allotment for walls should be inferred considering the intensity of the thrusts, the positions of their points of application, the adhesion of the materials, the friction that can take place in the sliding of a piece of the wall, and finally those resistors that can oppose the iron keys and all those means lozenges linked to well keep the walls of a same edifice. The problem, when we want to take into account all the circumstances that I accompany, it is very difficult and even solving it approximately, embarrasses into long, bothersome calculations, that in most cases are unnecessary, either because the edifices with vaults are very numerous, and because experience the teachings cannot fail, and points of comparison are easy to collect, and because each location offers sufficiently certain requirements that must be accepted as result of long experience. In Turin, the different planes of the civil factories, except the last one, are generally covered with vaults, and factories to be built with good materials, thicknesses* $x_p$ *and* $x_i$ *of the perimeter walls and the transverse walls can be considered as expressed by the formulas*

$X_p = 0,45 + 0,12\, n$

$X_i = 0,45 + 0,06\, n$

*being* n *the number of floors in excess of what is considered.*[32]

[32] Curioni, G. *L'Arte di Fabbricare*. Turin: Augusto Federico Negro, 1865, pp. 32-33.

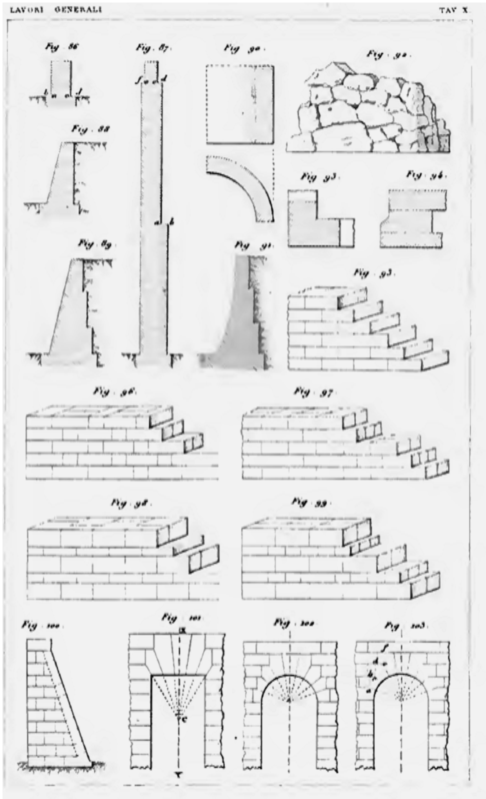


Figure 7. Table X from Curioni's: main forms of walls.

In the chapter devoted to the floors it is also stated that the calculation system of permanent and accidental loads that weigh in the slab and the dimensioning of the parts that compose it:

*Dimensions of the main parts of a floor. - The planks forming the boards, which usually are found on the floors beams, joists and beams constituting the beams, are the parts of which should calculate the size to give the project a slab whatsoever.*
*Both the boards as the joists and beams now indicated are solid prismatic horizontally arranged, having symmetrical cross sections with respect to the vertical through their surface centres and loaded weights that, in most cases, may be regarded as uniformly distributed over their length . [...]*
*In order to well understand what is the procedure to be held in the calculation of the dimensions of the main talk of a slab, let us suppose of having to built one over a rectangular area, which is essentially constituted of the main beams in iron T and crosses t leaned at their lower boards.*

The chapter on the floorings finally ends with the calculations on resistant sections of the walls and the individual beams.

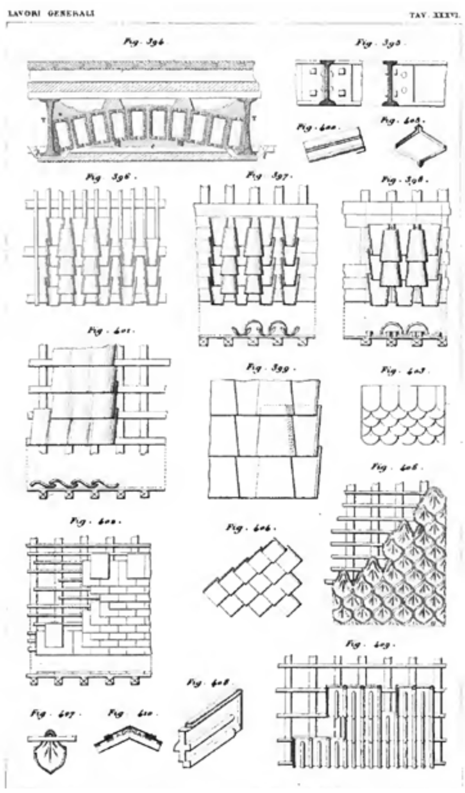


Figure 8. Curioni's: iron slab and roof of a timber roof.

Details are also given on the minimum heights of buildings[33]:

*In houses where the ground floor is occupied by shops, the height of the door is the one that determines the height of said plane. The comfortable transit for supporting structure requires that the width of the latter arrivals at least 2,80 meters, and that the height is at least one and half the width, which gives a height of door expressed by 4 meters, 20. At this height add after that of 0,80 meters, that there must be the highest point of the line that superiorly limits the light of the door up to the mezzanine floor, in order to understand the joke, the gash and the time from the entry in the hallway, and immediately turns out, because the ground plane must have a height of approximately 5 meters. You can decrease the height of the ground floor and reduce up to 4 meters, when you make sure that the lobby occupies the partitions.*

Camille Polonceau and the metal truss

A few years after the publication by Cavalieri di Sant Bertolo, we have an important innovation in the field of iron construction by Camille Polonceau in the *Revue Generale de l'Architecture et des Travaux Publics* in January 1840: it is the technical explanation [34] of a new timber and iron roofing system which will be called by the author, or "*Polonceau* truss".

[33] Ibidem, pp. 223-224.

[34] Polonceau, C. 1840. Notice sur un Nouveau Système de Charpente en bois et en fer, par M. Camille Polonceau. In *Revue Générale de l'Architecture et des Travaux Publics* vol. 2 (Janvier 1840). Paris: Ducher et al., pp. 27-32.

The author explains:

*Each system of construction is required to satisfy the double condition of durability and economy or in other words, all the materials used in a system of construction must be placed in conditions of resistance such that we can give them the thinnest possible dimensions and that the their assembly is of the greatest simplicity. Convinced of this principle, I composed the new roofing system that I go on to describe: to make it easy to understand, I will begin by presenting the exposure of the conditions that have led me to adopt it.*

*Each closure is composed of: 1 of two beams or inclined pieces following the slope of the roof, pushing one against the other by their top and intended to bring the cover; 2 of a tie that meets the lower parts of the beams to prevent them from coming off and to destroy the pressure that without it they would exert on the walls supporting them. There are then the other pieces which can be considered as auxiliaries and which are intended both to prevent deflection of the beams under the load they bear both to support the tie beam, which may flex under its own weight.*

*The bending of the tie beam is always easy to prevent because the force that tends to produce it is weak; but it is not the same for the beams, especially where they are of great length, because their squaring is very limited and they often support of very considerable loads. It is therefore on how to employ to oppose the bending of the pieces that you do especially careful. It easily prevents bending of a workpiece such that* AB *in putting under its half a* CD *mounting leg which rests on the iron tie rod* ACB *stopped in* a *and in* B *by two shells. It is evident in fact that the point* D *will not flex under the load if not for the breakage of the* ACB *rod; thus giving this guy the size proportional to the loads that you can consider this point as invariable. The Kick* CD *that plays then the role of the fixed support, reduces by half the extent of the work that can no longer deflect that by* AD *or* DB*. But you can very easily increase the rigidity between these points by increasing the strain of the* AC *and* CB *bars, since then tension reassemble the point* D *by the pressure on* CD*, the* AB *piece takes a curvature which gives it a great force. This curvature is indicated in the figure by dotted lines.*

*It has thus a very simple mean to make a rigid piece of a great length and is easily perceives that two reinforced beams as is* AB *will be very convenient to form the beams of a wooden closure; so are the two pieces so arranged that I have chosen to compose the beams* AB *of the new system that I propose. I gathered together by a* CC *tie beam wrought iron, fixed to the ends of the two legs* DC, D'C*. The tie beam is attached to the ends of the legs for several reasons: first, because it is always advantageous to place them as high as possible in order to leave more pass under the cover; then because its length is reduced to one third of the full aperture between the supports; and finally, because he is willing to act forcefully armour, as we make them see farther.*

*We must point out here that, just increase the length of the tie beam, we were able to suppress the punches; it follows that the tie beam, although pulled up, acts directly on the foot of the beams to the half of the bars* AG A'C *and forming an integral part of the reinforcements and that* *there are of the dual function of reinforcement for beams and tie rods to prevent the pressure tending to move the walls.*[35]

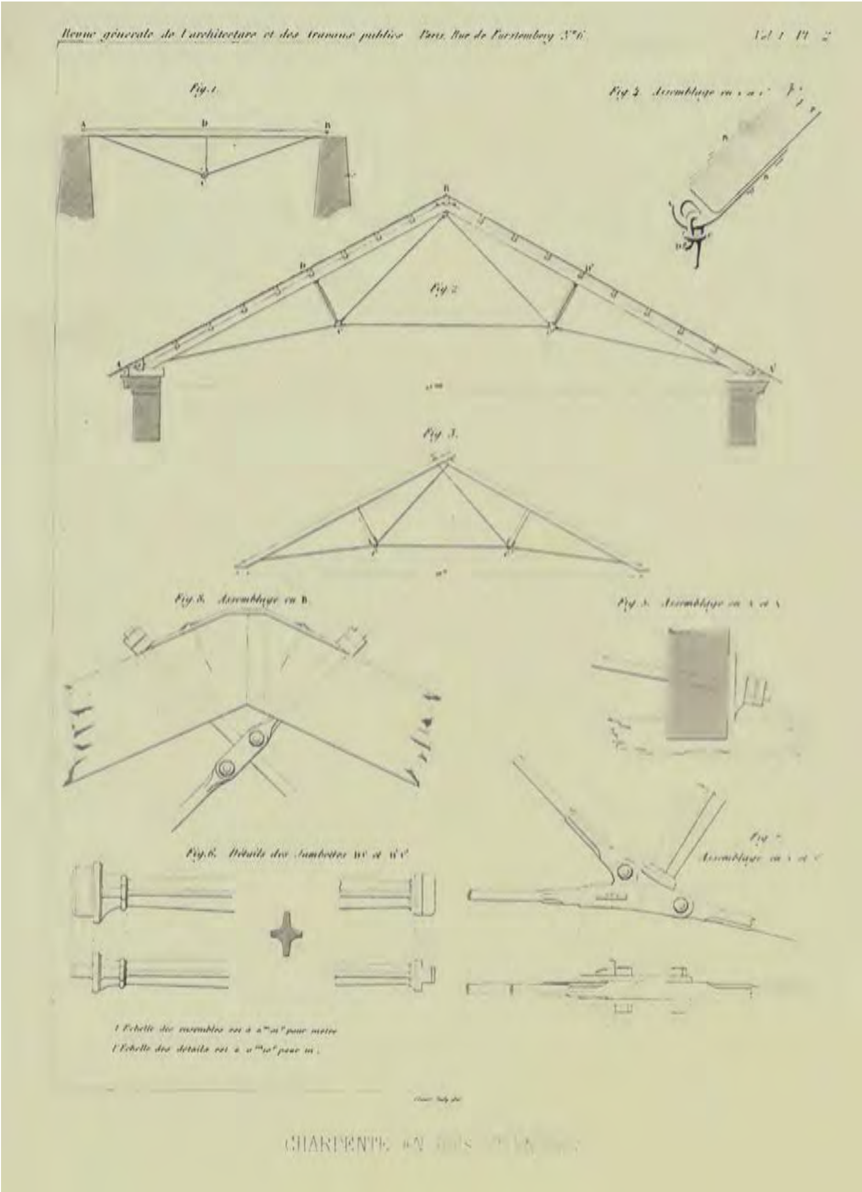


Figure 9. Details of assembly and metal and wooden parts that make up the joints of the truss Polonceau.

*We will end this part saying that for enumerating the advantages it presents, we know:*

1. *a great expenditure of economy, so that the attachment will try estimate of spans of 8.40 m, built in the railway of Versailles which did not cost more than 28 francs each.*
2. *A considerable economy of large building woods that become rare and which are here replaced advantageously in the ratio of lightness and duration, from the iron triangles of a few meters.*
3. *The suppression of the thrust against the supporting walls, although the cover is raised. This suppression has been demonstrated by the experiences cited above and from the*

[35] Ibidem, pp. 27-29.

*model to a tenth embodiment of a cover 12 meter range, placed Exposition of Industry products. This model, instead of the smooth iron rails, remained loaded, during two months, of a weight of 60 kg without experiencing the slightest alteration.*

4. *A great lightness. In fact, to put on one of the closures that I had built, they took only two men, who have taken over their shoulders at each end of the closure and that they put in its place halfway down the stairs. During this time, the other two humans maintained in a vertical position with the help of the court attached to its top. It took just half an hour to the implementation of each hedge.*
5. *Much of passage height under the shell as a result of the elevation of the tie beam.*
6. *A great simplicity of assembly, which leaves to the materials used all their strength, labour savings, and makes these so convenient funding for temporary buildings that for the definitive ones. Each beam has only one notch in its entire length and the irons are simply folded by one of their ends and threaded, they retain much of the strength and can be disassembled and used elsewhere without losing value.*
7. *The ease with which a cover is assembled and disassembled. First of all, because of its lightness that makes it possible to easily transport it from one place to another; and then it has only 4 shells to be put to mount, or to undo it apart.*
8. *The ability to withstand heavy loads that can suspend at points* B, D *and* D' *because the effort of these loads is reported directly on the iron rods to which you can always give enough strength to resist.*
9. *The only way to resume tightening the closure shells that moves or a beam that flexes.*
10. *The possibility, where there are no large pieces of wood, making the beams of two parts assembled at point* D.[36]

The spread of this new construction system crept in Italy in factories and industrial buildings at a time when the practice of metal construction was strengthened in the Country, a little late if compared to other European nations. The *Polonceau* truss, along with the *Emy* truss, then became part of the constructive non-residential building language, preceded by the metal joints – often made of cast iron – which were well described by authors such as Pizzagalli[37] and Valadier[38], whose works aim the successful attempt to unify the techniques of realization of the joints of the ligneous and for woodworking tools, thus freeing them from the local tradition[39].

[36] Ibidem, p. 30.

[37] Pizzagalli, F., Aluisetti G. *Dell'arte pratica del carpentiere*. Milan: presso gli autori ed editori, Ponte di San Marco, 1827.

[38] Valadier, G. *L'architettura pratica dettata nella scuola e cattedra dell'Insigne Accademia di San Luca dal Prof. Accademico Signor Cav. Giuseppe Valadier data alla luce dallo Studente d'Architettura Civile Giovanni Muffati Romano*. Rome: Società Tipografica, 1828 - 1839, 5 vols.

[39] Munafò, P. Le *capriate lignee antiche per i tetti a bassa pendenza: evoluzione, dissesti, tecniche di intervento*. Florence: Alinea ed, 2002.

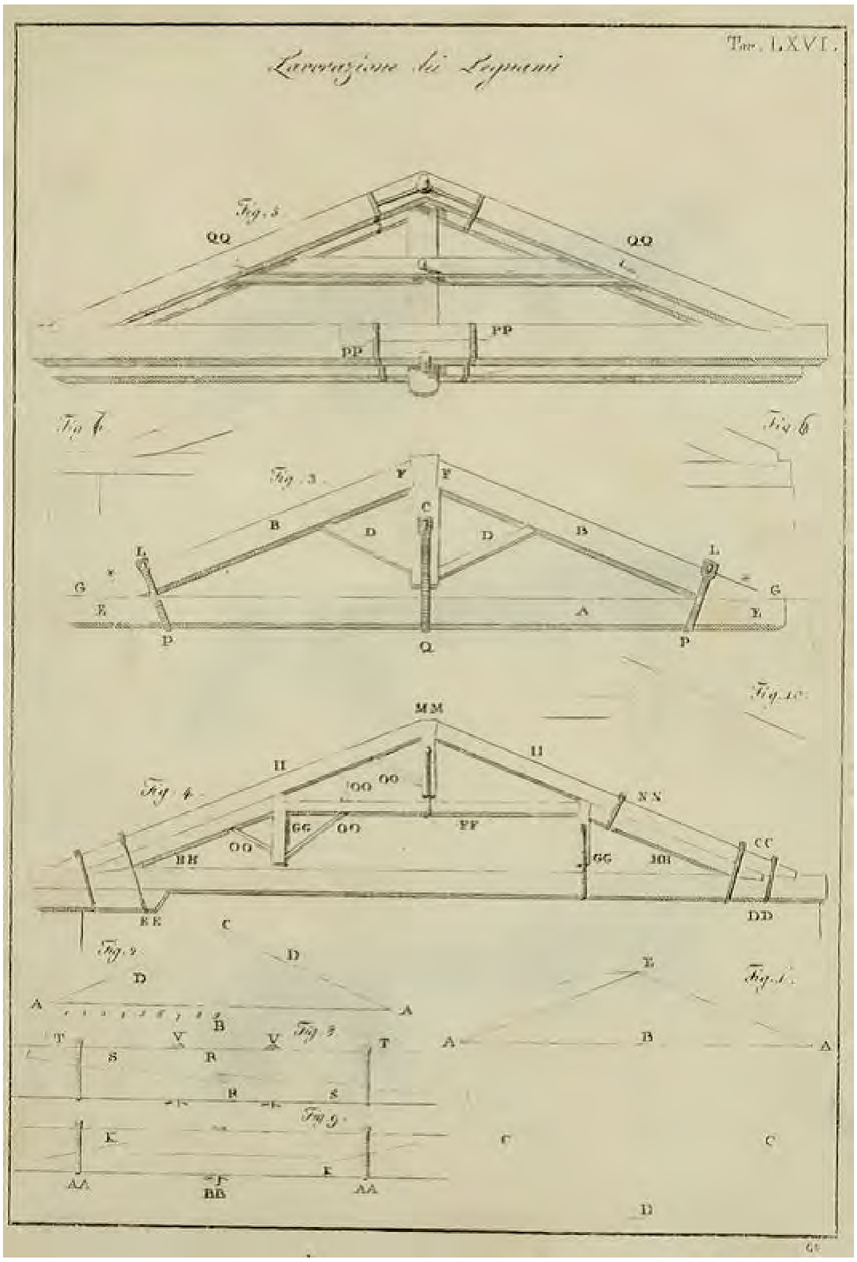



Figure 10. Valadier's Table LXVI: processing of wood. Schemes of timber trusses with metal implants.

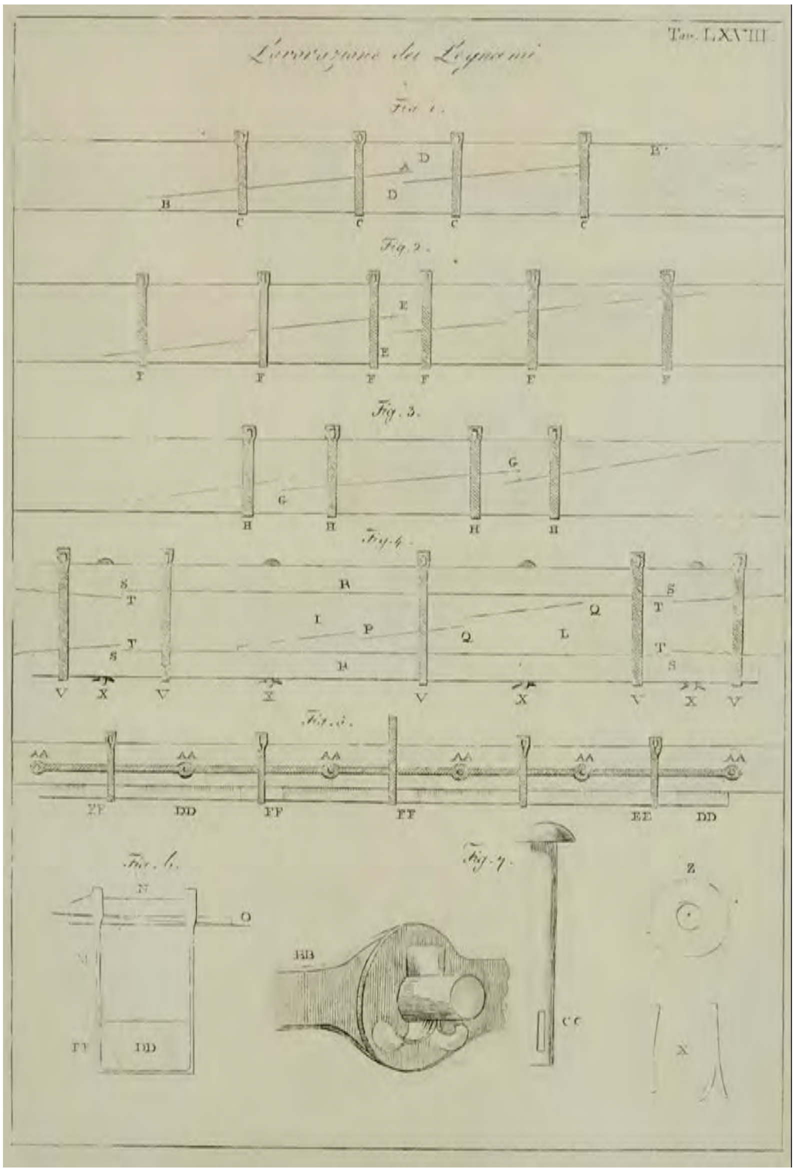


Figure 11. Valadier's Table LXVIII: processing of wood. Metal joining of wooden beams.

In a short time in the newly unified technique it appears on stage another treatise by Antonio Cantalupi[40] who follows the traces already marked by Rondelet and his epigone Curioni. The title is *Elementary Practice Institutions on the art of building Civil Edifices* and here it is possible to find some very interesting facts about the building practice that allow us to identify the procedures that in general were put in place at the time of construction of buildings. Starting from the roof, Cantalupi offers a comprehensive and clear overview of definitions and principles governing the timber roofing and sizing of the component parts, using the formulas dictated in

[40] Antonio Cantalupi (1811 - 1898) Engineer of the Royal Corps of Civil Engineers and collaborator since 1850s to technical magazines such as T *Il Politecnico*, *Il Costruttore* e *Il Giornale dell'ingegnere architetto ed agronomo*. See: Bigatti, G. *La città operosa: Milan nell'Ottocento*. Milan: Franco Angeli, 2000.

turn by French authors who had already summarized the principles in simplified tables. About timber roofs Cantalupi writes[41]:

*The roof [...] is that part of the building that is meant to protect the building from rain, the snow and other inclement weather. In the roof is divided into two parts, namely the* scaffolding and covered. *The armour may be of wood or iron. The covered is formed with verses materials, namely: with curved tiles or flat, with slates, with sheets of copper, lead, iron or zinc, or with asphalt, making no calculation of straw covers or boards, which we are not to be employed*.

Armour. [...]*is called* aquifer *the inclined surface on which shall commence the waters [...]. The intersection of the two flaps, i.e. the vertex of the roof, is named chimney, and the joist that is placed in this place is said colmareccio or* colmello. *The lower part of the aquifer is called the* gutter or gronda. *They appeal* roots (radici) *the beams that slide horizontally on the walls where it goes to lean against the armour of the roof. The props that you bring inclined to reinforce a beam of some length are said* struts (saette); purlins (arcarecci) *and* tempiali *are those beams which are placed horizontally along the pitch at equal distances between them, which serve to support the* rafters *and* battens (travicelli and correntini).

*It is called* paradox or cantonale *that beam that starting from the ridge goes to lean extreme with the other to a corner of the building and therefore determines the intersection line of two divergent flaps; it constitutes the ridge and in some cases the* compluvium.

*[...] The* trestle *is made from the* tie beam, *which runs horizontally and goes to lean against the wall of the building; by* struts *that are set to the tie beam and follow the inclination of the flaps;* king post *from which descends vertically from the ridge to the interposed struts; by* diagonal braces or arrows *that support struts in the middle leaning on king post. All these pieces joined together form a invariable triangle*.

*The armour of a roof can be simple or compound. It is called plain when it is of one, two or four flaps that overhang to form regular edifices of limited size. In addition to such armour* rafters *and* battens *we have only* the chimney *and* the purlins [...] *In this case the* trestle *is formed by the* tie beam, *by two* struts, *from the* king post *and two* diagonal beams. *The stands are placed at a distance of about 4.50 meters between them, and the purlins are distributed to approximately 1.50 meters intervals. Above these there are large wood joists arranged in the inclination direction of the flap, and placed to the distance between them to 0,50m from centre to centre. At right angles to the rafters upon you the flashboards or stringers, which are among them 0.12 meters deviates from centre to centre*.

*[...] To have a good coverage it is necessaries to have the following requirements, namely:*

*1. That the inclination of the strata is appropriate to the climate and the quality of coverage.*

[41] Cantalupi, A. *Istituzioni Pratiche Elementari sull'arte di costruire le Fabbriche Civili*. Milan: Domenico Salvi e Comp., 1862, pp. 206-209.

*2. That the coverage does not produce horizontal drifty against the side walls, and these are compounded as little as possible.*

*3. That the elements of the reinforcements are just the right size, cut and linked exactly and placed in the most favourable way.*

*[...] The solidity of armour in general depends on the right dimensions that are assigned to each member that composes it, in such a manner that they can provide their duties of resistance that they compete also in relation to the distance at which they are located. To this suitably serve the formulas and concepts dates on the strength of materials in general, of which the reinforcements are no more than a simple application. [...] The big beams are made exclusively of strong wood, i.e. oak or larch. No one admits chestnut, both because of the shortage of this material, both to ease the crash and chipping.*

*[...] we here take to consider the stand of plain weave, and to determine the size of its main parts, namely of the struts and the tie beam. Calling:*

p the load evenly distributed on the struts;

C the length of the strut;

C' the half length of the truss after

*the total weight of the roof, taking into account all the items as, seen from the following table[42]:*

| SISTEMA DELLA COPERTURA | Lamiera galvanizzata | Zinco N. 14 | Tegole piane | Ardesie | Tegole cave a secco |
|---|---|---|---|---|---|
| Inclinazione del coperto coll' orizzonte. | 20° | 20° | 40° | 40° | 30° |
| Lunghezza del puntone C . . . . | 1,064 C' | 1,064 C' | 1,214 C' | 1,214 C' | 1,155 C' |
| Peso di un metro quadr. di coperto (1) | 64 chil. | 64 chil. | 125 chil. | 100 chil. | 130 chil. |
| Superficie del coperto (2) met. quad. | 3,724 C' | 3,724 C' | 4,249 C' | 4,249 C' | 4,043 C' |
| Carico tot. dei puntoni p C, chilog. . | 242,06 C' | 242,06 C' | 531 C' | 425 C' | 525,59 C' |

Dimensions of the struts. - [...] *Calling* a *the width of section of the strut and* b *the height, and admitted that in the roughly processed wood is taken be equal in height to the width, the size of the struts, in the various cases of the practice, will be given by the following table[43]:*

[42] Ibidem, p. 211.
[43] Ibidem, p. 212.

| QUALITÀ DEL COPERTO | Lunghezza della catena 2 C | Legno rozzamente squadrato a = b | Legno squadrato colla scure a = 0,9 b | | Legno a quattro fili a = 0,75 b | |
|---|---|---|---|---|---|---|
| | | | b | a | b | a |
| | metri | metri | metri | metri | metri | metri |
| Zinco N. 14 . | 5,00 | 0,118 | 0,117 | 0,105 | 0,114 | 0,086 |
| | 6,00 | 0,133 | 0,131 | 0,117 | 0,130 | 0,098 |
| | 8,00 | 0,161 | 0,159 | 0,143 | 0,157 | 0,118 |
| | 10,00 | 0,187 | 0,184 | 0,165 | 0,182 | 0,137 |
| | 12,00 | 0,211 | 0,208 | 0,187 | 0,205 | 0,144 |
| Ardesie . . | 5 | 0,141 | 0,140 | 0,126 | 0,139 | 0,104 |
| | 6 | 0,160 | 0,158 | 0,142 | 0,157 | 0,118 |
| | 8 | 0,194 | 0,192 | 0,173 | 0,190 | 0,143 |
| | 10 | 0,224 | 0,223 | 0,201 | 0,220 | 0,165 |
| | 12 | 0,253 | 0,251 | 0,226 | 0,250 | 0,188 |
| Tegole piane . | 5 | 0,153 | 0,152 | 0,137 | 0,149 | 0,112 |
| | 6 | 0,173 | 0,171 | 0,154 | 0,168 | 0,126 |
| | 8 | 0,209 | 0,207 | 0,186 | 0,204 | 0,153 |
| | 10 | 0,243 | 0,240 | 0,216 | 0,237 | 0,178 |
| | 12 | 0,274 | 0,270 | 0,243 | 0,261 | 0,200 |
| Tegole cave . | 5 | 0,176 | 0,174 | 0,157 | 0,172 | 0,129 |
| | 6 | 0,109 | 0,196 | 0,176 | 0,194 | 0,146 |
| | 8 | 0,240 | 0,237 | 0,213 | 0,235 | 0,176 |
| | 10 | 0,279 | 0,276 | 0,248 | 0,273 | 0,205 |
| | 12 | 0,315 | 0,311 | 0,280 | 0,307 | 0,230 |

*When the struts are constructs with malleable or laminate iron of the shape of a prism with a rectangular section, in this case the thickness* a *is equal to 1, the height* b*, and the* R *coefficient of resistance becomes equal to 6000000, or to 8000000, according to the a greater or lesser resistance.*

*The size of these struts will have the formula*

$ab^2 = (p\ C / R) \times 0{,}75\ C'$.

*Size tie beams. - The horizontal tie beams are subjected to a tensile stress which exerts the strut at its base, and this effort, which is a fraction of the load* p C, increases with decreasing the elevation of the roof.

*Iron Fittings*[44]*. - In Due to the many difficulties encountered in tracing the thick beams when you have to build the big armour and depending on their cost that sometimes rises at a huge price, the same day it shall be adopted by the iron armour manufacturers, by means of which it removes the danger of fires, replacing the metal shell to the bricks and the slates for greater lightness.*

Figura 1.ª

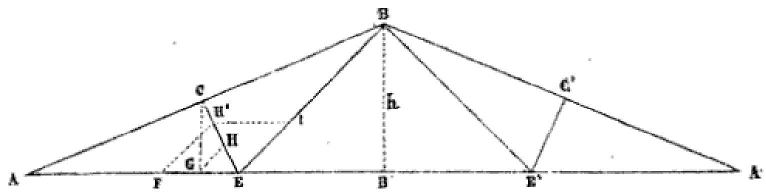



Figure 12. From Cantalupi's: Iron Fittings for roofs.

[44] Ibidem, pp. 215-216.

Briefly Cantalupi continues in presenting his study with two references to foundations and walls, for which provides empirical data based on both French and Lombard experiences:

Foundation walls[45]. *The solidity of a building depends largely on the more or less good construction of its foundations. It is therefore important that the architect-engineer ensures that those foundations are carried out in the best way [...] The foundation walls are built some decimetres bigger than the above ground walls, practicing cuttings or offsets at the top of them, in size that vary along with the thickness of the walls and the greater or lesser solidity that one wants to give to building.*
*Manufacturers in Lombardy assign to these offsets the width of 0,15 m, so that the walls in the façades are 0,75 m thick, the foundation walls are 1,05 m and the partitions are 0,90 m thick, when they are 0.60 m thick above ground. [...]*
*A medium used frequently with advantage to achieve the solidity of the foundations is to place a mass of bitumen formed from stones, bricks pests, hydraulic lime and sand in a manner to have a quick petrifying. This bitumen formed in a large compact mass conveniently, as well as presents a solid plan and evenly distributes the compression, provides to the spring, which are thus eliminated, which many times can be of inconvenience to the foundation of the walls.*

Walls in elevation or above ground. *In public factories walls are divided into two species, namely, the field walls or masters and partition walls. The main walls are those that surround the edifices, and enclosing the plant from top to bottom, they are left to themselves in the outside, and held in the interior of the roof timbers and floor. [...] The thickness of the main walls where the building is simple, as commented by Rondelet, should keep equal to 1/24 of the sum of the width and half the height; namely, if the edifice is 5m wide and 10m high up to the roof, the thickness of the walls should be equal to 5 + 5/24 = 0, 41 m. If the factory is double, the mentioned thickness should be equal to 1 / 24 of the half-sum of the width and height. [...] Rondelet notes that in the ordinary case where the height of the attic is not more than 3.90, but 4.87 m, to determine the thickness of the partition walls is enough to have regard only to the length of the space that divide and number the attic that should support. To these walls therefore you should assign the thickness of 1/36 of the amount of the length of the space and the height of the plane. [...] Furthermore, to get a convenient solidity in elevation walls it is necessary that their thickness should be gradually diminishing from the base to the top, but to a certain extent. [...] For the walls of context, the total decline from the base to the top of the building is 1/4 the thickness. So, if at the base of the wall is roughly 0,60m, the last upper floor it will be of 0.45 m, where the height of the attic is not more than 3,90 but 4,87 m, in order to determine the thickness of the partition walls is enough to have regard only to the length of the space which divide and the number of attic that must sustain. These walls therefore you should assign the thickness of 1/36 of the amount of the length of the space and the height of the plane. [...] Furthermore, to get a convenient solidity in elevation walls it is necessary that their thickness should be gradually diminishing from the base to the top, but to a certain extent. [...] For*

[45] Ibidem, pp. 195-197.

*perimetral walls, the total decline from the base to the top of the building is 1/4 the thickness. So, if at the base of the wall is roughly 0,60m, the last upper floor it will be of 0.45 $m^2$.*[46]

## The end of the Nineteenth century

As you can see the reference to the works of Rondelet, Belidor and Morin[47] confirms once again that the circulation of ideas, knowledge and constructive culture had taken place in a very marked way in the cultural and scientific climate of the mid-Nineteenth century. The evolution of the handbooks becomes increasingly rapid and varied enough to address not only the classes of Academies or Polytechnics but also builders, foremen and those who in practice had to have a clear concept of the building construction formulation. These handbooks are therefore accompanied by increasingly clear, three-dimensional and colourful drawings, in which emerges not only the completeness of the details in every particular but also the immediacy of reading and understanding for each building component, from the structural to the purely accessory ones. In 1880s and 1890s we see the spreading of explicative handbooks containing mainly illustrations, such as in those by Carlo Formenti[48], Luigi Cattaneo[49], Musso and Copperi[50] that show the different problems of construction, from the walls to the plants, the application of new materials and are intended for the management and organization of the building site with a range of innovative solutions; on the other side the insights in the technical and structural field related to the resistance of materials lead to the emergence of such works as Adolf Breymann's[51].

Of the first type, which we can define as the Illustrated Atlas, there is the one of 1874 by Archimede Sacchi[52], Professor at the School for Foremen and before at the Polytechnic. Sacchi held since 1867 for nearly twenty years a course of practical architecture, in which the theory and application merged with a wonderful harmony ". This volume is accompanied by texts and tables still in black and white and it uses the communication skills of isometric views and orthogonal projections – the first to propose the themes of architecture, the latter to describe the projects – and therefore forms a publication of practical architecture.

### Luigi Cattaneo: *The Art of Masonry*

The handbook by Luigi Cattaneo, published in 1889, is enriched by the author's long experience within the Royal Technical Institute and the annexed School For Foremen, where Cattaneo taught geometric design. The text is designed exactly with the same intent of the School, which form both the professional figure than the manpower coming from Technician Institutes or from the School for Foremen: tracing the series of teachings provided in the Institute that he himself

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[46] Ibidem, pp. 201-202.

[47] Morin, A. Cantalupi, A. (eds). *Resistenza dei materiali*. Milan: Salvi, 1854. Op. cit. in Cantalupi, A. *Istituzioni Pratiche Elementari sull'arte di costruire le Fabbriche Civili*. Milan: Domenico Salvi e Comp., 1862, p. 210.

[48] Formenti, C. *La pratica del fabbricare*. Milan: Ulrico Hoepli, 1893.

[49] Cattaneo, L. *L' arte muratoria* : dettagli di costruzioni. Milan: Antonio Vallardi, 1889.

[50] Musso, G. *Particolari di costruzioni murali e finimenti di fabbricati*. 2 voll. Turin: Paravia, 1885.

[51] Breymann, A. G. Baukonstruktionslehre. Stuttgart: Hoffmann, 1849.

[52] Sacchi, A. *Le abitazioni, alberghi, case operaie, fabbriche rurali, case civili, palazzi e ville*. Milan: Hoepli, 1874.

directed, in fact he provides extensive knowledge of the subjects of the biennium – surveying, agronomy, accounting and ornamental geometric design – and the address of "design and construction", i.e. civilians and rural construction, roads and hydraulic, which are the basis of the training of engineers together with practical exercises[53].
The index finally resumed themes such as land surveying and those specifically directed to the technical education of master builders: throughout the Nineteenth century in fact, this figure will always take more ground within the project and the construction site, although not performing the work personally but having close contact with the client, the workers, the architects and engineers, and therefore it requires a proper training, validated by theoretical and academic contributions as well as by the corporatist internship that prevailed until 1872, year of establishment of the School of Milan.
After the first theme dedicated to elementary geometry and geometric solids composition, the work is concentrated in a series of tables dedicated to manufacturing problems and turns almost explicitly to the masons and builders rather than to engineers, offering elementary solutions, simple proposals and intuitively appealing, sectioning the whole series of construction details accompanied by installation and by the realization in a workmanlike manner without skimp on measures to be taken, proportions, sequences of the procedures to be followed, and so on[54].
The language uses the traditional terminology, ancient we may say, which had remained alive in the language of the building site: for example, in defining the building blocks, still differentiated between *albasi* and *ferrioli* according to their cooking, Cattaneo goes back to the specifications of procurement from Sixteenth and Seventeenth centuries in Milan[55].

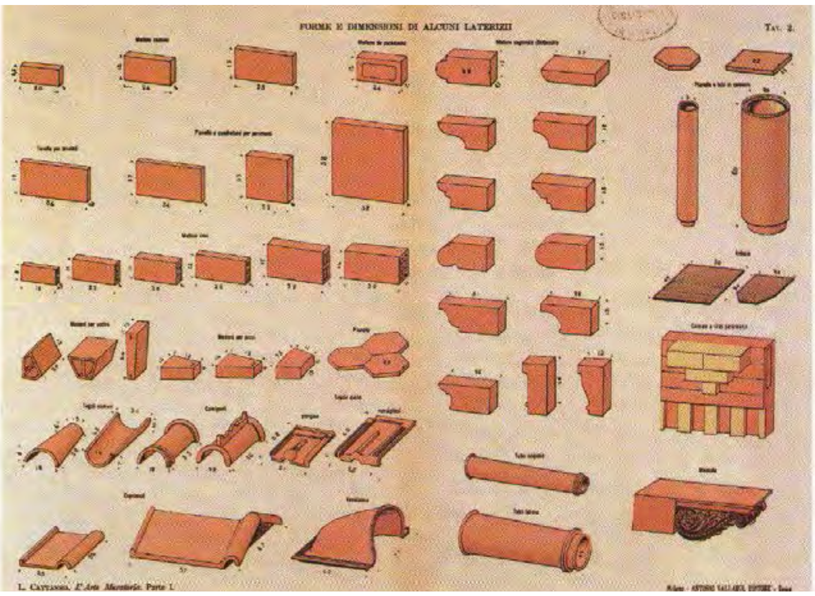


Figure 13. Cattaneo's: exampling shapes and sizes of bricks.

[53] Guenzi, C. (Ed.). L'Arte edificare. Manuali in Italia 1750 – 1950. Milan: Be – Ma Editrice, 1993, p. 130.
[54] Ibidem, pp. 131-134.
[55] Lacaita, C. G., Fugazza, M. *L'istruzione secondaria nell'Italia unita. 1861-1901: 1861-1901*. Milan: FrancoAngeli, 2013, pp. 270-271.

Giuseppe Musso and Giuseppe Copperi: *Details of wall constructions and buildings harnesses*

The category of illustrative handbooks includes also that by Giuseppe Musso and Giuseppe Copperi[56] published in 1885. In this volume there is a particular attention devoted to the construction procedures, with less prominence to the study of materials and their properties which, according to the authors, are already part of the cultural background of anyone who comes to the realization of the building and those to whom the text is intended.

In the introduction the authors already anticipate their artwork and editorial method: a series of drawings of details of wall constructions, accompanied by explanations and methods of realization, of rules and practices in force at the time of writing. The great simplicity with which they presented the building works is functional to the understanding of all the phases of construction, the use of materials and the realization of the constructive elements, the implementation and the correspondence of the building components to the functional requirements[57]. The reading public is educated on average, but not completely divorced from the site conditions; the detailed description of the tables should not suggest a superficial theoretical vision of building problems but a conscious need for immediacy and information on the topics, by virtue of technical and technological innovations that are advancing in Italy and abroad in those years. The listing and faithful illustration of the building site, the properties of materials and the best practices of building techniques are valuable in this treaty both for their quality and for the compliance with the architectural production of the time, providing important explanations on building practices and on the interventions on Turin artefacts of the late Nineteenth century.

The work consists of three parts: the masonry works, those of harness and the rural areas. The materials are described briefly at the beginning and then are widely treated within the embodiments illustrated in which they are used. The volume dedicated to agriculture reflects the academic setting of technical schools in which the agronomy and all its scientific forms was an integral part of the training programs for engineers and therefore it presents a large series on land reclamation, on irrigation, livestock and "industrialized" agriculture [58]. The authors are also interested in the hygiene and plant matters, particularly in rural residences, thus responding to the question from the theoretical and scientific debate in Europe in those years on the question of the health of agricultural buildings and industrial ones. Not by chance Musso and Copperi, in the second volume, choose to present a case study of a Piedmontese textile factory illustrating not only the distribution choices – where to place the laboratories – but also formal and structural ones – with mounting system of brick masonry, cast iron columns, wooden floors or concrete vaults[59]. However, the attractiveness to this as to other works is not only referred to the structures but to the whole works, with their equipment, their facilities and services, both for industrial type that the residential one. Long parts are then dedicated to auxiliary services, in

[56] Musso, G. Copperi, G. 1885. Op.cit. in Trivellin, E., 1998 and Guenzi, C., 1993.
[57] Guenzi, C. (Ed.). L'Arte edificare. Manuali in Italia 1750 – 1950. Milan: Be – Ma Editrice, 1993, p. 98.
[58] Ibidem, p. 108.
[59] Ibidem, p. 114.

particular the toilets, the heating, gas and hydraulic plants, all amply illustrated on par with numerous publications of the time.

To the question of the style this book leaves the choice to the architect, since the presented examples allow the maximum freedom of finishing and decoration – inviting to choose one style or another as long as it make the building "artistically beautiful"[60] – and thus it opens the doors to the general application of decorative and Eclectic linguistic criteria, faithfully to Piedmontese realities of the time. The formal control is therefore taken into consideration as to suggest even "poor" decorating techniques as the graffito that requires a simple application, low cost and low maintenance materials.

This reflection on the modern needs of the house, however, not immediately finds a systematic realization in the conception of the Nineteenth century living spaces and will have to wait until the advent of much more modern design criteria, inspired by the principles of the Twentieth century Avant-gardes.

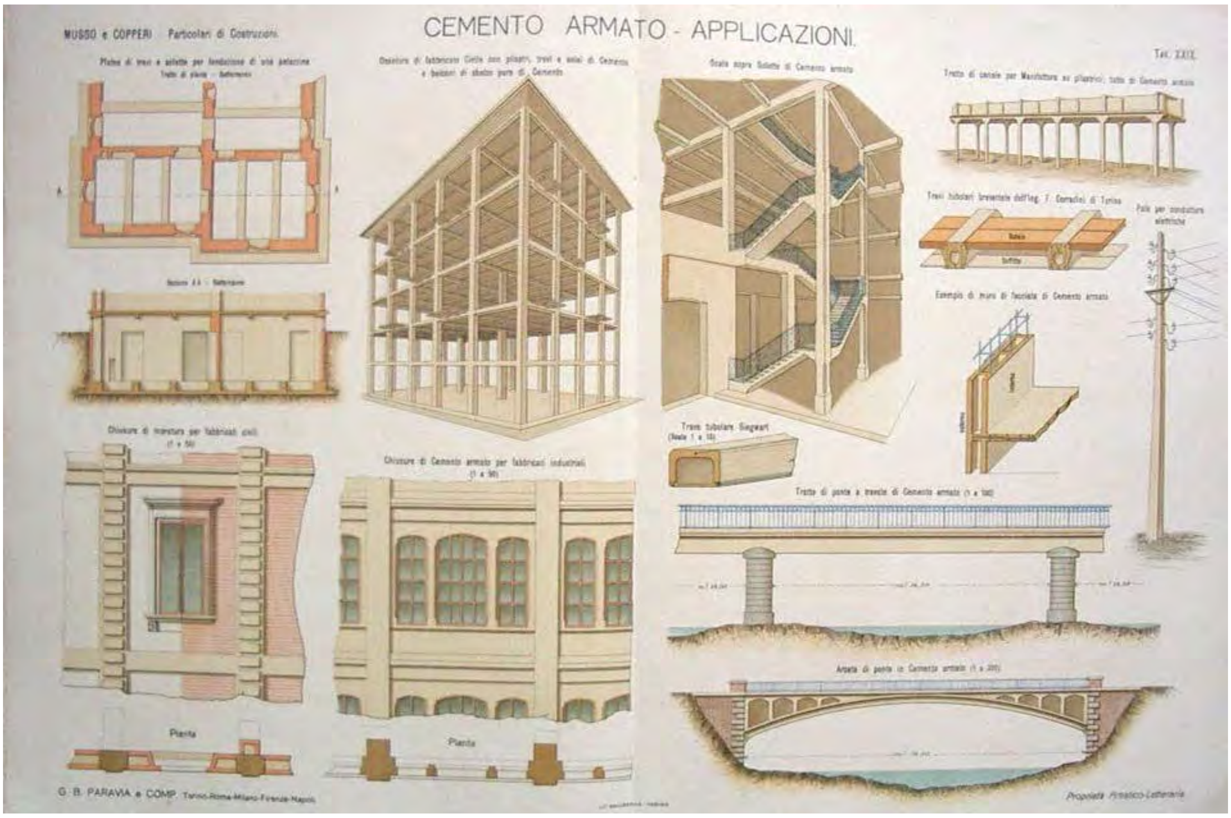


Figure 14. Musso and Copperi's: Details of wall construction. Table XXIX Concrete - applications.

Carlo Formenti: *The Practice of Manufacturing*

Definitely the most significant volume in the culture of Nineteenth century handbooks remains the work of Carlo Formenti, entitled *The Practice of Manufacturing* and published by Ulrico

[60] Ibidem, p. 115.

Hoepli in 1893. The author aimed here specifically at the professional engineer, developing a series of tables linked to the building features of the Milanese reality[61].

In 1866 Hoepli had published the work by Aristide Sacchi "*Hotels, workers' housings, rural factories, civilian houses, palaces and villas*" that summarized all the typological series that were the basis of the urban renewal of the mid-Nineteenth century in Milan and that is the prelude of Formenti's Handbook[62]: the presentation of "minor" buildings compared to the architecture of great works then signs the change in thinking that had invested the technical Schools and addressed to the rural buildings, schools and kindergartens, markets and services for the city. Formenti's work resumes this address and is addressed to the same typological analysis, representing a technical and constructive ideology which results in the graphical representation of the tables, systematically functional to the solution of technical problems, the use of new materials, new patents of constructions (Hennebique and Coignet[63]), completing the evolutionary picture of static constructions and plants of those years. The tables take advantage of the high quality design as the predominant tool for the narrative up to the details of construction problems, which become immediately legible and concrete, declined in the frequent type of the dwelling house: the graphic segment, the parties' section, patterning and captions offered in this work are a synthesis both of the author's professionalism and of the technician who designs and on the other hand emphasize that the practical knowledge and the survey of materials provide an undeniably greater assurance than the linguistic and formal refinement that the architects expressed in all the heterogeneity of the Eclectic repertoire.

The dwellings also provide an opportunity to explain all the changes that the building type suffered in those years, depending on its technological equipment and their role within the urban planning: it is in fact included in this Handbook by virtue of the large and long experience that Formenti practiced from 1892 in the projects of civilian homes and shops in Via Dante and the author generalizes and widens the series, offering the type of residence – store that will be established for a long time in Milan.

The problems associated with this type are primarily those of edification: Formenti illustrates the types of foundation, the delimitation of the site, its organization, the machinery and procedures in a highly detailed and "sophisticated" manner. Then, it follows the distribution of residential and commercial buildings, with large rooms on the ground floor for shops and cellars and deposits below street level, lit from outside through gates placed at higher elevations. The materials are the most modern ones: iron and cast iron for the floors, the openings of doors and windows, stairs and open roofs lit by skylights. The ultimate goal goes beyond the illustrative clarity and presentation of the series, because Formenti wants to contact the client so that he might see in an explicit manner the correspondence between design and practical realization, thanks to the similitude between design and completed reality: drawings of details, finishing, wood decor and stucco, wrought iron, and so on create an immediate understanding of the

[61] Trivellin, E. Storia della tecnica edilizia in Italia: dall'unità ad oggi. Florence: Alinea, 1998, p. 57.
[62] Guenzi, C. (Ed.). L'Arte edificare. Manuali in Italia 1750 – 1950. Milan: Be – Ma Editrice, 1993, p. 138.
[63] Ibidem, p. 139.

customers, encouraging them to take advantage of the professional engineer who is at the service of various formal choices. At this juncture we feel the stylistic attendance of Eclecticism and Historicism but the author did not express a preference for one or the other current, almost disinterested in the formal aspects of the project[64] and leaving to the drawing the task of communicating of the solutions to be adopted and introducing multiple material variants[65].

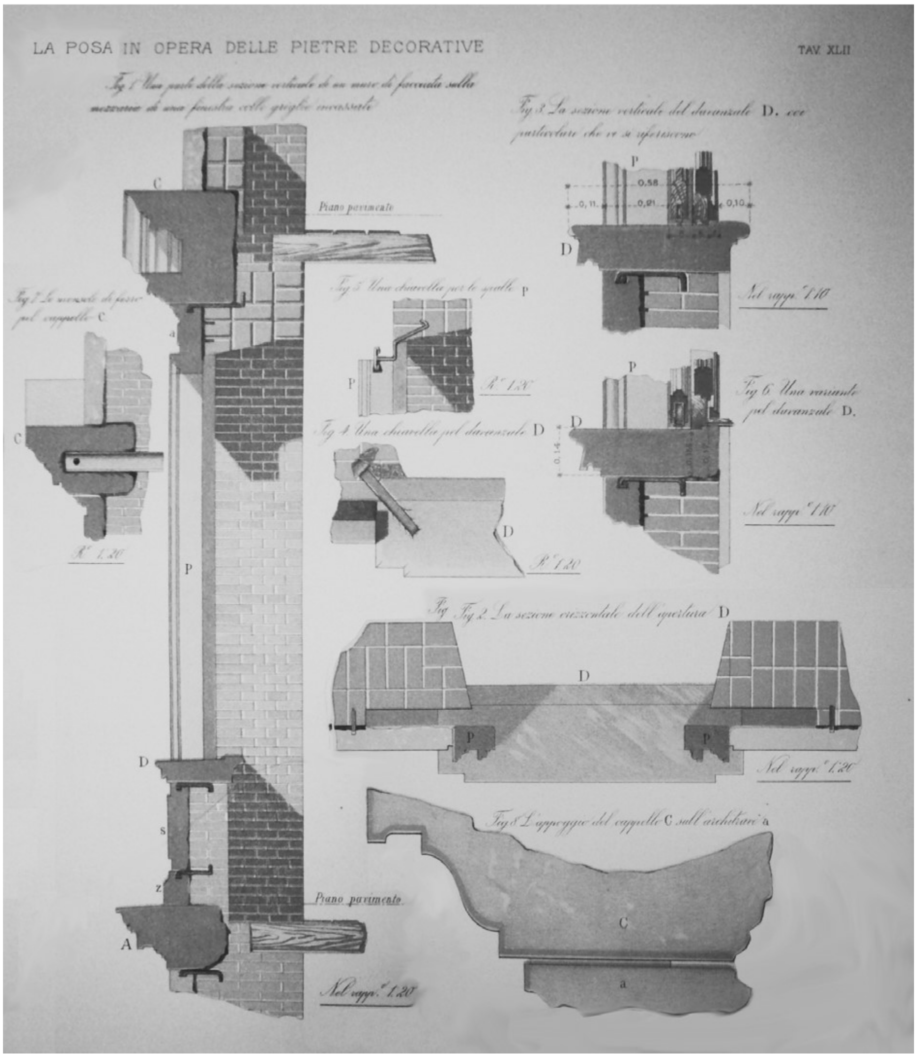


Figure 15. Formenti's The practice of Manufacturing. Table XLII: the laying of decorative stones.

[64] Trivellin, E. Storia della tecnica edilizia in Italia: dall'unità ad oggi. Florence: Alinea, 1998, p. 58.

[65] The industrial materials such as I-beams, pipes, cast parts are combined in this volume with handmade products of high quality but without being overwhelmed by the predominance of decoration and architecture leaving perceive the structural strength of the "iron and brick", one without decoration and compliant economic construction advocated by Boito and precisely applied by engineers to issues of hospital services, the cookers etc. See: Guenzi, C. (Ed.). L'Arte edificare. Manuali in Italia 1750 – 1950. Milan: Be – Ma Editrice, 1993, p. 153.

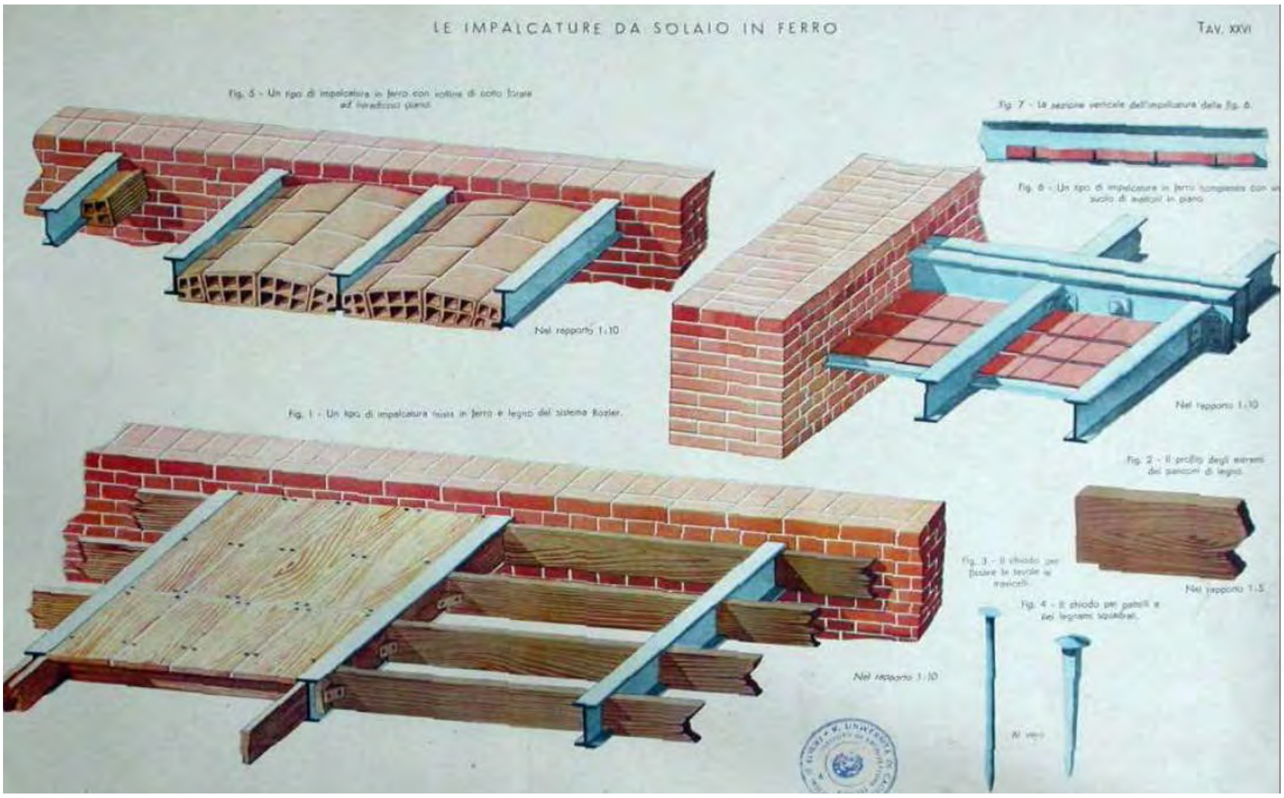


Figure 16 .Formenti's. Table XXVI: The ceiling by iron scaffolding.

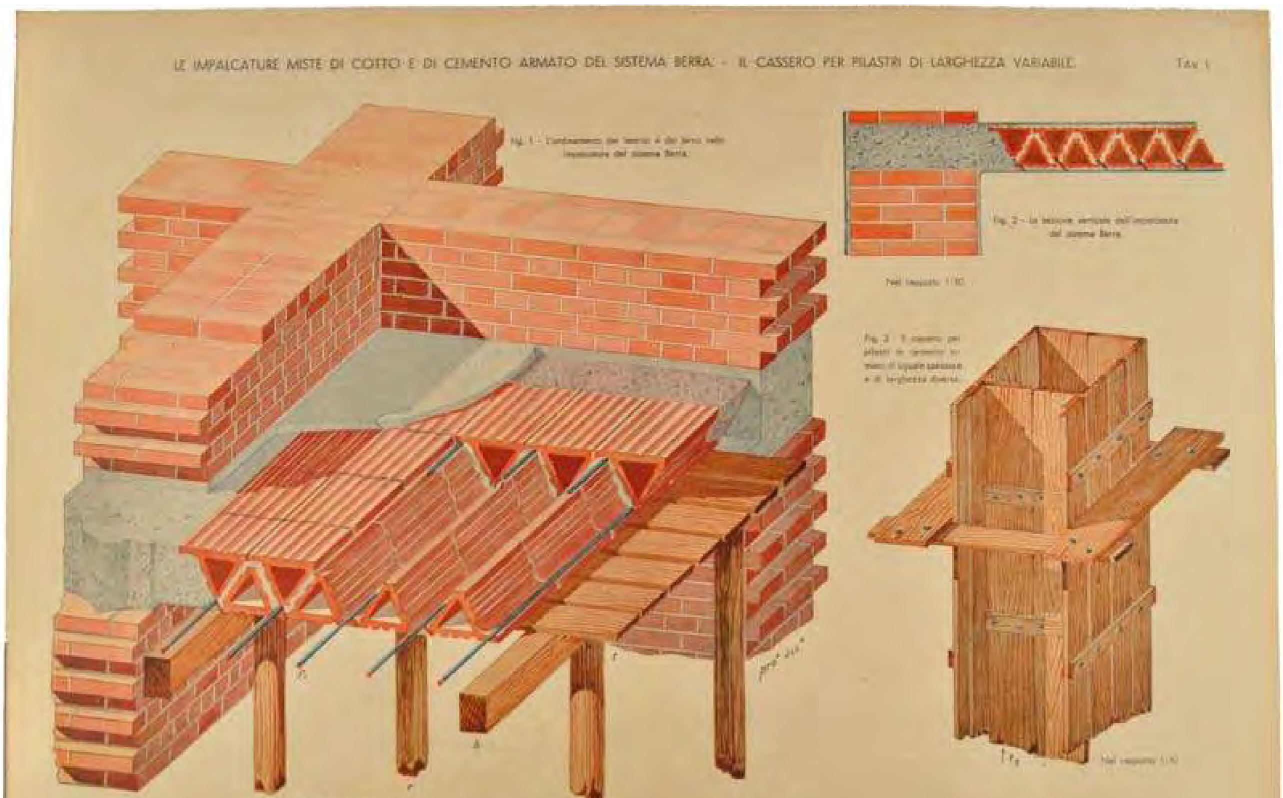


Figure 17. Formenti's: scaffold of bricks mixed to concrete and reinforced Berra system. Formwork for pillars of variable width.

Gustav Adolf Breymann: *General Treaty of Civil Construction*

Of the second type of handbooks, or those in which one finds a particular care in the analysis of scientific properties of materials and structures at the light of the theories of the newly formed Science of Construction, we would cite by way of example Adolf Breymann's work of 1849, entitled *Baukonstruktionslehre*, known in Italy as *General Treatise on the Constructions* and published by Vallardi in 1889. This work is certainly peculiar for its division into four volumes, each dedicated to a building material: stone, wood, metal and some pointers on building installations[66] (gas, foundations, ventilation, water, telegraphs etc ...). In each tome there is a deep and detailed review of formulas and diagrams on the structural analysis of materials. The latter part clearly indicates the author's intention to present scientific and technological innovations on the modern building science that is fully developed in the second half of the Nineteenth century.

In this work it is also paid particular attention to the use of the latest manufacturing technologies along with the theories of computation, introduced with the metric system, which according to the author must be an integral part of the habits and design standards together with the purely technical constructive discussion. The audience to which Breymann deals is the new generation of architects to whom convey information and knowledge on the elements and the systems used in civil construction, which will yield their awareness to put in practice when designing and building. The teaching will then results in an analysis of the individual elements of the architectural, which also includes products of building traditions and architectural style that are constantly being compared in order to present a universal tool for a lecture of the building that would not suffer from limitations of time and validity because of the constant technological innovations but that makes use of always acceptable and truthful contributions. The Treaty focuses on the fact that most of the building components on the whole and on its completion, opening up to the technological and manufacturing innovations that characterize the European context in which Breymann inserts his work. As evidence of this, in the first book dedicated to the stone Breymann introduces a study of hollow bricks already in use in Germany, describing the various equipment, the forms and various dimensions with the consequent possibility of selling them at a cheaper price than the standard bricks[67]. Even in this regard, Breymann shows the example in the Italian National Exposition of 1881 where we could see numerous samples of hollow bricks produced in upper Italy and cites the case of the Universal Exhibition of London in 1859 where these products appeared for the first time in a model building for four workers' families made entirely by perforated bricks – excepted for the foundations.[68]

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[66] As the exact title of the fourth volume. See: Breymann, G. A. *Baukonstruktionslehre. Voll. 1 – 5* Leipzig: Gebhartd's Verlag, 1894.

[67] In Italy, however, the exact opposite occurred for processing of clays costs. See: Trivellin, E. 1998, pp. 54-55.

[68] Trivellin, E. Storia della tecnica edilizia in Italia: dall'unità ad oggi. Florence: Alinea, 1998, p. 55.

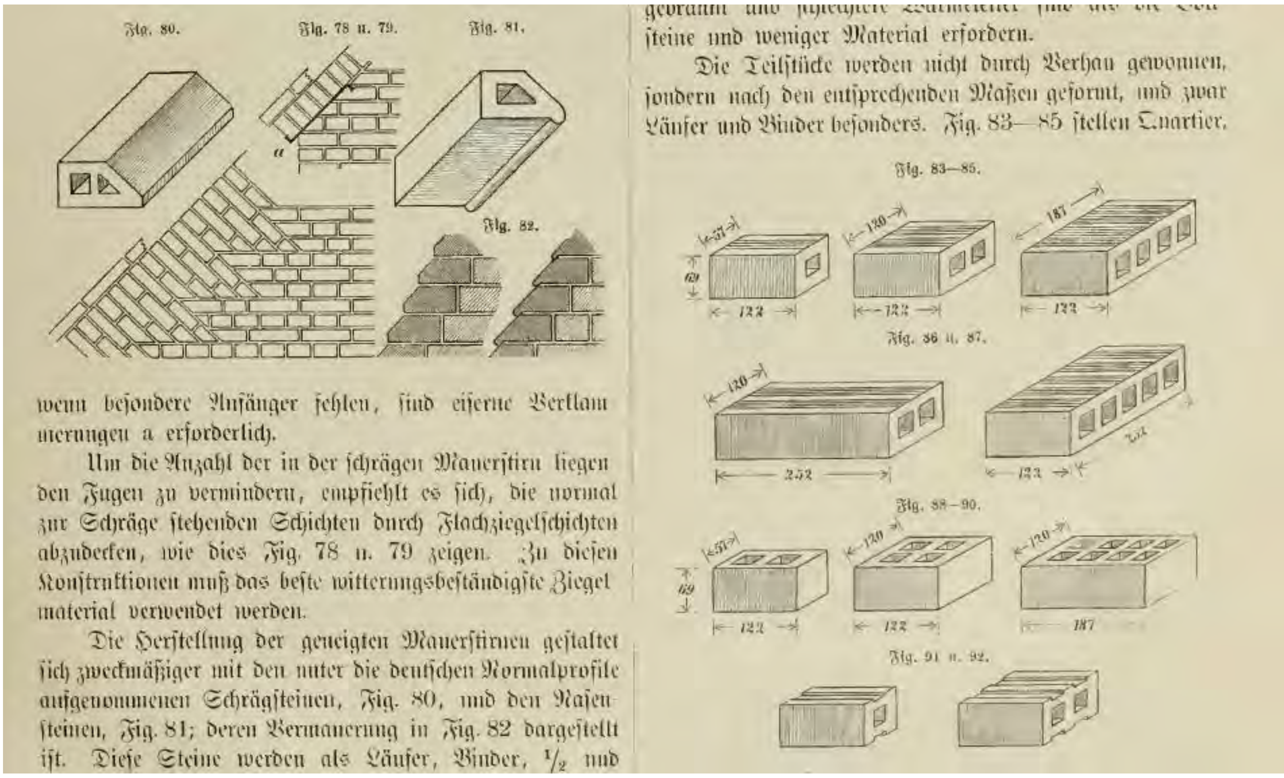

Fig. 80. Fig. 78 u. 79. Fig. 81. Fig. 82.

wenn besondere Anfänger fehlen, sind eiserne Verklammerungen a erforderlich.

Um die Anzahl der in der schrägen Mauerstirn liegenden Fugen zu vermindern, empfiehlt es sich, die normal zur Schräge stehenden Schichten durch Flachziegelschichten abzudecken, wie dies Fig. 78 u. 79 zeigen. Zu diesen Konstruktionen muß das beste witterungsbeständigste Ziegelmaterial verwendet werden.

Die Herstellung der geneigten Mauerstirnen gestaltet sich zweckmäßiger mit den unter die deutschen Normalprofile aufgenommenen Schrägsteinen, Fig. 80, und den Nasensteinen, Fig. 81; deren Vermauerung in Fig. 82 dargestellt ist. Diese Steine werden als Läufer, Binder, 1/2 und

steine und weniger Material erfordern.

Die Teilstücke werden nicht durch Verhau gewonnen, sondern nach den entsprechenden Maßen geformt, und zwar Läufer und Binder besonders. Fig. 83—85 stellen Quartier,

Fig. 83—85.

Fig. 86 u. 87.

Fig. 88—90.

Fig. 91 u. 92.

Figure 18. Breymann's. Examples of lightweight hollow bricks and masonry equipment systems.

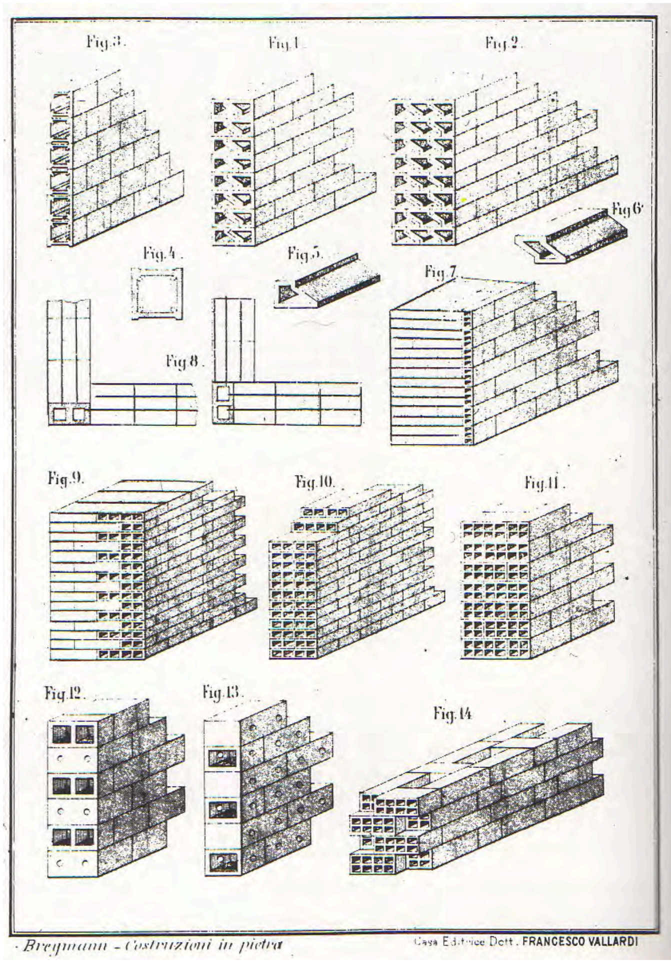


Figure 19. Breymann's: types of hollow brick walls including those employed in 1851 Expo in London.

### Eclectic architecture and productive buildings in the Nineteenth century Monteponi

From the considerations made so far on the development of the Nineteenth century building culture – driven by factors such as the dissemination of scientific and technological ideas even coming from the most advanced European countries, the introduction of new materials such as steel and reinforced concrete, the recourse to forms of expression where the construction technique merges with formal Eclectic and historicist choices, the creation of a network of Academies and engineering Schools constantly careful to the designers' and builders' practical training – we can define some important observations about the architectural and formal configuration of Monteponi's building heritage.

If in the early years of the late Eighteenth and Nineteenth century edification buildings were merely facilities at the service of working activities, such as the jail for those convicted to hard labours, the further arrival of engineers, trained in the territories of Northern Italy or even in German and Hungarian Schools, testifies a strong linguistic and constructive change.

In the case of Saint Real washery, built by Keller in 1853 and of which we report the images taken from the Ottelli's[1] publication, it emerges how the building was originally built with a double pitched roof converging to the eaves, with tiles coverage, and arcades opened in the south façade. Later to this volume was added a porch with masonry pillars, made of irregular stone blocks reinforced at the corners by cut stoned toothing, and a roof made with timber beams and a layer of tiles.

Figure 1. Saint Real Washery in 2011. Source: Ottelli, L. (2010).

[1] Ottelli, L. Monteponi (Iglesias - Sardinia) *Storia di eventi e di uomini di una grande miniera*. Sassari: Carlo Delfino, 2011, pp. 54, 113, 127 and 133.

Figure 2. The Saint Real washery and up the St. Vittorio yard. Source: Ottelli, L. (2010).

Figure 3. The Saint Real washery in the bottom right and the ancient jail in the upper left. Source: Ottelli, L. (2010).

Just 10 years later on Monteponi scene two buildings rose, permanently marking the architectural and stylistic level of the mine: the *Vittorio Emanuele* Shaft and the "*Bellavista*" Directorate. The first building, built in the area of Nicolay tunnel, in fact presents itself as a *connubium* of Modernity and Eclecticism starting from its volumetric and material articulation: a high and narrow volume characterized the south body, whose large opening leading into the internal asset to the machine floor level[2] appeared as an entry into a "Temple of Modernity." A large podium of 5,50 meters in height constituted its impressive stand, making the building mass towering over the smaller existing buildings, to signify the importance of the function performed in the inner "*holy cell*". The façade is designed in the manner of a Neoclassical temple, with Doric pilasters that frame the entrance and support a trabeation of 2,75 meters in height above which sets the pavilion roof (no longer existing). At the sides of the volume opens a series of double-height arches combined with Doric pilasters that frame the openings, the latter split and divided into upper oculi and arched windows, which penetrate the curtain wall flooding the light to the inner room.

To act as a counterweight to the *Vittorio Emanuele* as the "*temple of the production*", Pellegrini designed and built the new headquarter of the Directorate and as a stage to locate the new building chose a flat area just opposite the Shaft, on the slope that overlooks the entire valley below. This scenario will be the background for later works such as the lead foundry and the electrolysis factory. In contrast with the slender lines of the mining buildings of Monteponi, the Directorate building reflects the designer's intentions to respect the contemporary aesthetic canons and use classical architectural lines. As an inspiring model Pellegrini then followed the Neoclassical design standards that, starting from the late Eighteenth century Villa Reale by Pollack in Milan[3], marked the language of most of the villas and palaces of nobility and bourgeoisie of the next century. The building is in fact presented as a miniature of Pollack's work, following the same planimetric C-shaped configuration with two advancing and one central bodies, covered by pavilion roofs with clay Marseille tiles. From the outside you immediately feel the presence of the Late-Renaissance rigor given by the use of imitating ashlar, which incorporates smooth and undecorated openings left in the ground floor and becomes a base on which are set the upper floors, lightened by a series of full height pilasters framing the openings of the main floor. The bearing structure is made of hewn stone masonry of varying size linked with mortar and plastered, bricked platbands and floors made by iron beams and bricked vaults. In 1920 appears the volume on the ground floor, which is interposed between the two wings and constitutes a terrace to the main floor, followed by a tower with battlements and a frame that follows the perimeter of the pavilion roof, amended several times compared to Pellegrini's original version. The Art Nouveau hallmark of the transition period between the two centuries is strongly perceived in the openings and railings, where the floral and harmonious language is combined in an increasingly Eclectic decorative solution with previous decorative motifs, such as denticulation and Renaissance corbels that underlie at the base of the roof.

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[2] This is how it was called the level on which was placed the extraction machine, supplied by the firm Marcellis of Liege. Source: ASCI.

[3] Lai, MB, Olivo, P., Usai, G. (eds.). *Eclettismo e Miniere. Riflessi europei nell'architettura e nella società sarda tra '800e '900. Catalogo della mostra*. N.d.: Graphic sas,2004, pag. 50.

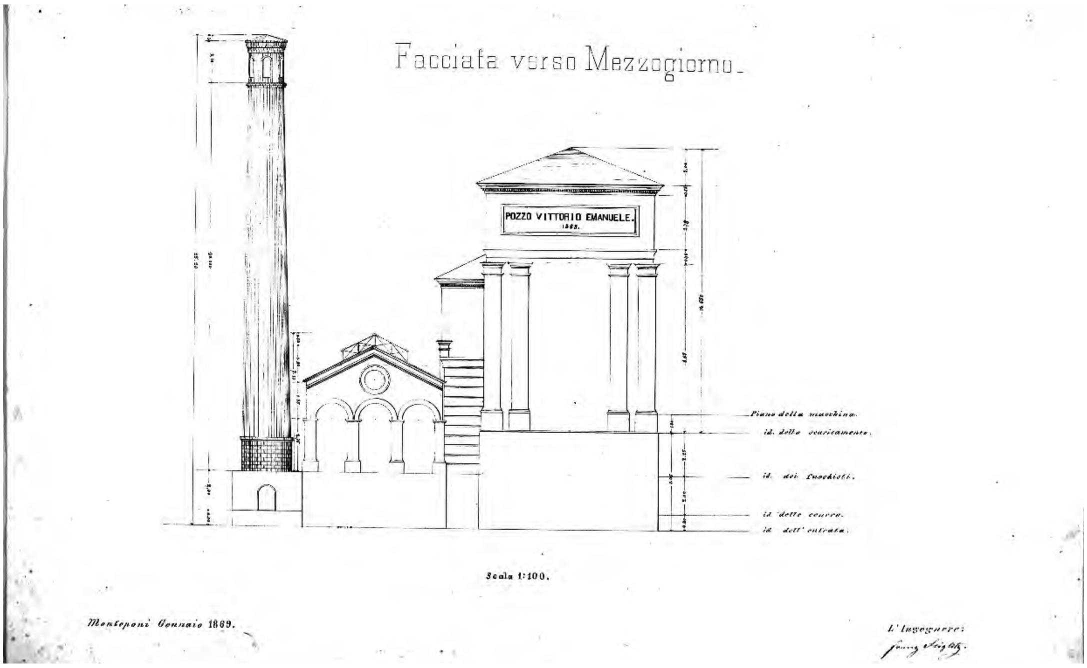



Figure 4. *Vittorio Emanuele* Shaft in a drawing by Franz Stiglitz, 1869[4].

Figure 5 Directorate and Manager's house "Bellavista" in 1866[5]. Source: Archive IGEA Spa.

[4] ASCI, Fund MP – MV, Series Drawings and Cartography, envelope n. 108, chest of drawers n. 4, drawer n. 2, inventory n. 9.

Figure 6. The Villa after the changes of the roof and the addition of the terrace. Source: IGEA Spa.

The third characteristic building in the mining architecture of Pellegrini era is the *Sella* Shaft, built to house the dewatering machines for groundwater and designed by engineer Franz Stiglitz in the 1870s. An analysis of the projects stored in the Historical Archives of the City of Iglesias clearly shows the contribution of the same designer of *Vittorio Emanuele* Shaft, here declined in a bigger scale. The construction consists of three contiguous buildings in which emerges the central block, which is the actual shaft. The whole complex is divided into three blocks, of which the central one is the extraction tower and the side bodies develop symmetrically respect to it. The architecture of the castle is really eloquent to show how much the Eclectic design language was capable of joining constructive solutions and cutting-edge technological solutions in the manufacturing industry, thanks to the perfect coexistence between the decorative motif in the façade - made up of a series of 18 arch windows and three central recesses. The great arch surmounting the façade recalls the circularity of the other oculi present in the fronts and initially included a tripartite opening created in turn by three arches, the central higher than the lateral ones, creating a movement of rounded shapes that is repeated in all façades of the central block and which contrasts with the linearity of the seemingly endless series of openings in the south façades. Here too, as in the twin Vittorio Emanuele shaft, there is a structural façade that simulates a podium with a fake smooth ashlar finishing, which continues in the pilasters connecting the openings at the base of the building and opens in the front for the entrance into the machine room. Here the formal taste becomes richer in repeated patterns, borrowed from Classical architecture and ancient Renaissance, finally creating a huge building block moved by protrusions, volumes and Eclectic decorations.
The interior of the shaft surprises as much as the outside. Here the decorative language made of volutes, flowers and arches, combines to a simple but perfectly modern structure: iron *Polonceau*

[5] Monteponi Company (eds.). *Società di Monteponi 1850 – 1950*. Turin: Vincenzo Bona ed., 1950, p. 91.

type trusses, below which stand the tracks to move the mining machinery, articulate the space regularly repeating until the central block to restart symmetrically in the other lateral body. The coverage of 2.5 cm thick brick roofers is set on a wooden framework with metal joints, constituted by 30 cm thick and 9 meters in length wooden cords, purlins of 15 x 15 cm in section and wooden rafters of about 10 cm. In the central body is certainly worthy of note the presence of a system of thick walls, decorated with fake squared capitals and smooth mouldings, which support two iron cantilevers of 2,70 m width, sustaining a metallic beam of 1,36 m of thickness that bears the dewatering pumps.
The masonry, as well as reports the content of the register in the inventory book[6] of 1873, consists of cut stone, while the roof beams and the floors are made of Swedish pine.

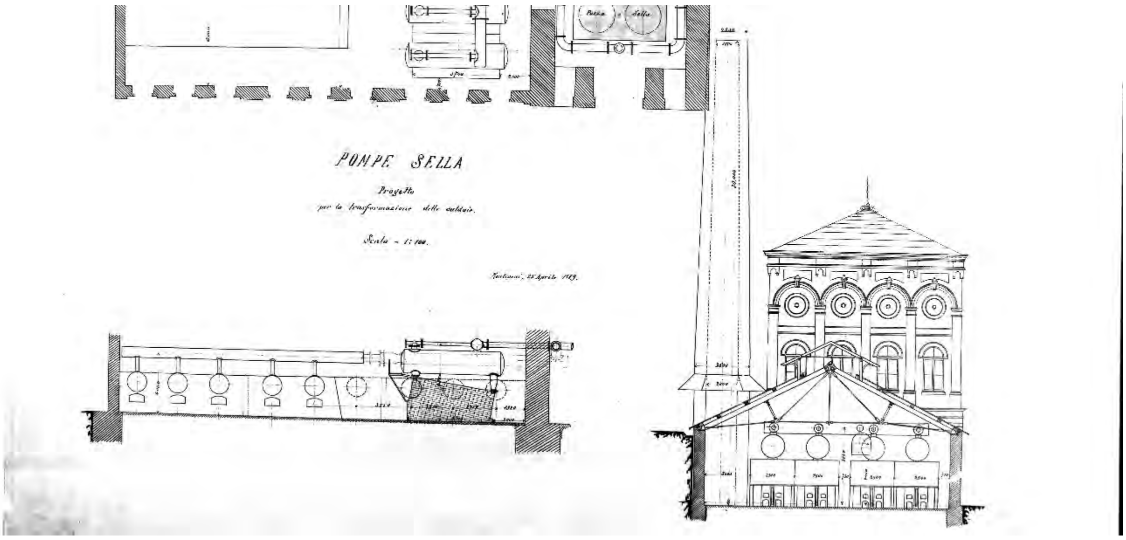



Figure 7. Sella Pumps: project for the transformation of boilers, a detail of the section[7].

[6] ASCI, Fund MP – MV. Series General Administration. Inventory Books 1873.
[7] ASCI, MP - MV Fund, envelope n. 107, chest of drawers n.4, drawer n.1, inventory n. 29.

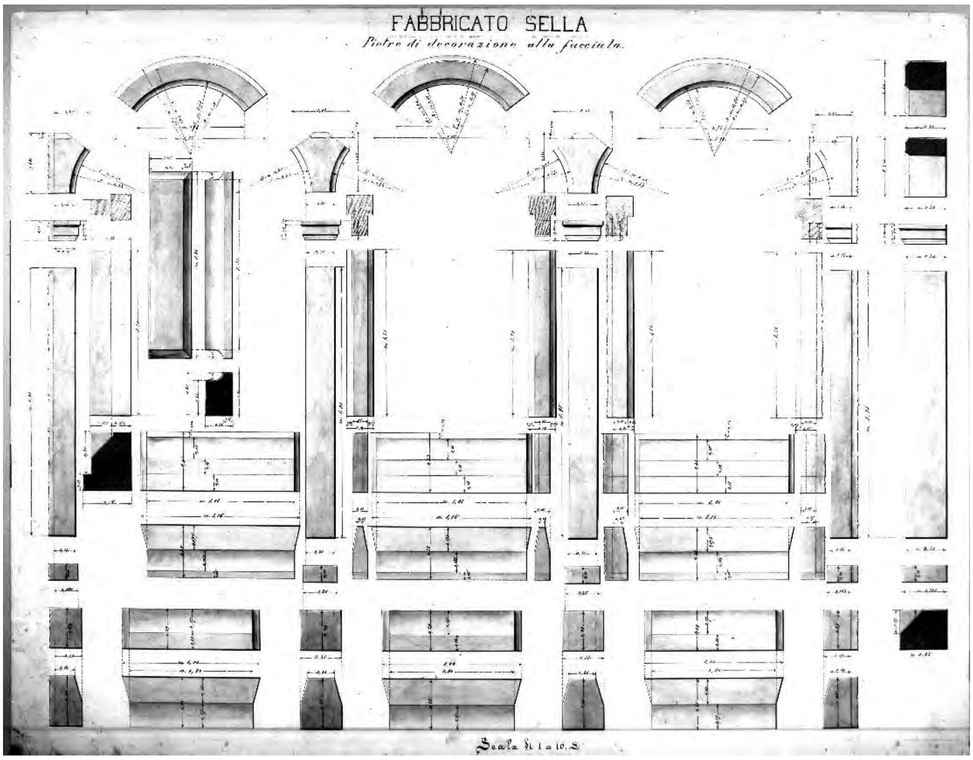



Figure 8. Sella Shaft. Detail of the decorative stones in the façade[8].

[8] ASCI, MP - MV Fund, envelope n. 107, chest of drawers n.4, drawer n.1, inventory n. 40.

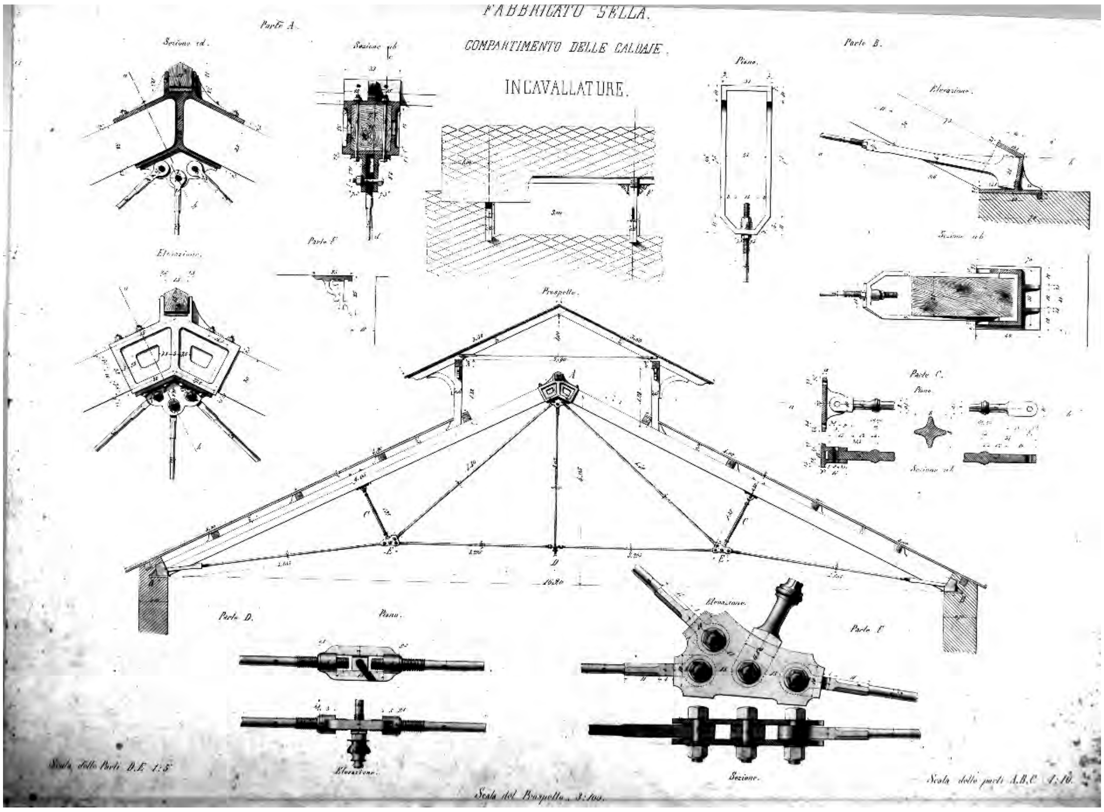



Figure9. Metal roof timbers of boilers compartment[9].

The building that housed the winch comes very close to the matter of the combination of construction techniques and Eclectic formal languages, as it features still today – and also at the time of realization, when most of the site was devoid of the voluminous body of electrolysis – a square temple within which the sacred cell houses the technological function, the movement, i.e. the control room of the inclined plane. Here too the bearing structure of walls and bricked platband is concealed behind a layer of "Terranova"[10] plaster, decorated with simple embossed frames and decorative patterns with diamonds placed at both sides of the opening. A thick trabeation, also decorated with a simple frame, supports the pavilion roof of the building.

With the end of the Pellegrini management, lasted from 1861 to the end of 1875, we see the early end of the production of the industrial buildings where the technical knowledge was wisely accompanied by an Eclectic language, as long as we have known it. With the advent of Erminio Ferraris in fact the purely historicist connotation of the production buildings began to be overcome, as they became more dry and synthetic in their formal configuration and left ample space to the structural components, often visible.

[9] ASCI, MP - MV Fund, envelope n. 107, chest of drawers n.4, drawer n.1, inventory n. 43.

[10] The *Terranova* is a type of coloured plaster made of petrifying silicates and natural colours, prepared according to an extensive range of colours and different shades, with varying grain size: fine – grained, medium – grained and coarse – grained. It is classified based on the type of application: sanded, spray, strolled. Scarzella, P., Zerbinatti M. *Superfici murarie dell'edilizia storica*. Ediz. italiana e inglese. Volume 2. Firenze: Alinea, 2010, pp. 159 – 160.

Eloquent examples of this evolution are the Calamine, the Pilla and the Vittorio Emanuele washeries, of which unfortunately there is no trace left. In these buildings is captured the presence of a thick masonry mass alternating to a series of arches that contain the windows; a trussed structure with iron rods and wooden plank holding the coverage of galvanized tiles; the extreme reduction of the decoration which, in Vittorio Emanuele washery, only results in the springing of the arches.
In the transformation from manual to mechanical washery, the formal language becomes even drier and more spartan than the previous version: the elevation from one to two storeys – interspersed with two bodies at three levels like a turret structure, with pitched roofs in galvanized roofing tiles and a central wooden headframe – suppresses entirely the decorative motifs and gives way only to the openings, arranged in a series that apparently could continue indefinitely, and the only sign of movement is given by the shape of the coverage in correspondence of the two emerging volumes. Next to the main body there is a building with a double-pitched roof, three arched openings in the ground floor and a very large central oculus in the upper part of the façade: this block, it will be noted, will be repeated in many occasions during Ferraris' management and it is frequently located in many washeries, such as the magnetic and the calamine, recognizable for the low and elongated structure where oculus and three arched openings are repeated in the same manner.

The Calamine washery closes this chapter making a further step forward in the structural definition of the mining buildings in the late Nineteenth century period: as in the prevalence of the metal structures, also here it is devoid of any hint of decoration or Eclectic style and left exposed on all fronts, characterized by the strong linearity of the rhythm of the structural elements, which prevail over the wall mass and displace where it is preferable a freer and a ventilated situation. The wall block shown in Figure 9 has nothing to do with the desire for elegance and formal decorum that characterized the architecture of the Pellegrini period and stands out in the industrial landscape as a building designed exclusively for the production, where there is no place for any decorative or classical accent. Even the fixtures, the balustrades, the iron pillars do not recall any of the decorative details that, based on the constructive practices of the late Nineteenth century, featured both the extraction shafts and the civil buildings.

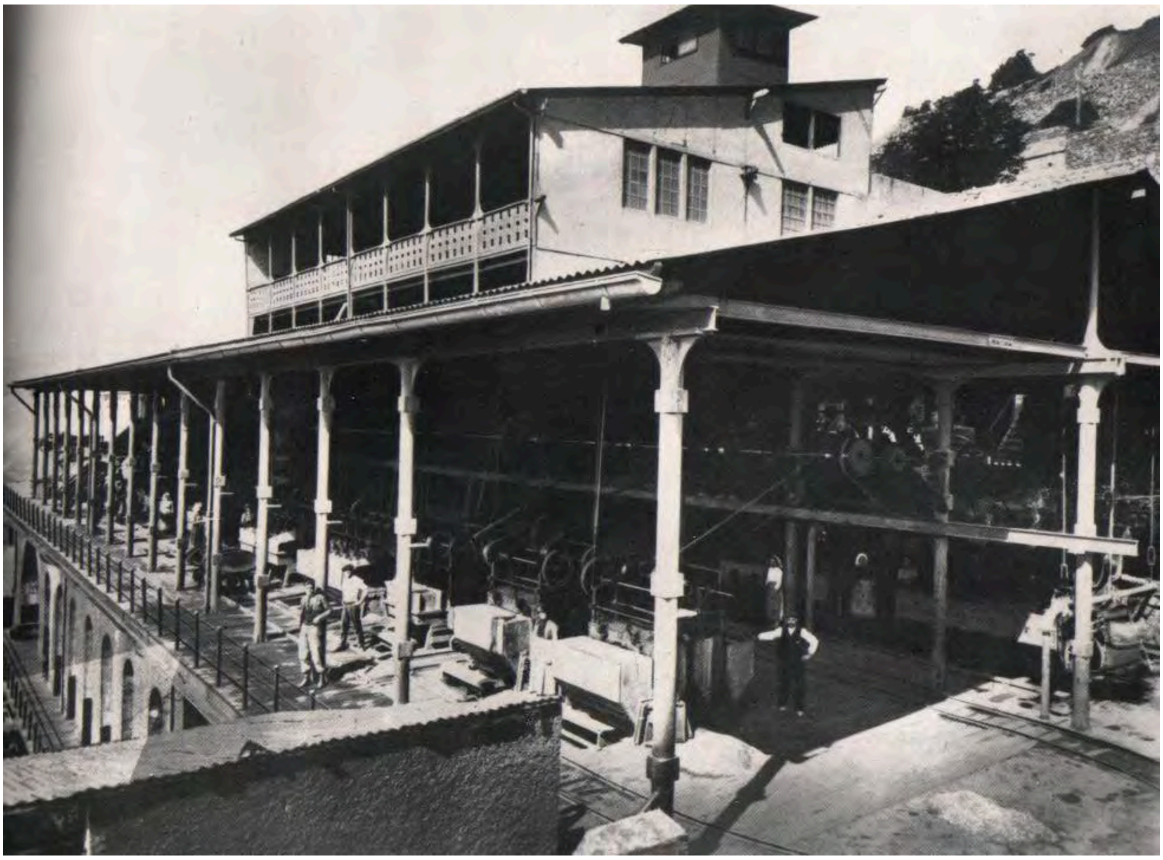


Figure 10.Washery calamine in a photo from the 1890s or so. Source: Company Monteponi (Ed), 1950.

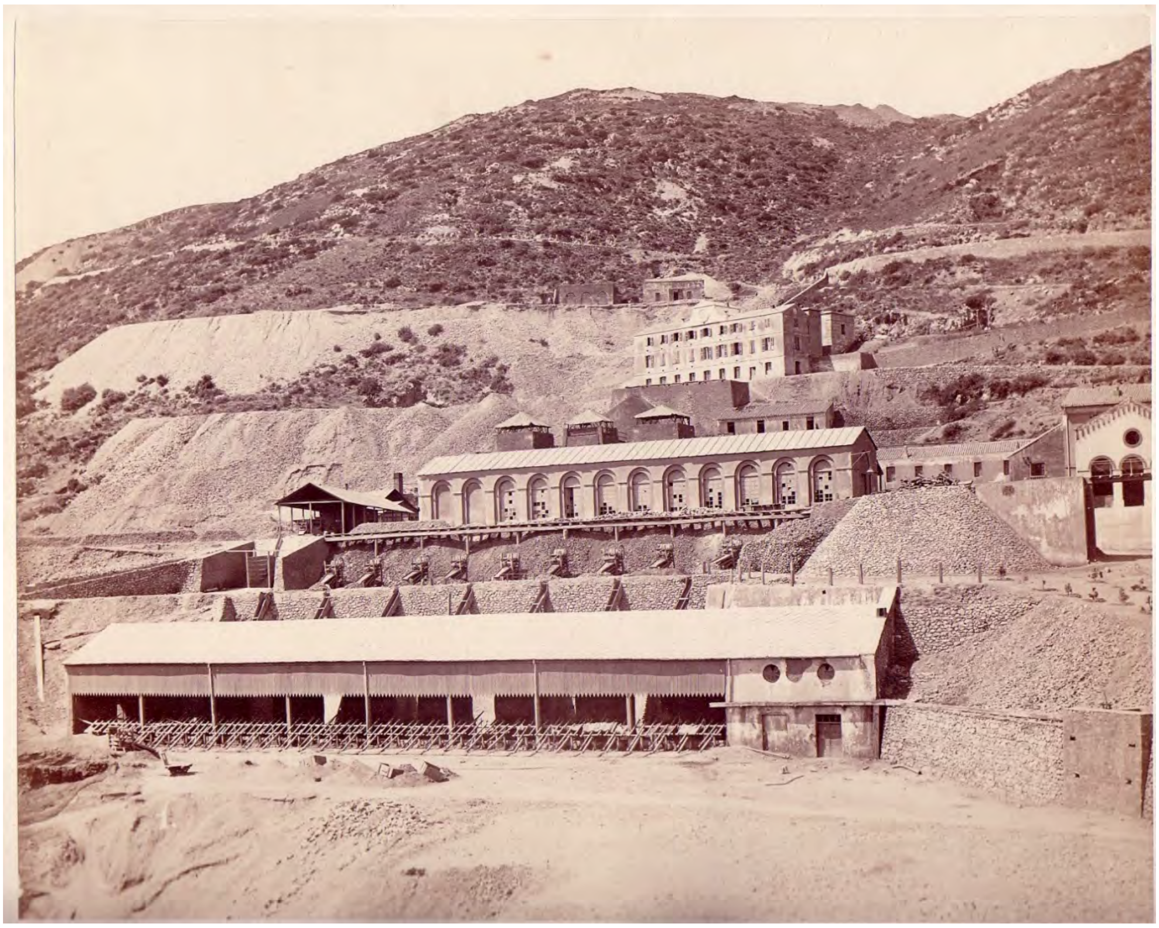


Figure 11. The *Vittorio Emanuele* manual Washery around 1875. Source: Archive IGEA Spa.

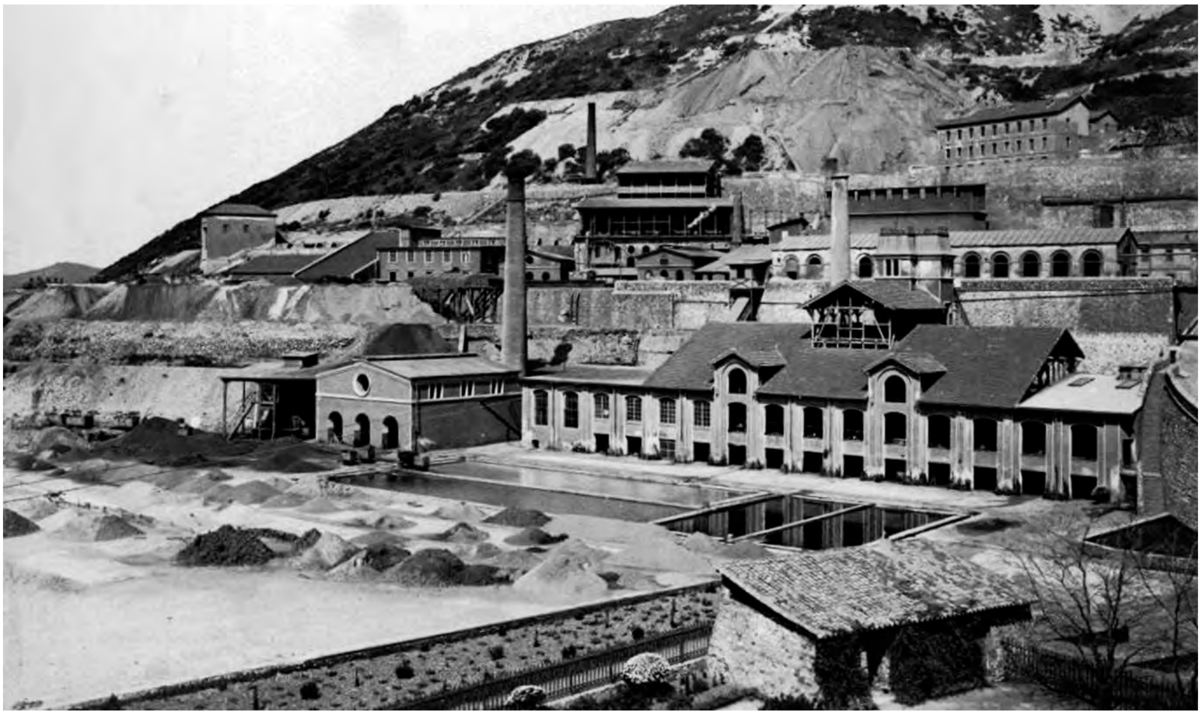


Figure 12. The *Vittorio Emanuele* mechanical washery after 1879. Source: Archive IGEA Spa.

Figure 13. Pilla and Sacchi washery in 1879. Source: Archive IGEA Spa.

The discourse on the issue of  the building practices in Monteponi is intended to run out with a last building, the electrolysis of zinc, definitely posterior than the Nineteenth-century period of the architectural characterization of the site, but just as important given the complexity and the dimension that characterize it.

This is not to address the issue of the various functions and vicissitudes that have led to the spatial configuration of the electrolytic complex, but it is rather worthy to mention the fact that in a structure of this magnitude, designed to accommodate a highly complex chemical plant, the designer chose to resume a certain contact with the decorative dimension and with the aesthetic choices of the previous period, perhaps to avoid a strong formal break with the surrounding elements. This choice can certainly be noted in the main façade of the building, which is in fact the one that communicates with the oldest buildings of the mine – the *Vittorio Emanuele* Shaft, the *Bellavista* Villa, the *Sella* Shaft – to which it must necessarily confront, maybe even as a compensation for the deletion of the huge complex of *Vittorio Emanuele* washery with its caissons workshop, sacrificed in name of the mining electrochemistry.

The use of reinforced concrete for the load-bearing structure – i.e. the trusses in reinforced concrete, the long series of pillars and beams – has not therefore denied the presence of the mass of full bricked walls, the permanence of the decoration in the frames in the openings, the frieze platbands, the trabeations, the fake smooth ashlar pilasters and the corner solution. The latter underlines through the use of squared blocks the massive presence of the main façade, the precise determination of its measures, putting an end to the apparently endless series of openings, and the delimitation of the square on which it overlooks.

The last of the great architectural works that substantially concludes the era of Classicist and Eclectic architecture of Monteponi's great buildings is therefore the electrolysis building, surmounted by a Nineteenth century pediment placed on the top of the main façade, with its dry and thin lines, stubby pillars at the sides and the plaque citing *1926*, which testifies to the long durability of that humanistic architectural approach, now substantially lingered well into the century of the Modern Movement and its iconic materials – i.e. steel and concrete.

Figure 14 The electrolysis building in the foreground just realized in 1926. Source: ASCI.

# PART 5

# STUDY OF A SYMBOLIC BUILDING

# OF THE MINING SCENARIO

## The Great Sella Shaft: Eclecticism and Modernity

Inside Monteponi's architectural scenario the building of Sella Shaft is certainly attributable as an emblem of the architectural conception typical of the Nineteenth – century Eclecticism and as a referring paradigm in the whole constructive epic that characterizes the golden years of Monteponi in the 1800s. In addition to its great mole, dominating on the most contained volumes of the Nineteenth century, which makes it perceivable in a *Gestaltic* perspective as a constructively and linguistically accomplished object in the totality of its components, this artefact is identified for its evocative character and for the equipment of the formal and structural choices as a perfectly resolved synthesis of the conjugation between Eclectic languages and technological Modernity: the attention devoted to the detailed study of the finishing, of the decorative motifs and of the stereometrical concept is in fact equal to that dedicated to the definition of structural solutions, to the proposal of building formulas in line with the international technical literature of the time, to the wise use of materials and to the knowledge of their optimal attitudes under stress.

In the study of this building the scientific literature and the wide range of technical treatises are the most helpful means since they reflect the international constructive culture by proposing distributive and structural solutions, aesthetic languages and decorative formulas that blend perfectly with the theories of the science of the construction and the technology of mid-Nineteenth century buildings. Secondly, the architectural and constructive surveys relating to this building are facilitated by the availability of numerous drawings of the project and of constructive and linguistic details, often dated and signed by the authors or at least attributable to a particular source basing on the recognition of the same drawings or of the designer's hand, who also designed the building of Vittorio Emanuele Shaft between 1863 and 1865.

The photographic material accompanying the drawings provides an additional assessment tool and a comparison of the original building core and its subsequent modifications, allowing to identify the linguistic and constructive permanence of the first project and alterations and additions that have been made over the years. In this context we can mention the changes to the cover of the forge room, detectable in the loss of symmetry compared to the boiler room for the suppression of the skylight or in the heavy alteration of the north façade of the central block with the addition of a rear volume, which erased the original decorative parties and the openings that reflected – albeit with a less evocative tone – those of the main south front. Less clear aspects emerge from the analysis of photographs dating from the period after 1880 – 1890 (Figure 3) because there were some inconsistencies about the appearance of the roof in the boilers room to the left, where the skylight is eliminated and recurred in most recent photos, shortened and lowered from the original version, built with a wooden frame and a layer made of Marseille tiles that can be observed still today. Even in the engine room, corresponding to the right wing of the building, the skylight is removed in a permanent manner (fig 2) and replaced by three glazed portions, inserted in the covering layer after 1917 and found in the photographs of the period 1926 – 1940 (figs. 4, 5).

Figure 1. 1875: the skylights are present in both of the side halls. Source: Monteponi Company 1850 -1950.

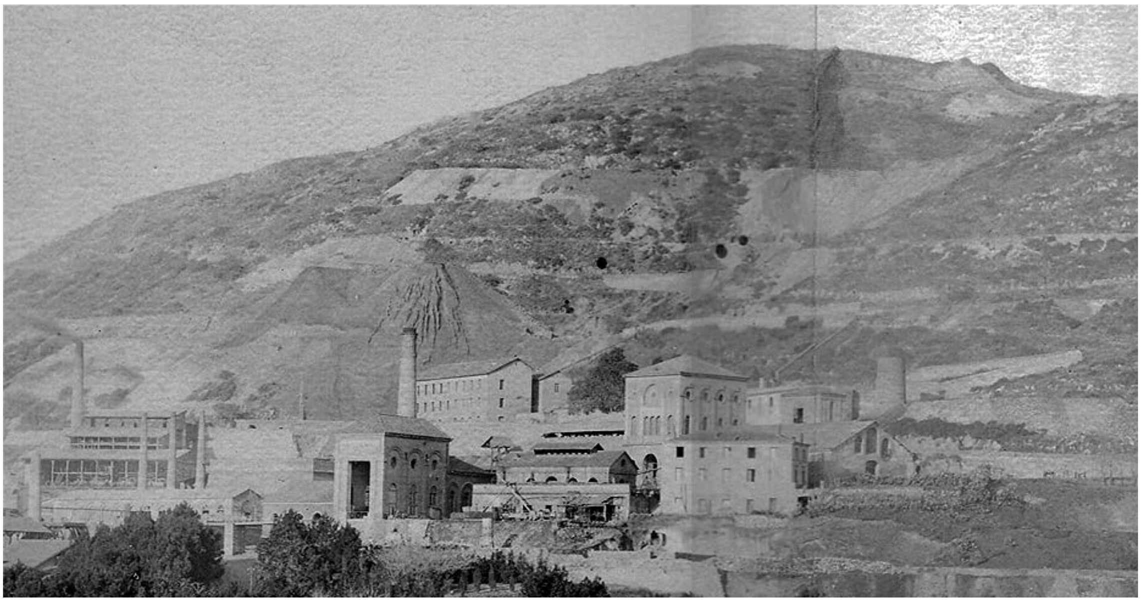


Figure 2. 1894: in the right room, the skylight was demolished and the central *trifora* was bricked up.

Source: Archive IGEA.

Figure 3. 1917 (?): The skylight is absent also in the left room. Photo by the author of a photo in the seat of the Sardinian Mining Association in Iglesias.

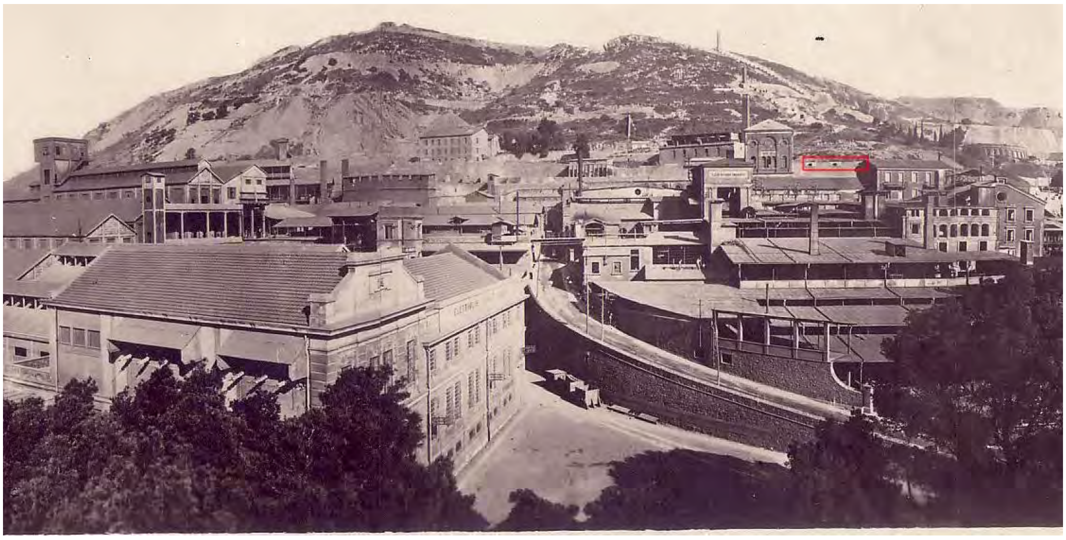


Figure 4. 1926: we see the three skylights in the right area of the Shaft. Source: ASCI.

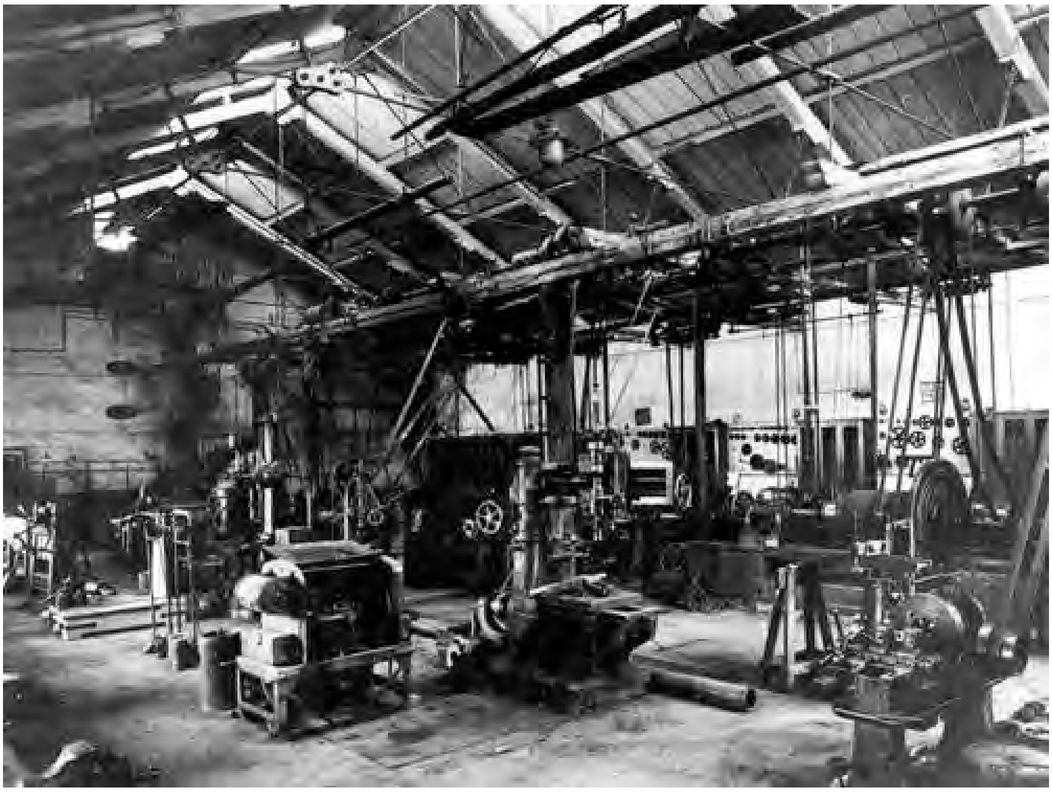


Figure 5. 1940 (?): The inside of the right hall with the light from the skylights in the roof.
Source: http://artbonus.gov.it

The addition of a rear volume on the north side of the central body, of which we do not know the date or the design, caused the loss of the original appearance of the building due to the suppression of the rows of arches, which are now located within the building and changed in their height to enlarge the span and combined with the original pilasters that decorated the façade (fig. 6). The added block has also deleted the cornices and the arched recesses – there are only three left (Figs. 7, 8, 9) of the entire row under the crowning of the central block – which replicated the Eclectic motifs of the main front, inevitably hiding even the pier which linked the edifice to the anterior slope where other buildings stood, such as the stocking room of the wooden models of the Sella foundry and the capstan building.

Figure 6. 1875 (?): The north side is still intact in the decorative parties and the connecting bridge; two skylights right and left. Source: https://www.facebook.com/photo.php?fbid=1344141605605293&set=g.167283790096285&type=1&theater

Figure 7. The north side today with the added volume. Photo by the author.

Figure 8.The interior of the carpentry today: the pilasters and arches are those of the original facade.
Photo by the author.

Figure 9. Inside of the central attic with the three recesses in the north. Photo by the author.

Even the capstan building, converted during the years into an laboratory for acetylene production for blowtorches, was not immune from substantial changes in the original linguistic features: this is evident in the progressive closure of the recesses, in the openings in the façades (fig. 10) and in the decay of the decorative motifs, now illegible, suppressed in favour of accretions and simplifications perpetrated over the years. All the left part of the initial factory body consists of a pale trace on the walls, deprived now of the pavilion roof and difficultly identifiable as the Neoclassical temple where the Eclectic language was eloquently researched and represented in the drawings by Franz Stiglitz, the designer.

Figure 10. The actual remains of the building of the capstan. Photo by the author.

*The project*

Sella Shaft was built by the will of the director of the mine Adolfo Pellegrini during the years 1873 - 1875 to house a dewatering pump system for the groundwater: the goal was to reduce the continuous and dangerous infiltration of water that repeated within the mining tunnels of the mine and that constituted a difficult obstacle to the continuation of the excavations in the subsoil. The pumps, of 500 horsepower each, were provided by Charles Marcellis Company of Liège and embarked in Antwerp to arrive at Cagliari on merchant vessel *Baron of Lambermont*[1] to be then transported up to Monteponi on a specially designed wagon[2]. The pumps came into

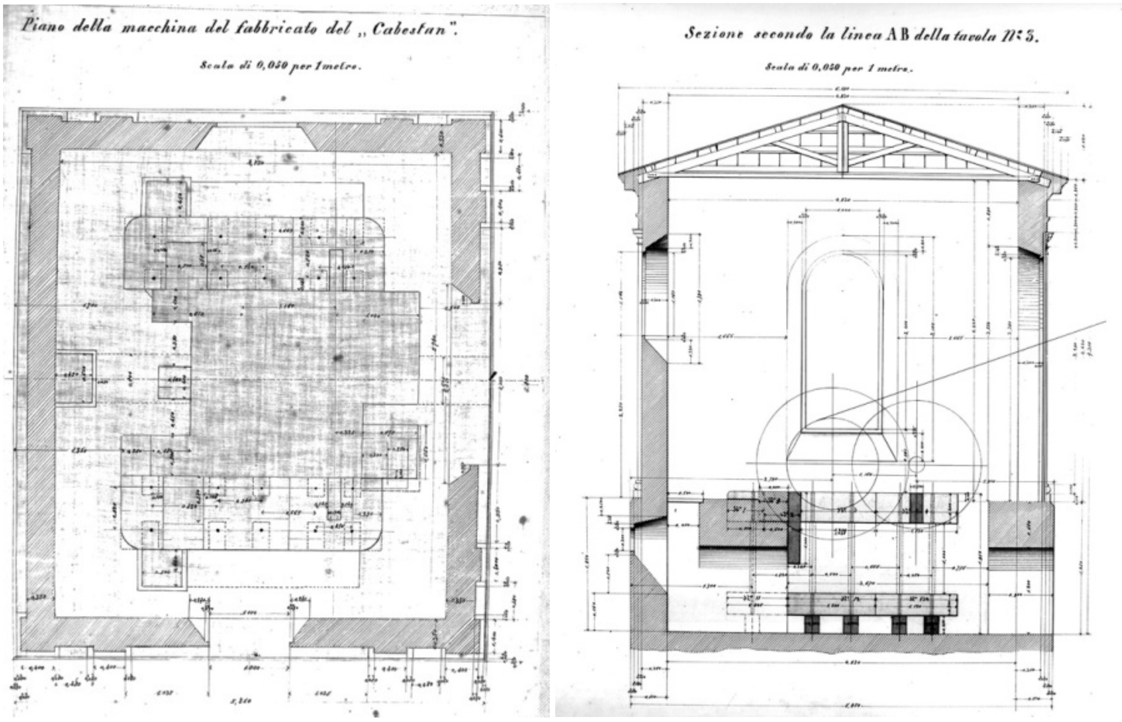
[1] In the Company's Inventory Book of 1873 has been reported the payment in gold for the freight of the shipowner Cateaux's vessel. See: Lai, M. B. Pozzo Sella. Le fonti documentarie. In Ministero per i Beni e le Attività Culturali Soprintendenza Archivistica per la Sardegna, Soprintendenza per i Beni Architettonici, il Paesaggio, il Patrimonio Storico Artistico ed Etnoantropologico per le province di Cagliari e Oristano (Eds.). *Eclettismo e Miniere. Riflessi europei nell'architettura e nella società sarda tra '800 e '900. Mostra fotografica e documentaria*. Cagliari: Graphic sas, 2004, p. 57.

[2] Pellegrini wrote to the Company on the transport of the dewatering pumps: "This morning the large cylinder, driven by 20 oxen and driven by 40 Bergamo people, realized without discomfort the Monteponi climb. The wagon built for this occasion behaved very well, while the railroad car was smashed. " See: Lai, M. B. Pozzo Sella. Le fonti documentarie. In Ministero per i Beni e le Attività Culturali Soprintendenza Archivistica per la Sardegna, Soprintendenza per i Beni Architettonici, il Paesaggio, il Patrimonio Storico Artistico ed Etnoantropologico per le province di Cagliari e Oristano (Eds.). *Eclettismo e Miniere. Riflessi europei nell'architettura e nella società sarda tra '800 e '900. Mostra fotografica e documentaria*. Cagliari: Graphic sas, 2004, p. 57.

operation on December 30, 1874 but in the light of subsequent events it proved insufficient for the solution to flooding in the galleries.

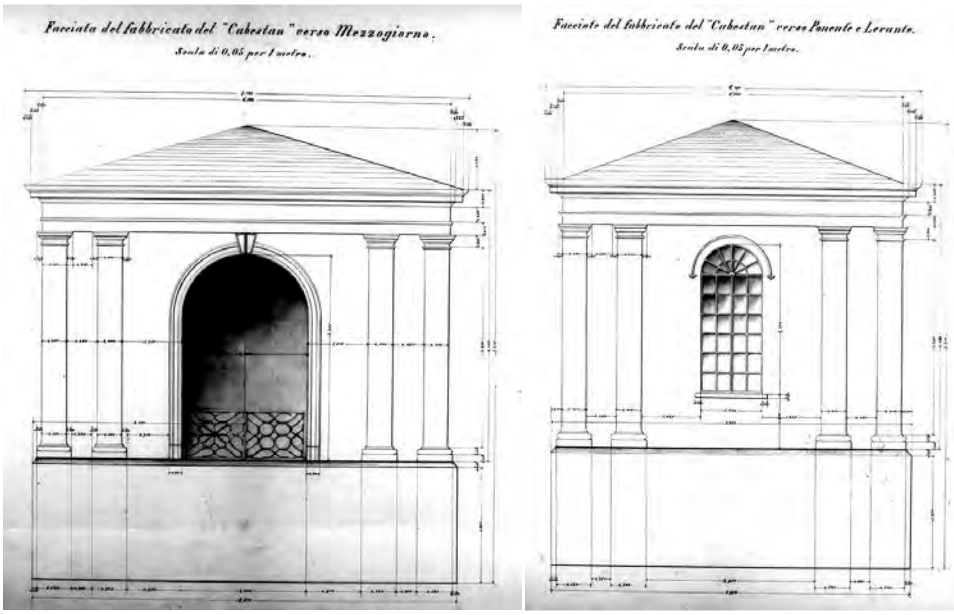
The choice of the designer of Sella Shaft fell on the same figure who had already prepared projects of the first shaft of Monteponi, the Vittorio Emanuele, built in 1863: this is the German engineer Franz Stiglitz[3], arrived in Sardinia in the early sixties.

In the Historical Archive of Iglesias (ASCI) are kept Stiglitz's drawings related to both projects. Regarding *Sella* Shaft the projects refer to the capstan, i.e. the building in which was housed the mining machine consisting of a winch that controlled the cages for the movement of men and minerals. Stiglitz signed in fact these designs from December 1872 until January 1873 illustrating the drawings of the foundations of the capstan, the machine room (drawing 1a), the section (drawing 1b) and the four façades ( drawings 2a, 2b).




Drawing 1: Plant of the machine room (a); section of the building of the capstan (b). Source: ASCI.

[3] Franz Xaver II Stieglitz was born on January 22, 1831 in Augusta, by Franz Xaver Stieglitz Stieglitz and Johanna (nee Memmminger). From this union the brothers Hugh and Mathilde Stieglitz Stieglitz were born.
Franz Stiglitz married Therese Stieglitz (born Binecker) and had six children: Theodor Josan Nepomuceno Stiglitz, Giulio Stieglitz, Henriette Katherine Mathilde Stieglitz, Laura Stieglitz, Ludovika Theresia (Louise) de Coularè De la Fontaine (born Stieglitz) and Mathilde Stiglitz. From the second marriage with Theresa Giuseppina Armanda Stieglitz (born Tarnozzi) had six more children Theresa Caterina Sofia Stieglitz, Francisca Callista Maria Stieglitz, Francesco Saverio Massimiliano Stieglitz, Francesco Saverio Fortunato Stieglitz, Amata Pollisena Maria Stiglitz and Clara Maria Theresa Caramagna (born Stiglitz). He died in Tatabania, in Hungary, at an unknown date.
Source: https://www.myheritage.it/names/franz_stieglitz




Drawing 2: South elevation (a); east and west elevations (b). Source: ASCI.

A second collection of unsigned drawings include the particulars of the stoned friezes of the south façade (illus. 3, 4) – consisting of arches, round windows, mouldings – that could be attributed to the German engineer, the details of the timber roof, of the trusses in the forge room and the freestone used for the decoration of the main front. A section in scale of 1:50 of the flue gas chimney indicates the mixed composition of the supporting structure, made of mixed masonry for the first two thirds and entirely in bricks in the last part.

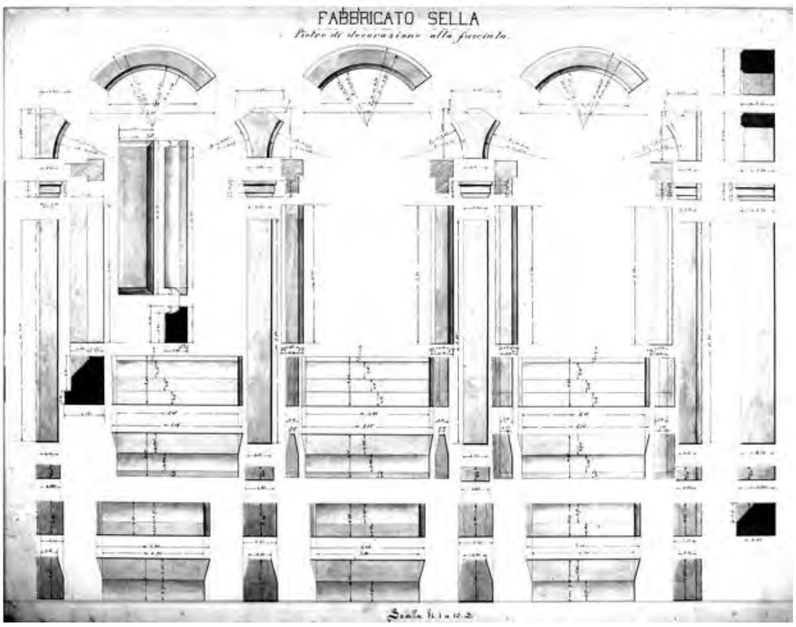



Table 3. Description of the stoned decoration of the main façade. Source: ASCI.

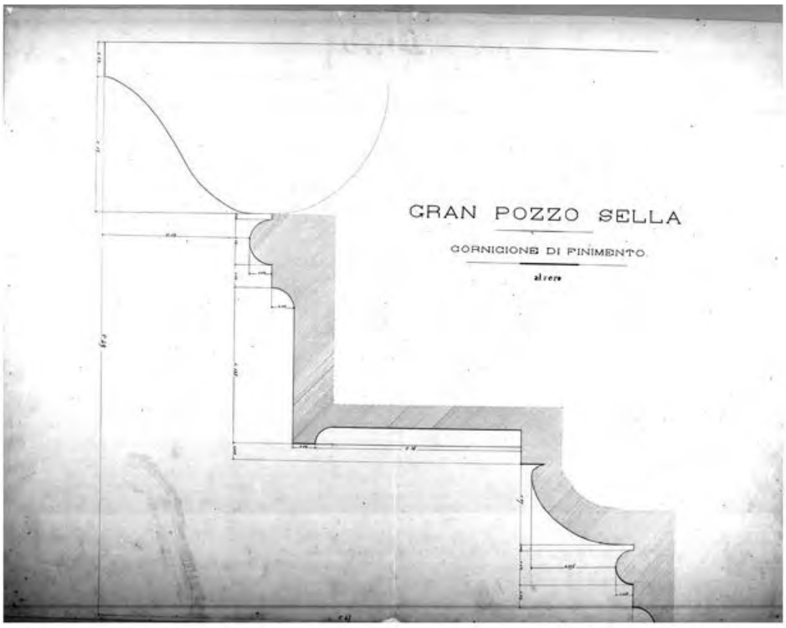



Table 4. Section of the harness ledge. Source: ASCI.

In addition to Stiglitz's drawings there are other drawings of the project and the details of the building, in particular those made by the firm *Marcellis* in Liege, a supplier of the steam engines of both the Shafts, which include: detailed drawings of the stoned foundations of the hall of the capstan, the general arrangement of the buildings housing the steam engine and the detail of metal structures of the mining castle, called "*belle fleur*" under Belgian terminology. In the drawing entitled "*Disposition d'ensemble des batiments pour les machines n. 824. 825. 826. 827. 828. et des chaudiers à vapeur* "(drawing n. 5), unsigned but presumably realized by the atelier *Marcellis* of Liege, two cross sections of the central tower and the forge room are compared: it is possible to observe how the upper sections of the central body and of the capstan offer – albeit in summary form – a material and dimensional definition for the main structural elements, such as the large steel girder which supports the first floor of the engine room, the wooden beams which take the upper floors, Palladian and composite Palladian trusses bearing the slabs of the central tower and the capstan. In the lower section, which instead interested the boilers room, one sees an unusual system of crossed wooden beams combined with a composed truss but where the king post is absent and the tie rod is "replaced" by a pair of asymmetric diagonal braces on the left and by only one brace on the right. The volumes behind, i.e. the central tower and the house of the capstan, are drawn in the prospectus, clearly faithful to Stiglitz's projects for the capstan and the final configuration of the central building.

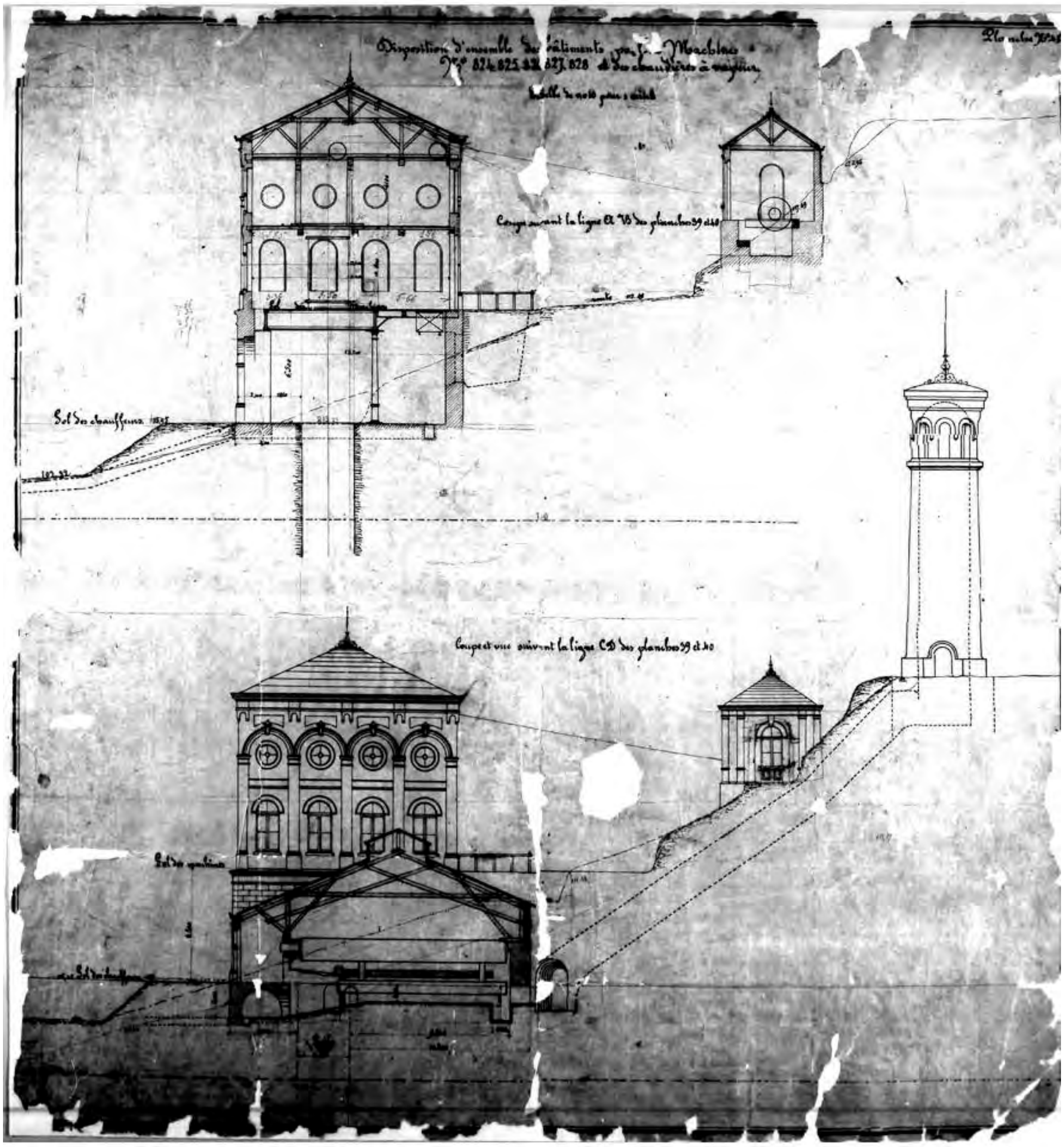


Figure 5. *Disposition d'ensemble des batiments pour les machines n. 825. 826. 827. 828. 824. chaudiers et à vapeur*. Source: ASCI.

From 1899 only three tables dedicated to the modifications of the boilers room in the building on the left of Sella Shaft are preserved: the first table (tab. 6), dated February 1st 1889, is a cross section in scale of 3:1 with quotations and dimensions of the metallic elements that make up the Polonceau trusses and the structure of the skylight that overhangs the ridge of the pitched roof. This latter is made with wooden rafters and purlins on which rests the metal structure of a double pitch skylight, raised with respect to the ridge level thanks to two 1.38 m high wooden pillars. The same section is also reported in the table dated April 25th 1889 (pl. 7), where it is inserted in an overall view with the central body in elevation and with the section of the 30 m high chimney, positioned inside the same room. In this drawing there is also the general plan of the boilers room and a prospectus of the central body, which reflects the physiognomy of the forge room, located on the opposite side of the central volume but not represented.

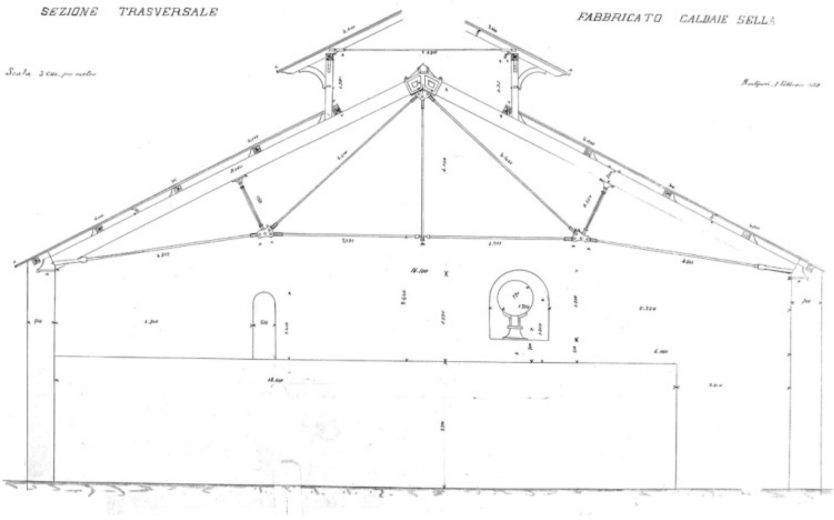



Table 6. February 1, 1889: Cross section of the Sella Made boilers. Source: ASCI.

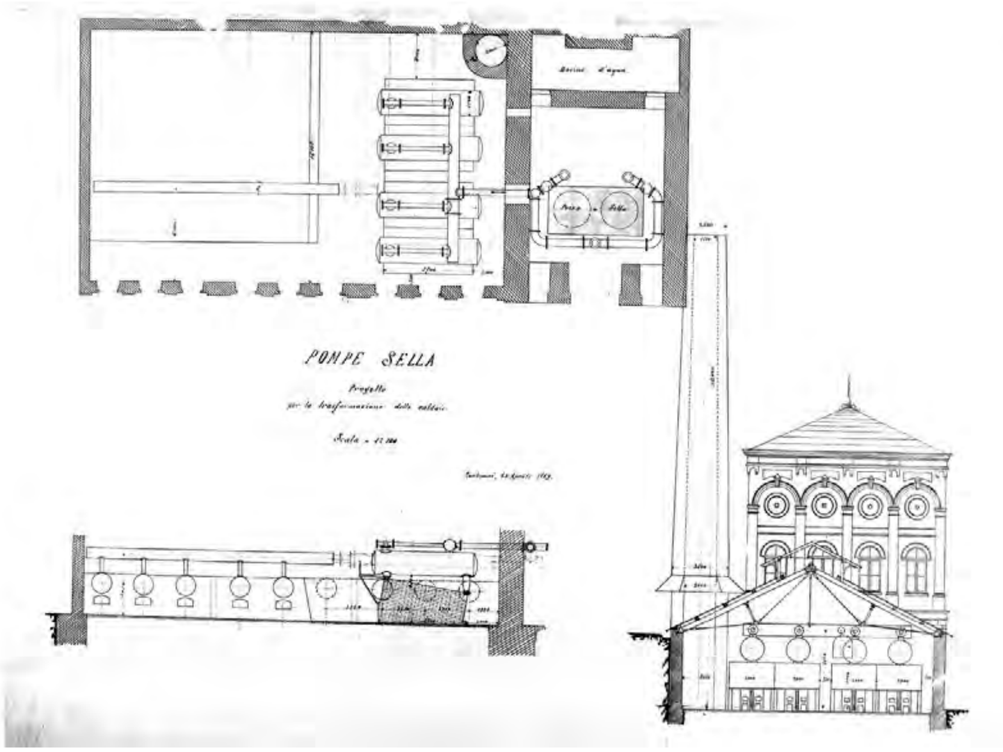



Table 7. April 25, 1889: Project for the conversion of the boilers. Source: ASCI.

The third table of the series, dated March 14th 1889 (Table 8), is a front view of the Sella pumps in a scale of 1:20. In addition to an interesting view of the machinery, this table provides a detailed dimensional and a graphic description of the beam system and two iron brackets that support the room: the 1,360 m high beam extends to a span of 8,570 m, supported by two 2,14 m high and 2,70 m wide cantilevers, whose bolted plaques are still visible in the perimetral walls of the central block which overlook the internal halls.

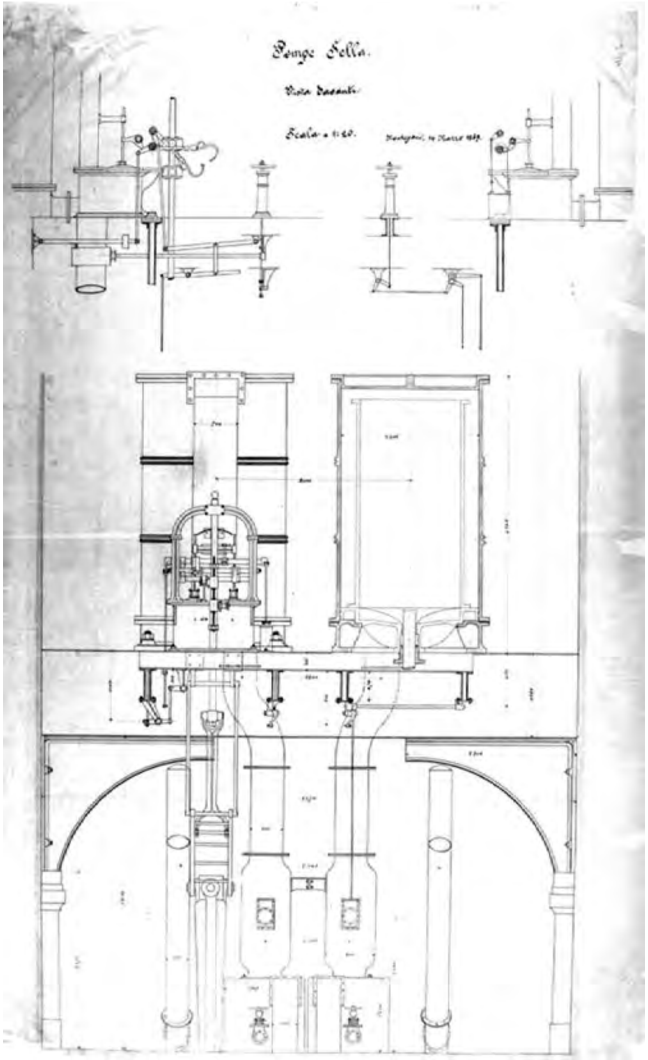


Table 8. March 14, 1889: front view of the Sella pumps. Source: ASCI.

From the formal point of view the building of Sella Shaft is characterized by the coexistence of elements borrowed from the Neo-Renaissance and Neoclassical language, explained in detail the series of arches and pilasters that mark the score of the openings along the main front. A long series of round arches and pilasters frame the windows and doors of the boilers and is amplified in the central volume, expanding into a large arch, flanked by two smaller arched windows, which becomes at the same time both the portal of the Shaft room – occupying a third of the height – and a New Renaissance base treated as a fake smooth ashlar. This amplification results even stronger in the definition of the remaining two-thirds of the south elevation of the central tower (pl. 9), highlighted by a thick stringcourse frame, tripartite by three large arches in which the decorative elements identify the openings: the two side portions limited by high pilasters incorporate the upper oculi and two arched windows, while the large central arch houses the two overlapping *triforas*. Oculi and arched windows then become the decorative matrix and the functional characteristic of all the façades of the central body, drawing a clear Eclectic polyline that intercepts the prospectuses and divides them into regular spans to accommodate the openings.

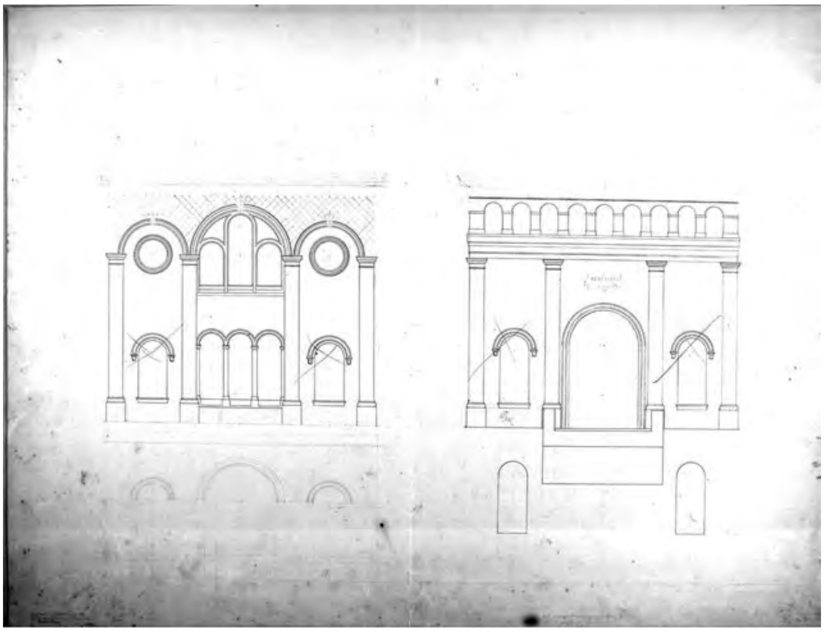


Table 9. Statement of the south and north sides of the central body. Source: ASCI.

*Architecture and construction of the Great Shaft Sella*

The complex of Sella Shaft is composed of three contiguous buildings, pivoted around the central volume with a rectangular plan to which are attached the two smaller lateral wings, made of load-bearing masonry with variable thickness in cut stone, fireclay bricks and ordinary bricks[4].

With the restoration works implemented in 2004 the lesions present in masonry have been healed by means of the removal – replacement technique and injections of a consolidating mixture based on natural hydraulic lime, *pozzolana*, carbonate and siliceous inerts injected into inclined holes distributed on a 50 x 50 cm mesh and for ¾ of the depth of the masonry. In external stoned containment masonry the joints have been restored, when necessary, with the insertion of the missing segments and with hydraulic lime injections instead of concrete joints[5].

The entire building is based on a variable height embankment absorbing a difference of altitude between the right and left sides of the southern front, from 1.60 to 7,20m in height, determined by the slope of the road.

The south façade, finished with "Terranova" type plaster with the colours of natural earths, extends for a length of 66,42 m and is punctuated by the regular rhythm of the 18 arched

[4] These items are shown in the inventory book of the Company of 1873. Source: Lai, M. B. Pozzo Sella. Le fonti documentarie. In Ministero per i Beni e le Attività Culturali Soprintendenza Archivistica per la Sardegna, Soprintendenza per i Beni Architettonici, il Paesaggio, il Patrimonio Storico Artistico ed Etnoantropologico per le province di Cagliari e Oristano (Eds.). *Eclettismo e Miniere. Riflessi europei nell'architettura e nella società sarda tra '800 e '900. Mostra fotografica e documentaria*. Cagliari: Graphic sas, 2004, p. 57.

[5] Technical – illustrative report for the work of restoration in Sella Shaft in the mining complex of Monteponi in January 2001, p. 5. Source: Igea SpA

openings and by the great pattern of the arches in the central tower, which rises with respect to the two lateral blocks to a height of 20 m (fig. 11). The plasters were restored due to damage from moisture and water penetration from the coverings by means of remaking with three layers of premixed hydraulic lime mortars, with the addition of stones – where they were missing – injections of hydraulic lime mortar in order to re-anchoring the plaster at the points of detachment and a fine trowel finishing[6].

Figure 11. 1875: Sella Shaft, the top *trifora* window is still open. Source: ASCI.

The two wings, containing originally the boilers room, the machine workshops and the forges, elevate up to 9,30 m to the ridge, dominated in the original intentions by two twin skylights high in total about 2.30 and realized with a metal and wooden structure. The roofs in the lateral bodies were made in origin of metal sheets – then replaced by a layer in Marseilles tiles – combined with clay tiles on a wooden structure, supported by a system of *Polonceau* trusses with a span of 16,20 m and 0,30 m thick wooden struts and 9,06 m long; the trusses are in turn set on a height of 4,70 m from the ground on a 0,70 m thick stone masonry. In the central volume the load-bearing walls assume the relevant thickness of 1,54 m to support the grandiose system of cantilevers with a wideness of 2,70 m that support in turn the beam that carries the wooden framework of the first floor level, consisting of joists of 0,18 m in height and a planking. A second slab is made entirely of wood at the height of the exterior oculi, with beams that support the wooden deck. The coverage of this central body is entrusted to the structure of wooden beams and mixed king post in wood and iron, in which the tie rods intersect at the centre (Fig.

[6] Technical – illustrative report for the work of restoration in Sella Shaft in the mining complex of Monteponi in January 2001, p. 6. Source: Igea Spa

12), while the 0,45 m thick wooden beams connect the east and west walls of the building (fig. 13).

Figure 12. Bottom view of wooden and metal framework of the central volume. Photo by the author.

Figure 13. The beams that contain east and west walls of the central body. Photo by the author.

The crowning of the central body is constituted by a thick cornice that hides the hipped roof view, originally made of metallic sheets and subsequently replaced by a layer in Marseilles tiles. In projects and vintage photos we can see beneath the pavilion roof of the central volume the treatment of the surface bounded by the eaves and the upper arches along all fronts, constituted by a dithering at 45 ° engraved directly into the plaster (pl. 10) and also present in the top of Vittorio Emanuele Shaft, which might suggest the attribution to this series of drawings of detail at the same Stiglitz.

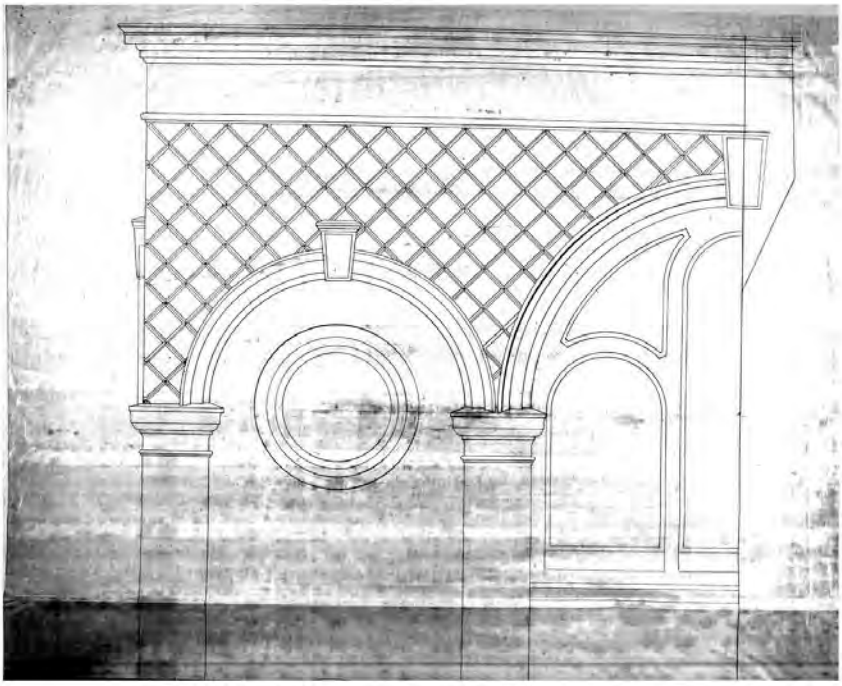


Table 10. Detail of decoration above the arches and below the crowning cornice. Source: ASCI.

The vertical connections are made by means of a spiral staircase in cast iron, decorated with a liberty motif of round and rhomboidal geometries (Fig. 14), which connects the level of the forge with the carpentry floor, placed in the upper level of the central volume and overlooking originally on the lower floor.

Figure 14. The cast iron staircase connecting the engine room to carpentry. Photo by the author.

*The carpentry*

The carpentry has arisen within Sella Shaft to accommodate the carpenters and the machineries for the production of wooden models through which were realized spare parts of the mining machines: when they bought a machinery, this was disassembled in the individual components that were then replicated in wooden moulds in which were carried out the cast iron castings in the foundry of Sella Shaft, in order to obtain spare parts or new machineries in a virtually infinite loop. After 1880 – an expected date – the building of the carpentry was expanded with a rear added volume, which still exists.

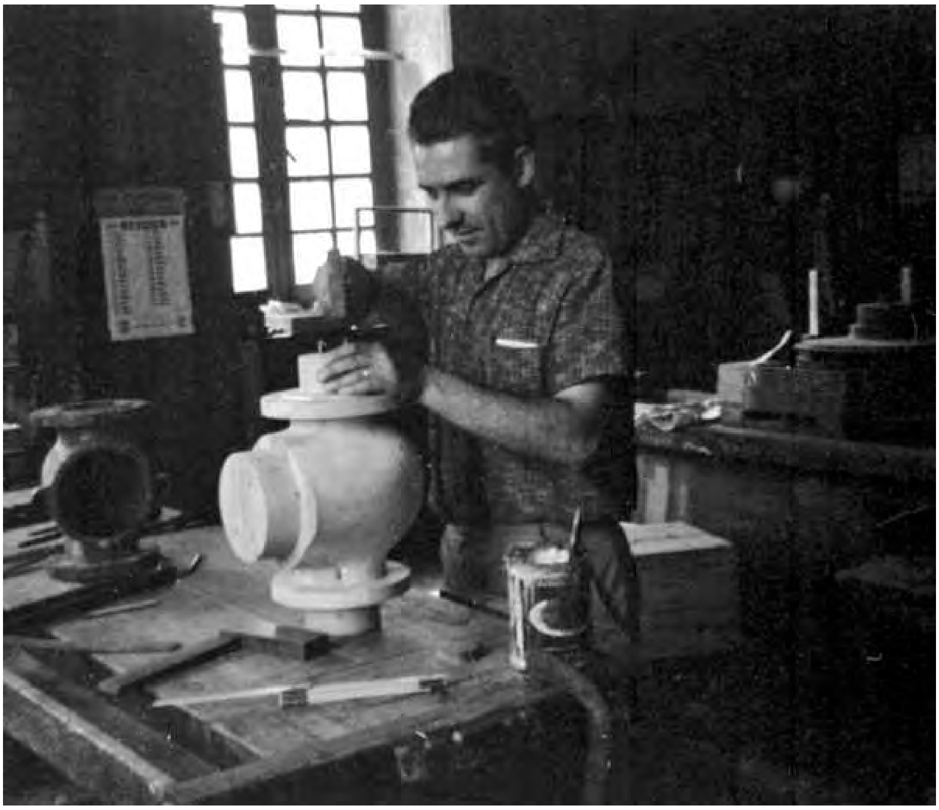


Figure 15. A carpenter makes a wooden model of a valve. Source: www.facebook.it

This facility is located in the central body of the Shaft at an altitude of approximately 6,00 m above the level of the boilers and the foundry: it is divided into two parts by the corresponding wall, originally belonging the north façade of the central block, which now locates the engine room on the north side of the added volume – recognizable by the different pavement that follows the footprint of the old bridge – and the sector of the original carpentry facing the south side.
A wooden staircase connects this level with the attic, where there is a clock gear inserted in the middle of the oculus in the south façade. In this level the wooden floor occupies the entire surface corresponding to that of the underlying carpentry and the room faces on the east, west and south sides thanks to the original circular openings with the exception of *trifora*, no longer existing since it was closed and replaced by the clock; in the north side the three recesses, spared by the modification of the prospectus and closed by fixtures, can be still observed (fig. 15). The iron shelves on the walls were used for the aging of the wooden models manufactured in the carpentry below, left hung to dry before being used for cast iron castings.

Figure 16. The three recesses of the northern front viewed from inside the attic. Photo by the author.

*The windows*

After the renovations the glasses in the windows and in French doors and a number of wooden frames, which presented an advanced state of decay, have been restored. The absence of glass curtain walls had also caused the proliferation of microbiological, animals and corrosive attacks inside the facilities, particularly in the attic of the central volume where the guano had reached very destructive heights.

Sella Shaft's windows are mostly made by huge wooden frames: at the lower levels of the two wings there are arched windows and French doors, distributed originally in the south front with a "window – French window – window" rhythm that went lost after the restoration works (currently there are two French windows only at the ends of each wing). In the central body the arched windows in the outer gallery level are smaller and surround the large central arch which originally did not contain fixtures and served as a large portal of the Shaft, while the upper level is divided into two typologies: two arched windows, each in the lateral areas identified by the four Doric pilasters on which are set the upper arches, and a central triple - arched opening (fig. 16) above which there is the inscription "Sella Shaft"; in the higher level – corresponding to the attic – there are the circular openings in alignment with the lower windows and the great arch that framed the original *trifora*, consisting of two twin lateral arches and a higher one, destined to disappear from the façade in next twenty years to make room for the clock. In this order of upper openings and in the big portal the central keystones are highlighted by inverted trapezoids, while the arches of the underlying openings are set on decorated shelves, repeated in the east and west fronts of the central volume and instead absent in the long theory of arches of the lower level (fig. 17).

Figure 17. The openings of the carpentry level: the two arched windows and central mullioned window. Photo by the author.

Figure 18. The Sella Shaft around the year 1890.
Source:https://www.facebook.com/photo.php?fbid=1331157296903724&set=g.167283790096285&type=1&theater

*The floors*

The floors of the boiler room in the left wing of the building were made directly in the foundry of the Shaft by squared cast iron slabs measuring 50 x 50 cm (fig. 18) with diagonal grooves, which still give a strong sense of depth to the whole building.

Figure 19. The cast iron plates 50 x 50 in the boiler house. Photo by the author.

The floors of the mechanical workshops are made of wrought concrete for almost half of the surface and in cast iron plates measuring 30 x 30 cm.
In the central sector there are two types of tiling that can be identified: hexagonal tiles measuring 6 cm to the side in the area that connects the two wings; rectangular tiles measuring 7 x 14 cm in the area behind the cantilevers system which supports the carpentry.
In the latter the floors are made of wooden planks with axes of 400 x 30 cm and in part with the pseudo – circular plugs (fig. 19) formed of wood processing, corresponding to the old bridge decking that connected the rear of the Shaft to the hill.

Figure 20. The floor in the wooden dowels in the added volume of the carpentry. Photo by the author.

*The appurtenances*

To the west of the building is set a two-story building probably built shortly after the Sella Shaft, frequently altered with the addition of new volumes and openings, which housed some mining offices. This building, which in the Nineties and Noughties housed the *Erminio Ferraris* Association (and still preserves the sign on the main façade), was originally used as offices of

Major Corporals and subsequently became the headquarter of the Miners' Association[7]. Around 1875 the building appeared as a modest volume in three levels, with a row of three blind arches on the southern front that framed the door on the ground floor and the top – level windows and three simple windowed openings aligned with the ones below; the coverage was realized with two pitches and a layer in Marseilles tiles (fig. 21). To the north the façade was divided in two levels, set on a higher elevation than the opposite side thanks to an embankment: here a staircase and a gallery put in communication the openings arranged in axis between them. A simple volume leaning on the west front showed a single pitch, orthogonal to the main building and of the same width of the western elevation (fig. 22).
Subsequently, the prospectus on this building occurs without the arches, probably filled and embedded in the exterior plaster, thus leaving "free" the windows and doors but keeping the stringcourse, which in the previous version also served as a line of sets of arches . The windows are also equipped with sharp-edged frames that surround all the profiles of fixtures and underline with an increase in the width the lintel inside the masonry (fig. 23). In a further step of modification – presumably towards the end of the 1890s – the building featuring a single pitch roof orthogonal to the main volume was replaced by a three – storey block, higher than the other, covered with a pavilion roof disposed above a thick cornice and on which there are the chimneys of fireplaces.
In this new building, the openings have simple rectangular frames that surround the windows on the west front, while to the south in the last level is realized a balcony with a carved stone balustrade; the openings at the intermediate level are tripartite by two vertical elements topped by a thick cornice: this solution is then replicated in the adjacent volume, replacing the simple rectangular windows on the first floor with the three triple-arched frame. On the ground floor, however, remains the simplification of the openings which are therefore simple rectangles containing the window. The stringcourse frame, borrowed from the first configuration of the façade with the arches, extends itself over the whole perimeter of the two buildings between the ground floor and the first floor, and it replicates also between the first and the second floor in the highest volume (fig. 24).
Currently this building has maintained a certain familiarity with the latest configuration of the façades bringing the right body at the same height than the left and replicating the *trifora* and the underlying string course over the entire width of the last level; the balcony, which opened on the outer, corner has instead been removed in favour of an analogous *trifora* like the others (fig. 25).

[7] Ingegno, A., Ottelli, L. Serra, S. *Complesso di archeologia mineraria di Monteponi. Catalogo delle risorse*. [?]:[?]

Figure 21. The body adjacent to Sella Shaft around 1875. Source: Archive Igea Spa.

Figure 22. The building with the stairs of the embankment and the balcony; bottom right the single pitch coverage orthogonal to the building. Source: https://www.facebook.com/photo.php?fbid=1344141605605293&set=g.167283790096285&type=1&theater

Figure 23. The south façade of the late Nineteenth century: the arches have been dropped in favour of the window frames. Source:
https://www.facebook.com/photo.php?fbid=1331157296903724&set=g.167283790096285&type=1&theater

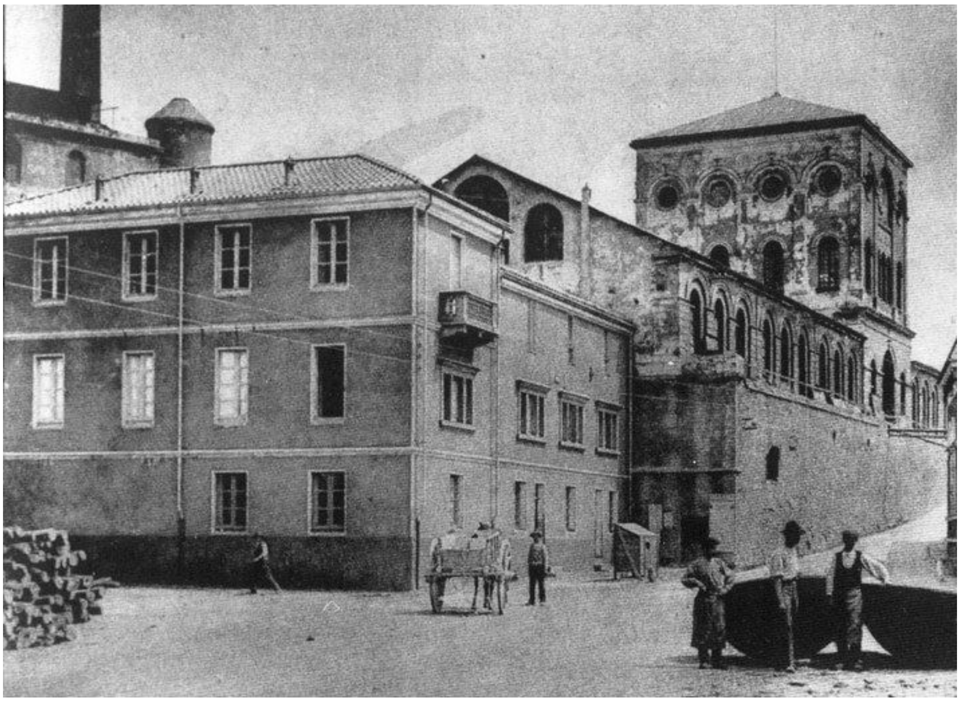


Figure 24. The building in the early Twentieth century: you can see the west windows, balconies and arched windows on the first floor. Source:
https://www.facebook.com/photo.php?fbid=1590472910972160&set=g.167283790096285&type=1&theater


Figure 25. The Association's Building E. Ferraris today. Photo by the author.

To the east on the other short side of the Sella Shaft there is a shed or a metal shelter, also present in the early Twentieth century photos, which blocked almost completely the arched window on the right of the east front, making it perceptible only from the inside and therefore wiping out the original symmetry of the openings (Figs. 20, 21, 22). The structure of this added body is made of masonry and cast iron pillars, identical to those present inside the mechanical workshops for the support of the bridge crane, holding here the metal frame which carries the metal corrugated sheet covering.


Figure 26. Vintage picture: you notice any of the three arched windows in the machine room. Source: www.museoscuoladiminiera.it/?page_id=227

Figure 27. 1920 - 1930 (?): The metal structure set against glimpse of the arched window on the right. Source: https://www.facebook.com/photo.php?fbid=1358127430873377&set=g.167283790096285&type=1&theater

Figure 28. The east facing today: the arched window on the right was removed from the volume set against the engine room. Photo by the author.

## Constructive – linguistic comparison between Sella Shaft and the International mining heritage

At the light of the considerations made about the history of the construction of Monteponi's heritage and in particular about Sella Shaft, from a historical, linguistic and technological point of view we may now synthesize the main constructive features of the most representative architecture of the whole Sardinian compound, in order to explicate how the influences and the traces of the Nineteenth constructive culture can be enlightened and explored both in the case of Monteponi and in the coeval episodes of edification in the international examples. This passage is in fact necessary to appreciate the importance of the formal and the technical choices that influenced the architectural palimpsest in Monteponi, as well as the development of common paths in the edifications of the mining facilities that constitute the most important containers carrying the historical – cultural and social values interested by the international experiences of reuse and valorisation.

Monteponi's heritage and in particular the Sella Shaft are in this sense a sort of unexplored field of comparison with the other mining realities of the period 1850s – 1900s on which we could analyze the common heritage properties that characterize both its architectural past and its possible reuse: we have seen how the evolution of the main stylistic and technical peculiarities evolved in a very rapid way – in a range of twenty or thirty years – thanks to the ingenious approaches led by the most important managers and designer in the conceive of the main buildings and facilities, showing important evidences of the passage from a "celebrative" architecture to the "technological" buildings devoted to the productive purposes.

The Sella Shaft, belonging to the first typology, offers a sort of dialogue between these two approaches: on one side it was conceived as a technical building – as we said it housed forges, foundries, dewatering pumps, engines and a carpentry – and it presented all the features of an industrial building. On the other, however, it exalted its role celebrating it through a very remarkable formal language: we have seen that the projects regarded both the constructive and volumetric definition of its functional components, with a detailed description of the building characteristics; of the materials, i.e. the introduction of new techniques in the use of metallic structures, joints, beams and cantilevers; of the expertise in the dimensional control, such as in the wise use of massive, light and overhanging elements and so on. But all these features are counterbalanced and underlined by a very celebrating language, carefully designed in order to amplify the significance of its role: the "holy cell" of the first shaft is converted here in a great central volume, towering over the other compounds and keeping that sense of vital functions enhanced through the stylistic expressions that combine Eclectic and Neoclassical evocations, which confirm the influences and the knowledge of external approaches – borrowed by the coeval literature and civil architecture. In the whole architectural panorama, this is indeed the only building which underwent the lightest modifications keeping its formal and functional features until nowadays, thanks to the extraordinary completeness and accuracy of its design both in the technological and in the decorative apparatuses.

The previous investigation of the architectural evolution of this emblematic building lead in this part of the dissertation to the exploration of the possible affinities and the differences in the architectural and constructive characterization of the mining heritage belonging to the international case studies that have already been explored in the second part of the thesis as a part of the state of the art in virtue of their typological and historical consistency and in the positive experiences of reuse and valorisation. It is undoubted that in these sites we assist to different evolutions of the linguistic and technical choices – intended as the more or less intense presence (or amplification) of the formal influences derived from the historical collocation and from the relative cultural approaches. We find in fact the use of combinations of vernacular and innovative expedients in the constructive formulas featuring these mining palimpsests and a possible coexistence of "celebrating" buildings and "functional" facilities, the first dedicated to remark the power of the mining Companies and the latter to improve the productivity purposes.

The pursuit of Modernity in the international cases confronts itself with the permanence of traditional approaches, offering therefore a field of confrontation with the main case study of this thesis, even thanks to the possible addresses of preservation and valorisation of the historical and architectural values applicable in Monteponi. We saw in the previous chapters how the methodologies and the purposes of restitution of these sites, in virtue of the importance for the communities and for their valuable heritage, have approached in different manners to each site, dedicating new functions and modifications at various stages in the most respectful way for the preservation of the original connotations and for the installation of new facilities.

We now proceed to investigate the main features of these heritages in order to further confront them with the main case study and to analyze the possible borrowable approaches to safeguard and to preserve the linguistic and structural identity of the Sardinian site in a sustainable plan of recovery.

### Constructive connotations of the mining heritage in the Nord – Pas de Calais – Wallonia Basin

At the end of 1850s the buildings of the mining heritage in the northern France and Belgian basin featured the influences of several linguistic styles, combined with a marked structural presence. The latter was mainly made of wooden components and cast – iron elements, which integrated perfectly with the formal attention paid to the concept of the whole building, along with the decorative accents and the machineries. The first impression is that of a compromise between the technological application of modern building solutions and the reminiscence of formal motifs that are borrowed from different architectural styles, such as the Neoclassical and the Neo – Renaissance: in that sense we can figure out how the representative intentions were imposed both in the outer and inner conceive of the industrial building through the modulation of the masonry and of the bearing parts and the wise use of the Eclectic language to exalt each other the most important components. We still find the presence of the bearing walls, with consistent width, combined to the single metallic elements that parted and divided the surface to create different areas. Moreover the light is provided through rows of openings that recall the arcades of the Classical buildings, declined in a Neo – Renaissance manner to elegantly pierce the most representative façades. Frames, protrusions and recesses are intended to add movement to the whole building but at the same time to limit its extension and to define its consistence: this is the same attitude that we find in Sella Shaft where the long and apparently endless arcades in the main façade are stopped by the presence of frames and reinforcements in the masonry, by pilasters and recessions that lighten and pause the openings.

This expedient is traceable, for instance, in the building of the extraction and the triage (sorting) of coal in the mining complex of Grand Hornu Shaft in Belgium. The details contained in the volumes of the *Bulletin of the Mineral Industry*[1] of 1857 show a building consisting of various volumes, distinguished in the house of the steam machine, the workers' barrack, the forges and other technical facilities. The general plan is an overturn L that contains in sequence the hangar of triage, the steam machine hall, the miners' barrack, the forges and finally the resting room for the miners and the children. Looking at the plans contained in the *Bulletin* we may notice immediately the permanence of the wall mass, moved by the presence of protrusions and recesses that articulate all the façades containing the arched windows and the decorative oculus. Although the presence of walled sections we get the general impression of a light spatial composition where the surfaces are balanced in an equilibrate and rational confront that allows the hall of the steam machine to be counterbalanced by the large presence of a free room, the barrack, which contains the main paths and routes involved in the whole building.

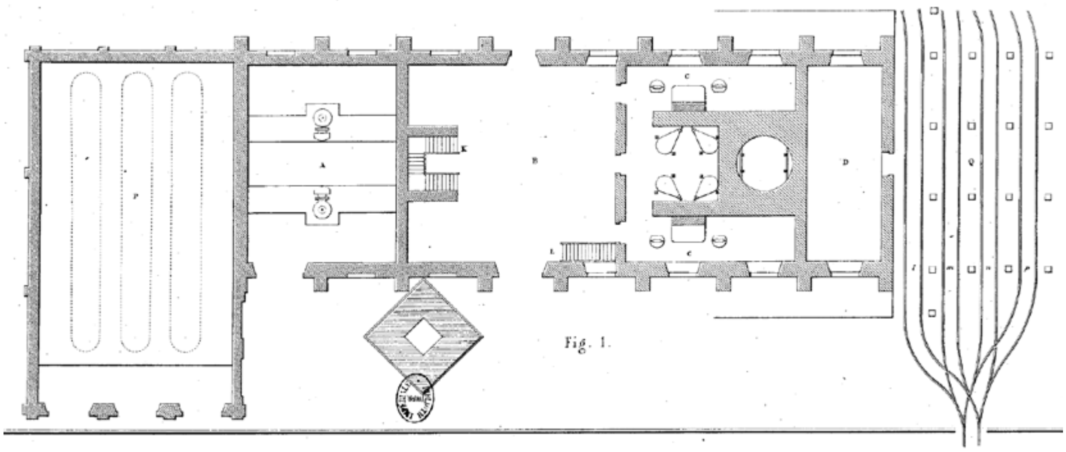



Figure 1. Plan of the pit n.12. Source: Atlas de la Société de l'Industrie Minérale, planche XII.

The structure is based on the bearing masonry, wide 0,60 m on average, which parted the space identifying the different areas and elevating until the lowest level of the roofing to separate the areas destined to the workers and those intended for the machinist and for the cages. The slabs and the roofing are made of wooden planks and beams with various widths that run from the external walls and pass along the inner partitions. The pavilion roofs are made of a wooden

[1] Glëpin, H. G. Mémoire sur le nouveau mode d'extraction et de Triage de la houille appliqué aux Mines du Grand-Hornu. (Belgique.). In *Bulletin de la Société de l'Industrie Minérale*. Paris: Dunod Editeur, tome II, vol. 4, 1856 – 1857, pp. 214 – 281.

framework consisting of horizontal and vertical bearing beams and diagonal struts reinforcing and sustaining the strains in the highest level, under the ridge.
A 0,60 m thick wall divides the surfaces parting the steam machine from the barrack and elevates up to the level of the framework in the roof, reinforced by two bricked counterforts sustaining the level of the steam machine and measuring 0,60 m of largeness and 2,57 m of wideness at the base and then 1,85 m after the elevation on a 2,50 m high slope.

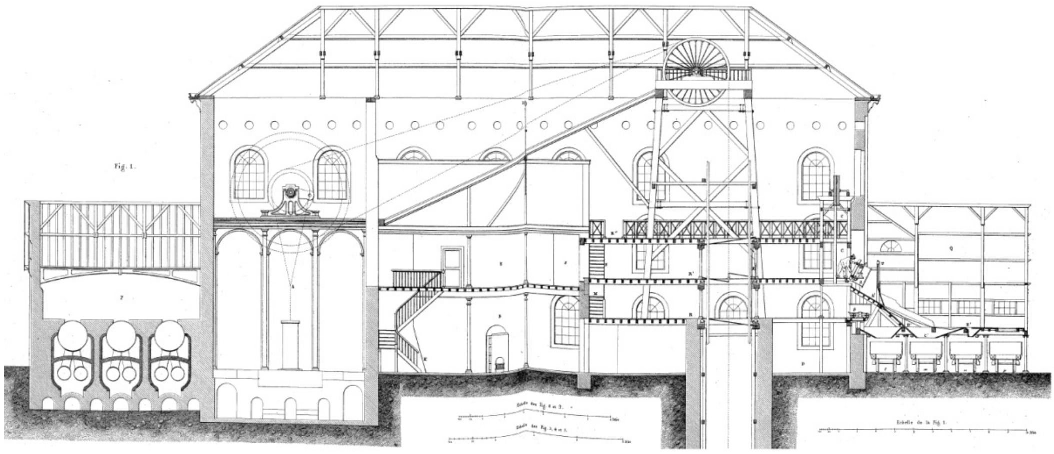


Figure 2 Section of the building of pit n.12. Source: Atlas de la Société de l'Industrie Minérale, planche XII.

Along with the masonry there are also cast – iron pillars (designed and produced by the Grand Hornu Company itself) sustaining the slabs in the mid span both in the workers' barrack *B* and in the room of the forges, where the pit stands. These pillars feature a mixture of different stylistic approaches that evolve from a synthetic appearance to an eloquent Eclectic evocation: in the room of the forges, containing the pithead, the pillars are conceived as Neoclassic Doric columns placed around the wooden structure of the pithead sustaining the beams of the upper slabs in the levels of the accesses to the pit. In the next area, the barrack, we see that the pillars feature a Neo – Renaissance design on the ground floor, which is evident in the use of the squared *pulvinos*, i.e. a sort of Brunelleschi's trabeation, to enhance the growth in height of this central room; in the first floor the reduction of the height is supplied by Doric pillars sustaining the adorned trabeation. In the most important area of the building, the hall of the steam machine, we find an amplification of the decorative approaches dedicated to the structural components: the cast iron pillars here look like long, thin and grooved Doric responds that frame the round arches set over shorter Doric responds, both sustaining a thick corniced trabeation.
Moreover, the machinist's station is sustained by a lighted cast iron girder whose structural presence is overwhelmed by the Neo – Gothic balustrade, consisting of elaborated ogival figures forming an intricate web that recalls more the Cathedrals and the Venetian palaces instead than a mining facility.
The interest for the decorative language is even more evident due to the way this is generally applied both to structural elements – in the moulding of the pillars, the arches, the trabeation –

and to accessorial elements such as the balustrades and the cornices: we may state then that the sense of this design is to formally celebrate the role of the most important machinery in the whole exploiting process through the application of the highest Eclectic expressions.

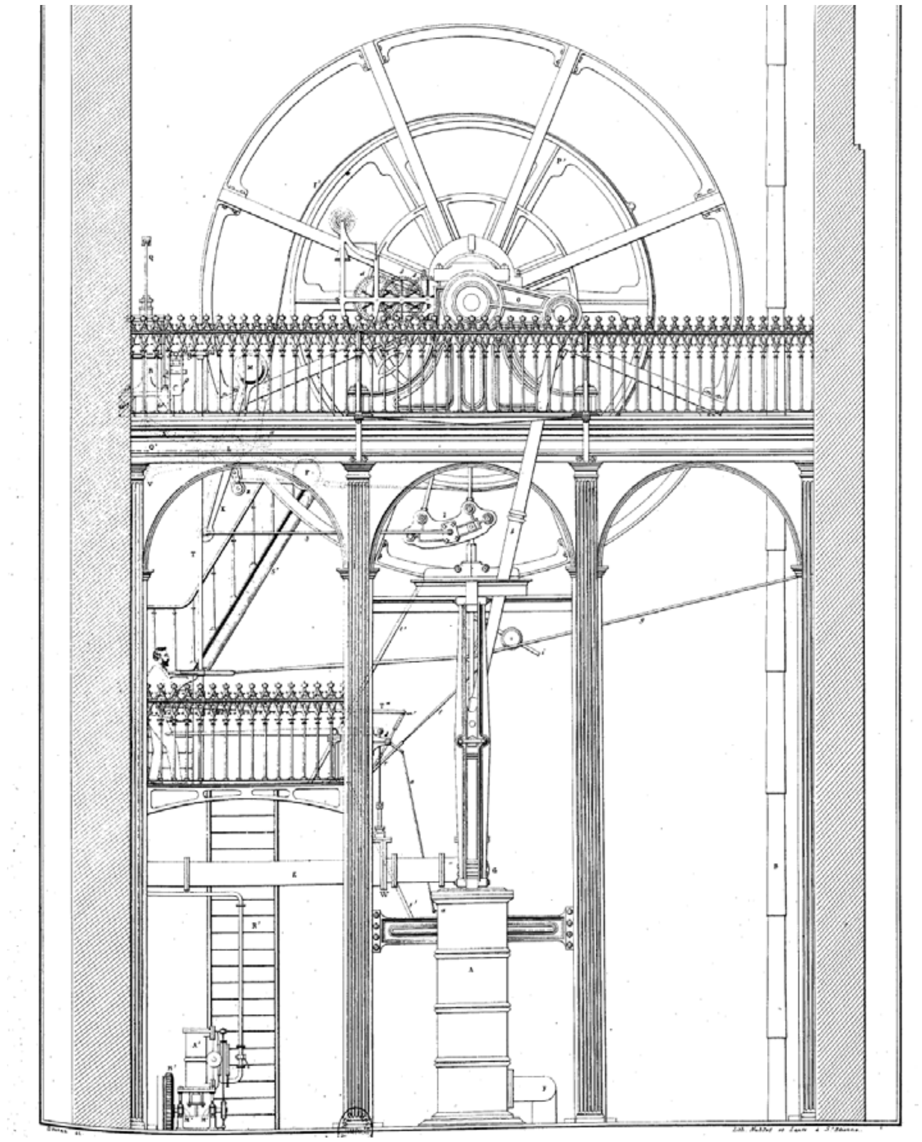


Figure 3 Elevation of the steam machine. Source: *Atlas de la Société de l'Industrie Minérale*, planche XIII.

The pithead shows on the contrary a more aseptic design, occupying almost the total height of the building with its wooden structure, connected to the hall of the steam machine through cables and tie rods that cross the space above the central room. All the pavements in the main front of the accesses and before the pit are covered by a cast – iron slab, 0,015 m width, while the rear fronts are covered only for an extension corresponding to the largeness of the extraction pit in order to ease the rotation of the wagons carrying the coal when entering and exiting from the cages, before and after being emptied out.

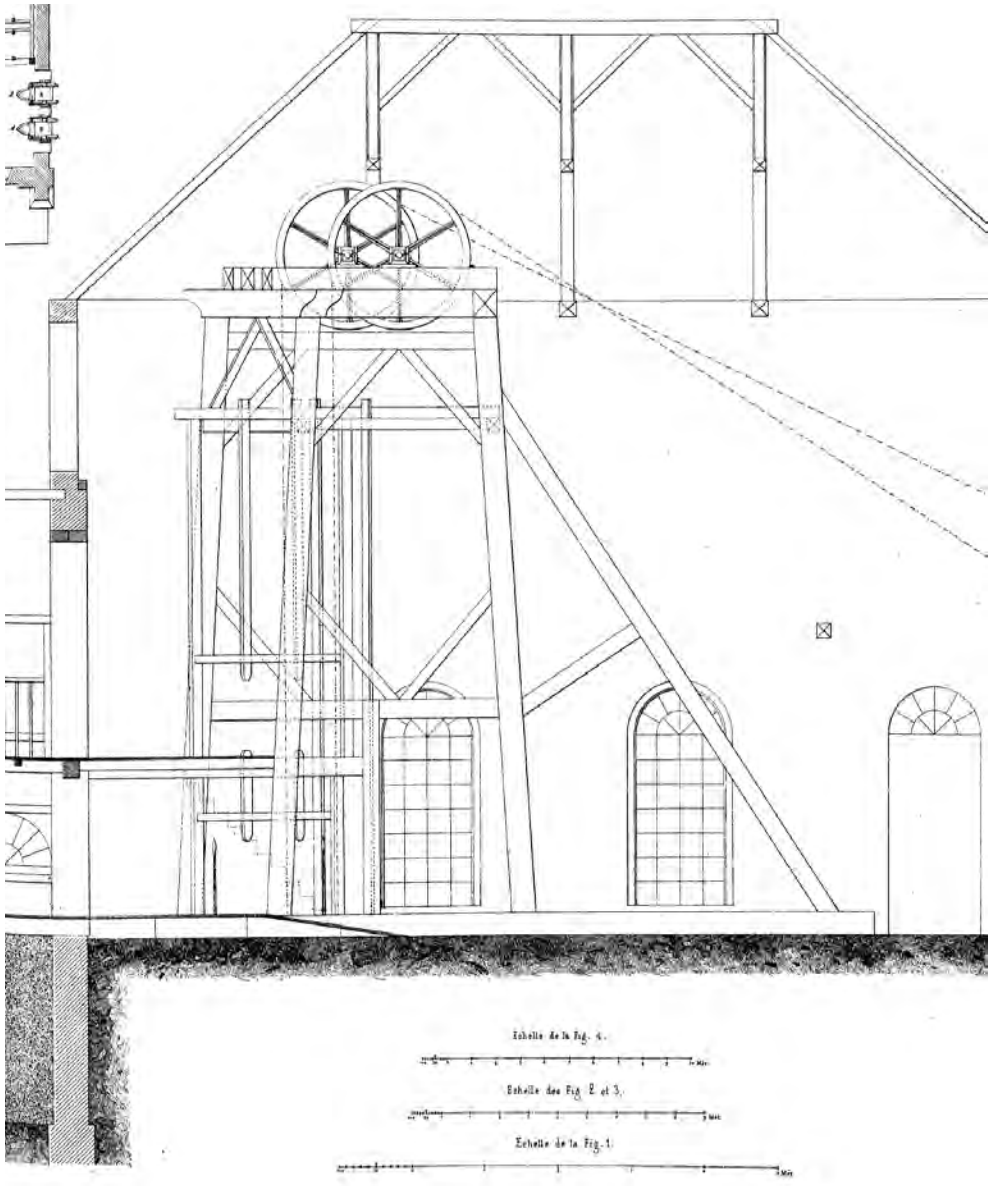


Figure 4. Longitudinal section of the pit. Source: Atlas de la Société de l'Industrie Minérale, planche VIII.

Also the design of the main façade remarks the dual presence of structure and Eclectic formalisms: the arched openings are in fact defined between a double layer of responds – one starting from the first level to the second and containing the arched windows – and the outer one covering the whole façade and ending below the eaves with a rhythm of three arched moulding combined with the oculus. The role of these Neo – Renaissance arched windows is, however, almost only figurative since they want to give the impression from the outside of a traditional vertical partition of the building that is promptly denied in the inside: as we may see in the section there is not a correspondence between the outer levels – individuated by the openings and the string courses – and the inner slabs that depend only from the pit and from the steam machine. Certainly their purpose is to flood the light inside of the building, but this appear to be secondary respect to the aim of creating a legible composition of the façades, with a coexistence of elements borrowed by the stylistic influences of the moment: the general impression is therefore of a civil building, a sort of *résidence bourgeoise* that formally would have nothing to share with a pit.

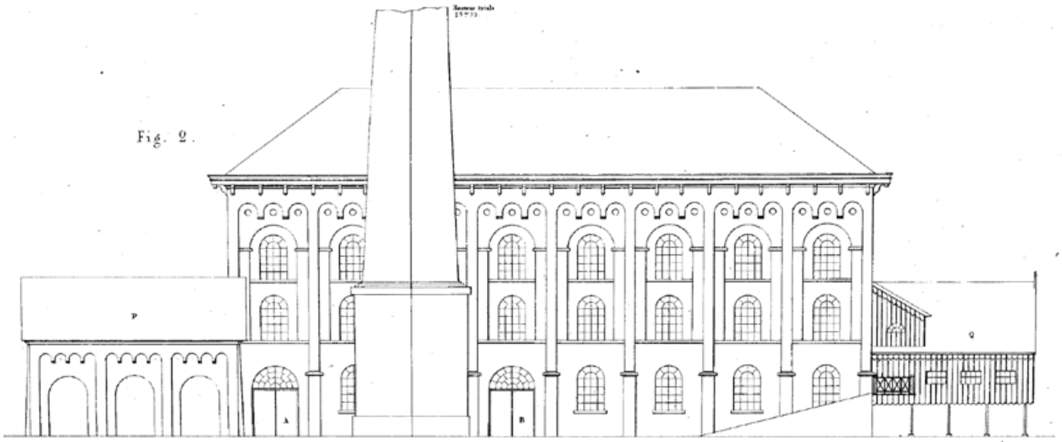



Figure 5 Main front of the pit n.12. Source: Atlas de la Société de l'Industrie Minérale, planche XII.

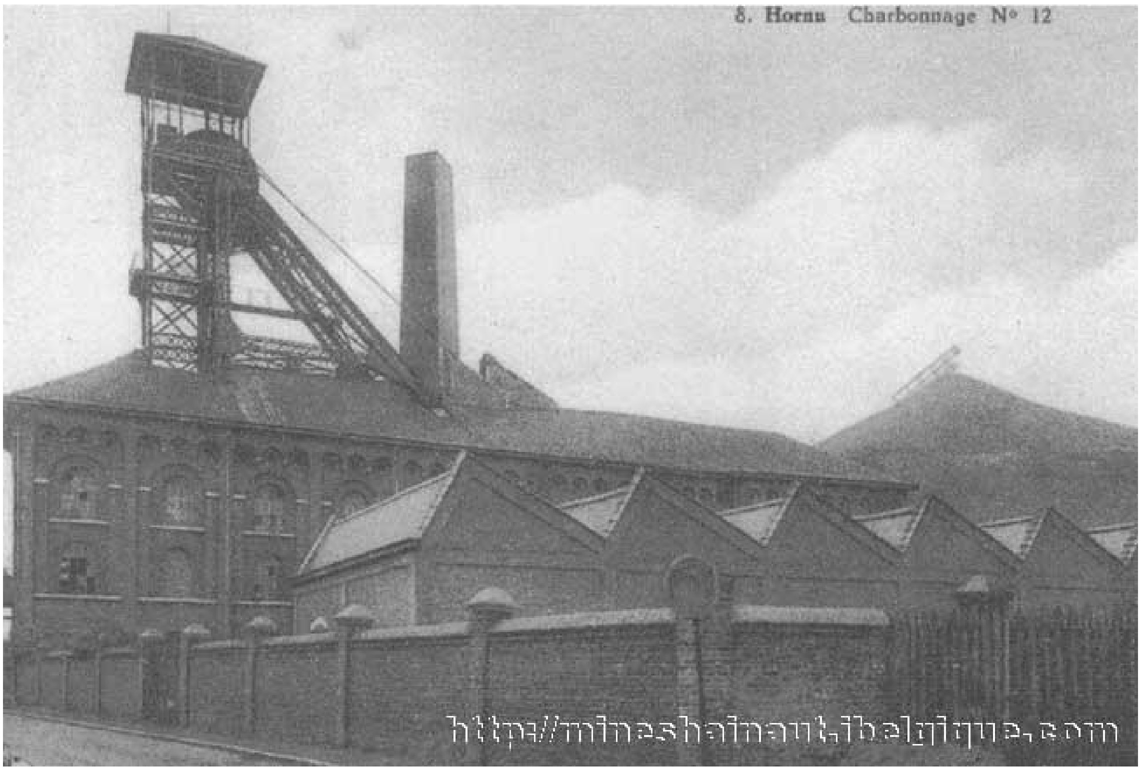



Figure 6 Lateral view of the pit. Source: http://les-charbonnages-borains.skynetblogs.be/hornu/

The lateral volumes *P – Q* ,standing at the sides of the main building, are the hangar of the triage and are distinguished by two different constructive approaches. The hangar *P* on the left featured a bricked masonry construction, covered by painted wooden planks, and a combination of two lighted cast iron cantilevers, recalling the one sustaining the machinist's station, connected in the midst of the span. The roof featured the same wooden framework of the main building, with diagonal struts sustaining the ridge; although not visible, the *Bulletin* specified the presence of glazed panels placed in openings on the roof in order to let the light flood inside. The prospectus evoked the same *leitmotif* of the main façade thanks to the use of a rhythm of arched moulding, placed under the eave, that parted the three openings of the hangar.

On the opposite side, the hangar Q is built on eighteen cast iron pillars placed on the ground floor distributed in rows of four, sustaining the wooden slab on the first level. Externally it is completely covered by vertical wooden rounded planks and bargeboards that evoke a sort of alpine architecture due also to the heavy slope of the pitched roof, whose head beams cross together on top over the ridge, and to the small terraces featuring a reminiscence of *heimatstil*. The openings on the first lever are totally different from those in the main volume due to their rectangular and narrow shape that contrasts with the oculus located on the side, which is on the contrary a smaller version of the one corresponding to the second level of the pit.

The general impression of this building may contrast with the one of the main volume because of the absence of the masonry and the presence of a lighted structure on the ground floor, which reveals completely the presence of the cast iron pillars: this intention could be connected to the different purpose of this building since it contained the rail tracks in charge of the movement of the wagons to and from the pit, needing therefore a free surface that could be achieved only through the use of punctual elements.

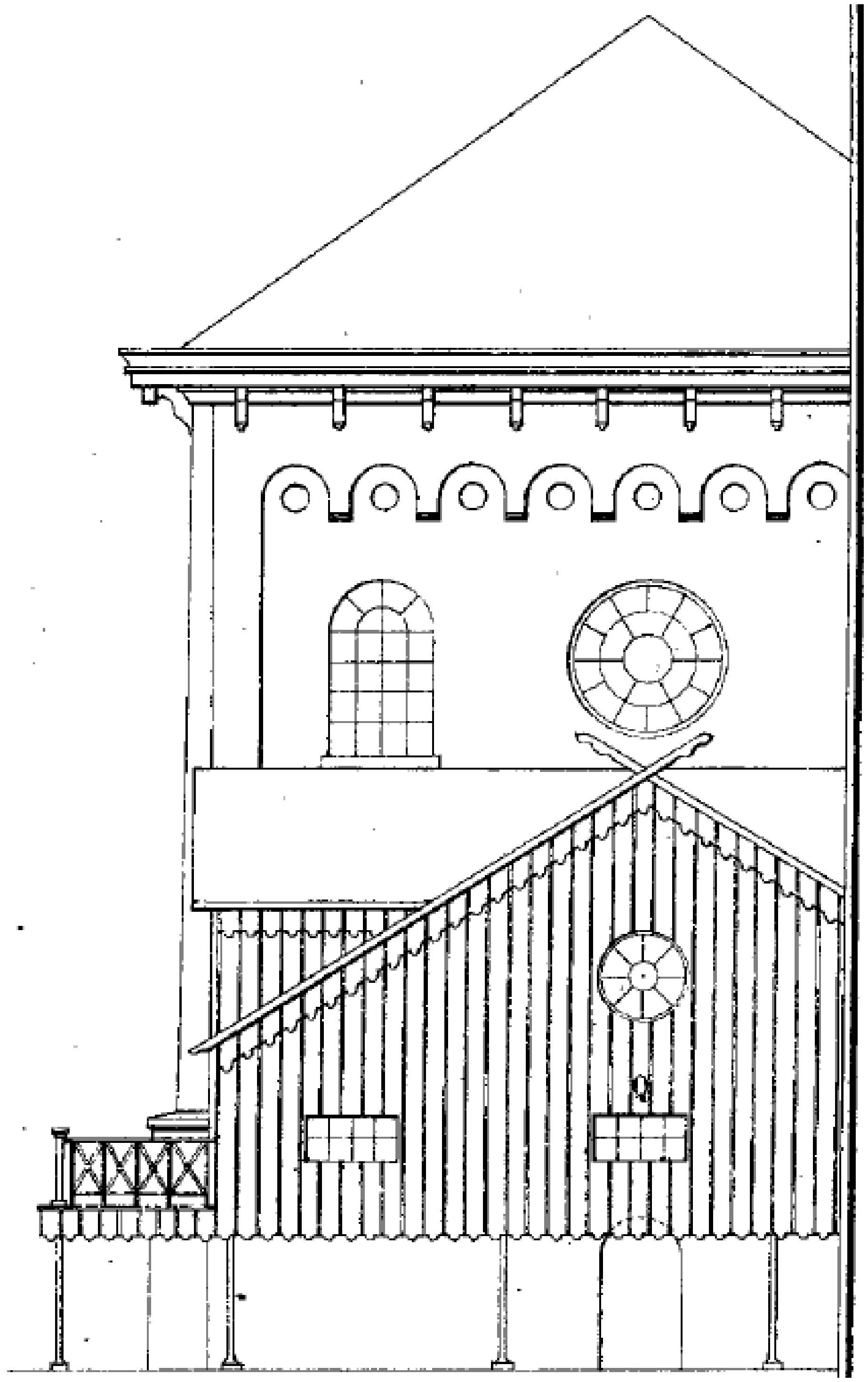


Figure 7 Lateral facade of the hangar of triage Q and the main building on the background. Source: *Atlas de la Société de l'Industrie Minérale*, planche XII.

*Inner distribution*

The main hall *A* containing the steam machine measures 8,20 x 11 m and contains a 1,85 m large opening located on the first floor that opens in the corridor *x* in order to let the machinist see the pit from its position. The workers' barrack *B* is a semi – squared area linked to the corridor *x* on the upper floor by a stair *K*, located between the counterforts, and consequently to the entrances of the pit and the annexed rooms. Initially this stair should have been used by the workers when moving to and from the pit and the barrack, but the builder failed in the disposition of the engine of the extracting machine – which should have put the machinist at a height of 7 metres above the ground floor and the passing workers – and therefore was added another stair *L* to let the miners reach the barracks and workplace. The pit featured three entrances: the lowest *R*, the upper *R'* reachable by the stairs *M* passing through the corridor *J* and the lamp room *E* (*lampisterie*) where the workers collected their lamps and finally the upper entrance *R"* through the stairs *N*.

The accesses R, R' and R" connecting the different levels of the pithead and the pit are separated by a parting wall, against which are leaning the lateral staircases *M* and *N* which linked the accesses to each other and the central entrances to the corridor J. This wall extends for a largeness of 3 m and faced the pit in order to let the machinist visually control the extraction process. While *R* and *R'* occupy an extension corresponding to the main façade of the building, the highest R" is placed between the two struts of the pit and is delimited by a cast – iron balustrade that serves as a fireguard. The latter features a geometric and dry design, simpler than the balustrade in the steam machine hall, since it is made of vertical, horizontal and diagonal elements with nothing in common with the Renaissance echoes of those in the machinery hall.
Finally, between the forges C – C, located at the right of the barrack, and the bricked body that constitute the head of the extraction pit there is the compartment for four bellows, placed in order to keep a free central area where the cages could be moved and put under the structure of the pit in case of maintenance of the other cages.

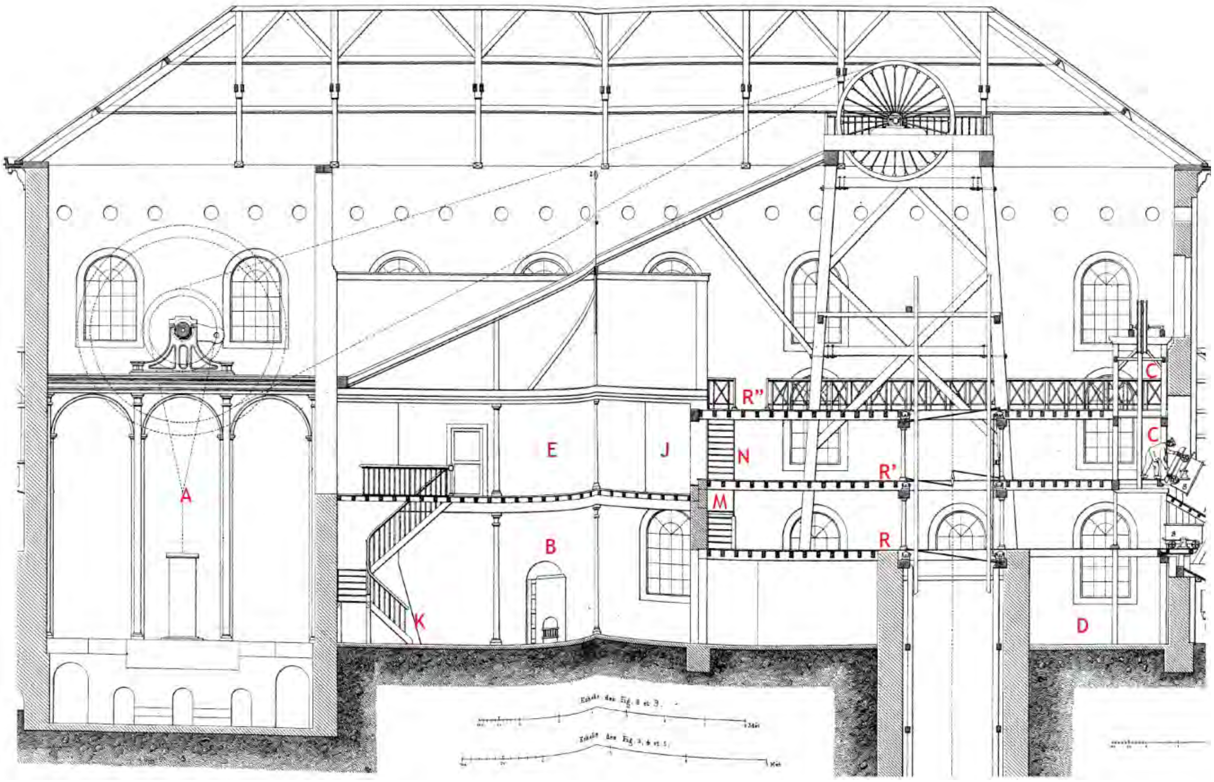



Figure 8 Inner distribution of the main building. *Atlas de la Société de l'Industrie Minérale*, planche XII.

At the light of these considerations, we may confront this building with one built ten years later and described in the Bulletin of 1867 – 1868 in order to understand the evolution and the modification of the formal and structural languages involved in the design of the mining facilities. The *Robiac* shaft, built by the *Compagnie Houillère de Bessèges*, developed on a L – shape plan measuring 29 x 12, 20 m containing the hangar of the *chevalement* (i.e. the pithead), the machinery hall and the boilers room. Differently from the *Grand Hornu*, the structure entirely relied on the bearing masonry, consisting of a mosaic of irregular stones with mortar joints that delimits the whole perimeter of the complex and the various compartments. The thickness of the masonry, 1 meter from the base to the top, kept constant in order to add the most possible weight over the transversal components of the pithead and to reduce the strain caused by the vibrations. To this purpose a further reinforcement consisted of iron tie rods inserted inside the masonry at the level of the springers of the vaults, as well as two iron ties located 4 m above the other ones and placed inside the gables.


Figure 9 Panoramic view of Robiac Shafts in the first years of XX century. Source: https://subastas.catawiki.es/kavels/9323085-francia-f-bricas-e-industrias-48-n-mero-de-tarjetas-animadas-en-varias-ciudades-1900-1940

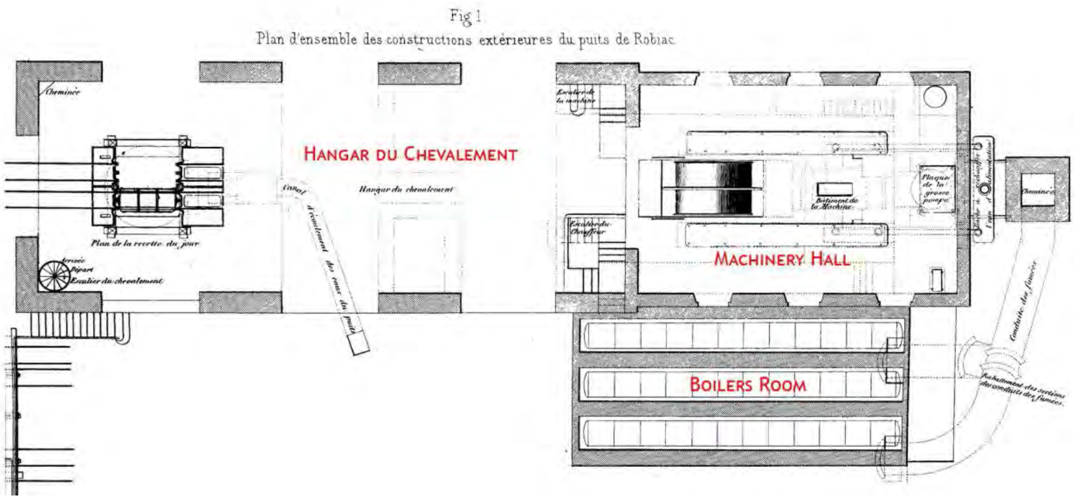



Figure 10. Plan of the Robiac pit. *Atlas de la Société de l'Industrie Minérale*, 1868, planche XXII.

The pit headframe too shows a simplified architectural approach: it consist of three fir beams measuring 50x50 placed transversally and leaning on the lateral walls of the hangar, with a span of 10,30 m. The central beams are sustained in the middle by the tracks carrying the cages, while the third is reinforced by a double T iron beam, 0,50 m high and 0,40 m wide. Smaller metallic girders link the four beams, sustaining also the wheels and rising them enough to be preserved by the accidental elevation of the cages to the limit of the guidance. Above the main beams there are wooden planks allowing to circulate around the wheels, reachable through an helicoidal cast – iron stair located in one of the corners of the hangar.

The extremities of the beams are inserted for 0,90 m inside the masonry, working as tie rods, to connect the lateral walls: to this purpose they contain iron rods and cast – iron plaques in the ends, fixed by the bricked masonry and the cement mortar that form a strong cohesion and distribute consequently the strains on the walls, avoiding the dislocations due to the vibrations of the iron carpentry. The transversal beams of the headframe were placed during the construction of the hangar and are independent from the guidance of the cages, which were placed later in order to not interfere with the structural components of the hangar. The strain that these beams can bear, with a span of 10,30 m and responding to their limit of elasticity, is considerably important since there are not intermediate supports and it was proved thanks to practical tests conducted and described by the author himself[2], in order to determine the maximum stress: "*we have wanted to understand* [the maximum deflection] *before going on, in these conditions, with the placement, the excavation of the pit and the installation of the guidance. To this purpose, we have separately placed, on 10,30 m distant solid supports, one of the fir beam and the iron beam, then we have charged both of them in the middle with cast iron ingots of known weight*." The values of the deflections in millimetres were reported in a table referring to both the beams:

[2] Marsaut, J. B. Sur l'installation de puits de Robiac de la Compagnie Houillere de Besseges (Gard). *Bulletin de la Société de l'industrie minérale*, tome XIII, 1867 – 1868, pp. 452 – 453.

| Epreuve d'une poutre en sapin de 0,30 sur 0,30 de côté, reposant sur deux appuis espacés de 10m,30. | | Epreuve d'une poutrelle double T en tôle, dont la Fig. 3, Pl. XX, représente une section en travers, reposant sur deux appuis espacés de 10m,30. | |
|---|---|---|---|
| Charges en kilogr. | Flèches produites en millim. | Charges en kilog. | Flèches produites en millim. |
| 1,000 k. | 2,7 | 950 k. | 1,9 |
| 1,980 | 5,0 | 1,940 | 3,0 |
| 2,960 | 9,0 | 2,911 | 3,0 |
| 3,936 | 11,9 | 3,898 | 4,2 |
| 4,906 | 16,0 | 4,848 | 6,0 |
| 5,711 | 19,5 | 5,858 | 6,7 |
| | | 6,813 | 8,2 |
| | | 7,793 | 9,2 |
| | | 8,758 | 9,7 |
| | | 9,733 | 11,0 |
| | | 10,713 | 12,7 |
| | | 11,693 | 13,2 |
| | | 12,683 | 14,7 |
| | | 13,648 | 15,7 |
| | | 14,613 | 18,0 |
| | | 15,413 | 19,0 |
| | | Flèche permanente après déchargement, 0m,0063. | |

Figure 11. Table showing the different levels of deflection both in the fir and metal beams. *Bulletin de la Société de l'industrie minérale* 1867 – 1868, p. 453.

At the light of this test we see that the metal beam shows a resistance three times higher than the wooden one, even thanks to the presence of light joints among the parts and to their integrality, confirming therefore the safety of the whole construction. Moreover, the vertical oscillations are reduced to minimum thanks to the extension of the rails of the cages, while the horizontal deflections, towards the machine, are irrelevant because of the dimensions of the metal carpentry.

The hall of the machinery measures 15 x 10,30 m and elevates for 5 m above the ground: it is lighted by six French – windows, three on each side, and by one large window that separates it from the hangar of the *chevalement*, leaving the entrance to the mine and the headframe visible. The machine is placed over an ordinary masonry foundation – 12,13 m long, 7,30 m large and 4,50 m high – placed immediately on the ground and covered on top by a thin, stone – cut layer. In the base of the foundation we find the galleries for the anchorage bolts and in the upper part the pits or the galleries to house the barrel, the brake and all the pipes. These elements, as well as the vaults, are made of bricks that simulate a sort of decorative motif. Two bricked vaults, in particular, link the foundations to the lateral walls of the building of the extractive machinery to achieve a greater stability.
The level under the machine, in the area free from the foundations, has been used to place a huge pump and the power machine of the boilers. The big pump is connected to a 16 m deep pit and pumps the water up for 50 m to propel the drainage of the coal and the domestic duties. It also fills the reserve tank of the boilers. The hall of the pumps is covered with a system of vaults bear by double T beams, 0,16 m high, which elevate the floor of several steps, and it is lighted by two window placed in the triangular gable of the machinery hall.

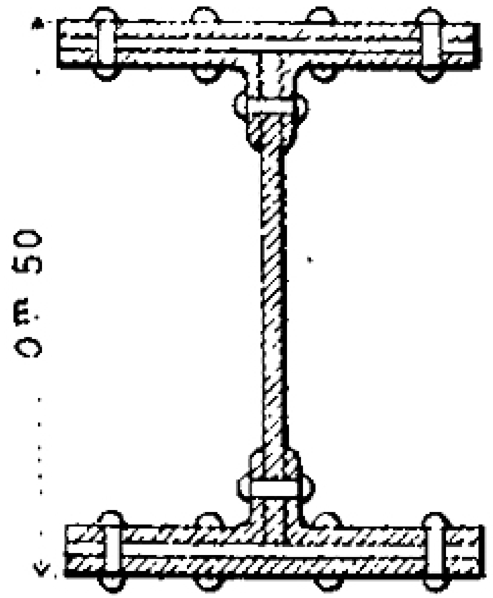



Fig.3

Figure 12. View of a composite metallic beam with metal joints. *Atlas de la Société de l'Industrie Minérale*, 1868, planche XX.

Under this area we find two symmetric caves at the sides of the pump: one contains a reserve of air and the other the pump fuelling the generators and the hydraulic conducts. Walls here are covered by an ordinary white gypsum plaster.

Finally an inclined ramp made of wooden planks accommodates the resting cables when they are not used by the machinery and protects them from rubbing on the stoned pavement.

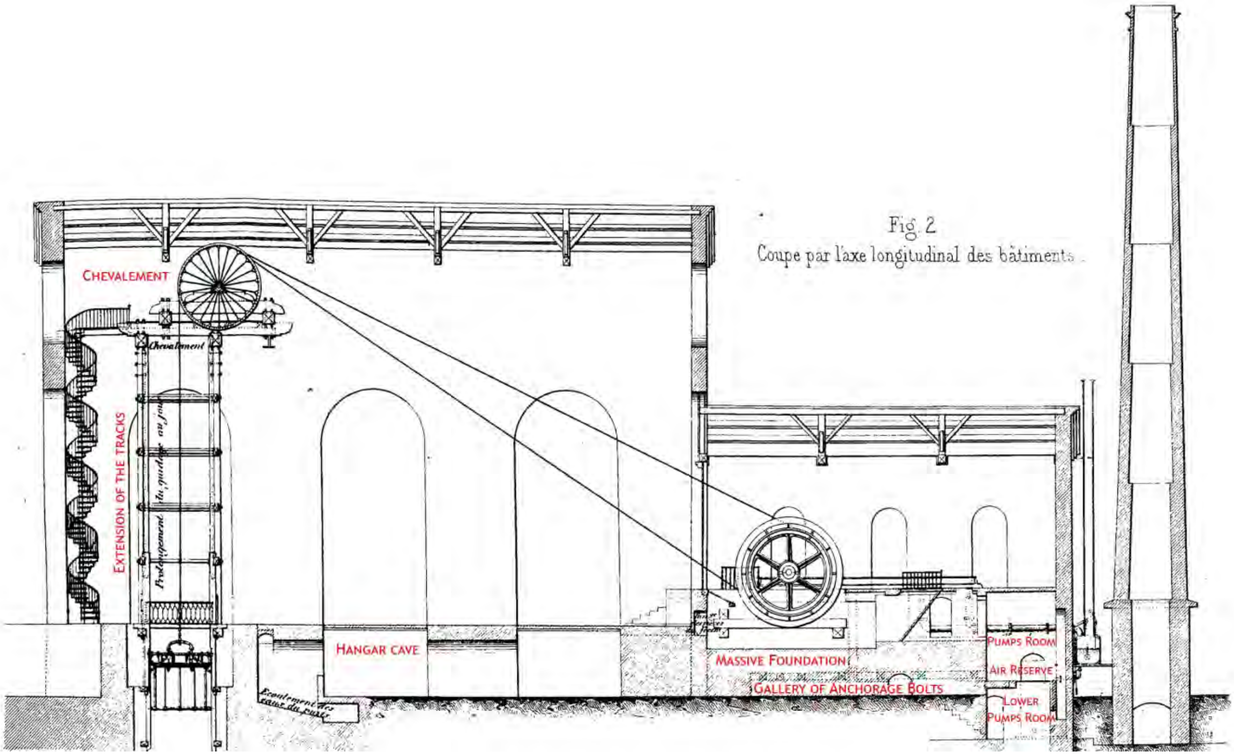



Figure 13 Longitudinal section. *Atlas de la Société de l'Industrie Minérale*, 1868, planche XX.

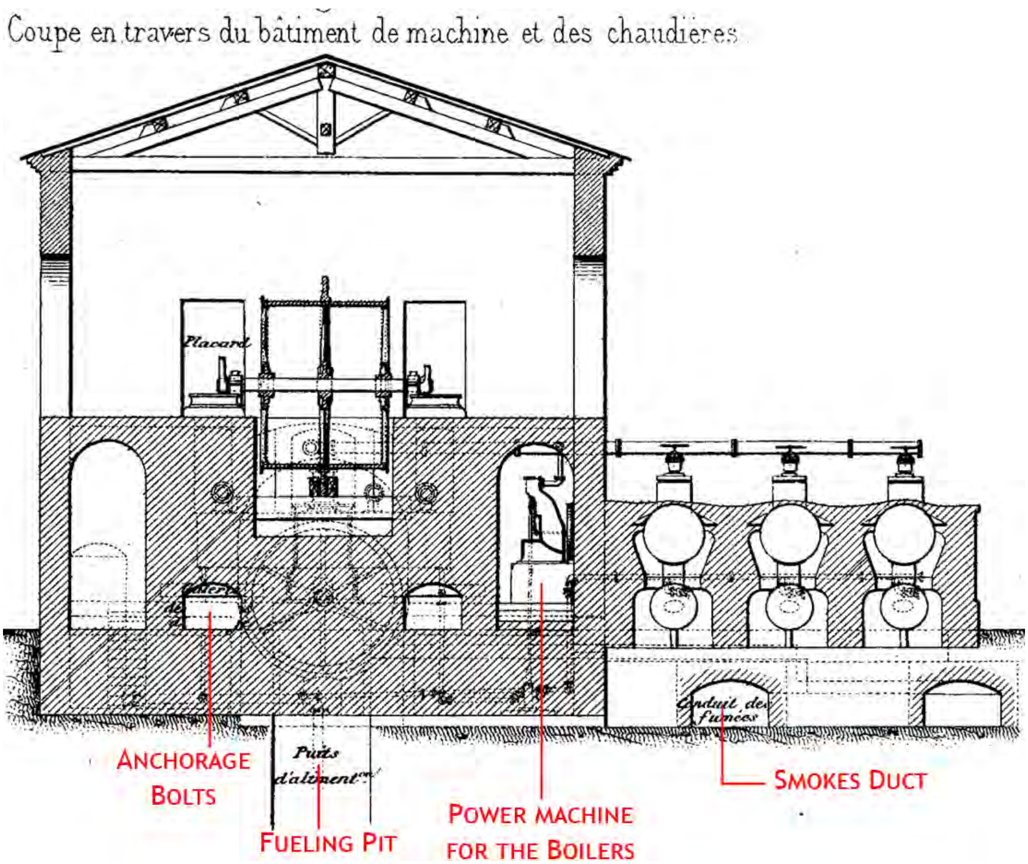



Figure 14 Transversal section in the machinery and boilers building. *Atlas de la Société de l'Industrie Minérale*, 1868, planche XXI.

*Formal and linguistic considerations*

Differently from the previous building, we may state that in this mining complex the attention given to the stylistic accents is clearly weaker: there is in fact a slight trace of a decorative intent traceable only in the external views of the building, reduced merely to the only red – bricked *encadrement* of the French windows, the windows and the corners of the walls as we may see in the project of the façade. The former dedication to the expression of the industrial activity, the underlining of the presence of the machine, the enhancement of the human and mechanical roles is abandoned in favour of a more synthetic and rapid concept of the whole building system: the formal approach proves here an attention for the maximum utilization of the space and a consequent dismissal of the Eclectic and Neoclassic tastes like we have seen before. The thresholds and the hollow of the barrel are merely the only elements showing an "aesthetic" finishing, consisting of cut – stoned stringcourses delimiting the openings and the volumes. Inside there are no traces of the former use of metallic elements that celebrated both the ductility of cast – iron and the presence of the industrial activities, but a simplification of constructive systems and a massive use of bearing masonry instead of pillars: wooden trusses constitute the roofs and the framework of the *chevalement*, in the latter combined with reinforcing double T girders, metallic rods connecting the walls and composed beams that feature simple geometries and no linguistic elaborations. The presence of the bearing masonry, both in walls and foundations, reveals the intention to create voids and recesses intended not to "Eclectically" move the façades and the volumes but to allow the installation of technical machineries and devices, such as in the hall of the pumps that develops deeply with several galleries and caves. Even the description of the building underlines the importance of the structural expedients and the wise occupation of the volumes to grant the highest economy and stability of the construction and it does not mention any decorative or celebrating use of metal components excepted for the use of red bricks in the external cornices. Along with this description there is also a mention of the resistance properties of the employed materials, suggesting a knowledge and a mastery of the Science of Construction principles.

We may state therefore that the use of the Eclectic language, where Neoclassic and Neo – Renaissance features mixed to underline the peculiarities of the building, is replaced here by a traditional composition of volumes and structures, despite the development and the predominance of iron structures in the coeval production of industrial architectures as in Great Britain, Spain and Germany. The traditional construction is evident thanks to the presence of heavy masonry portions, pierced only by the series of arched openings in the fronts, that represents the bearing system for the wooden trusses and slabs, which are reinforced by metallic elements just for a matter of stability and safety; moreover the masonry in the foundations elevates in height to occupy an important section of the hall of the machinery and is combined with bricked vaults instead of punctual structures as in the former building. The linguistic synthesis, which prefers the constructive application of vernacular elements to the celebration of the industrial work, is therefore the key to read this building in a optic of progressive abandon of the Eclectic approach.

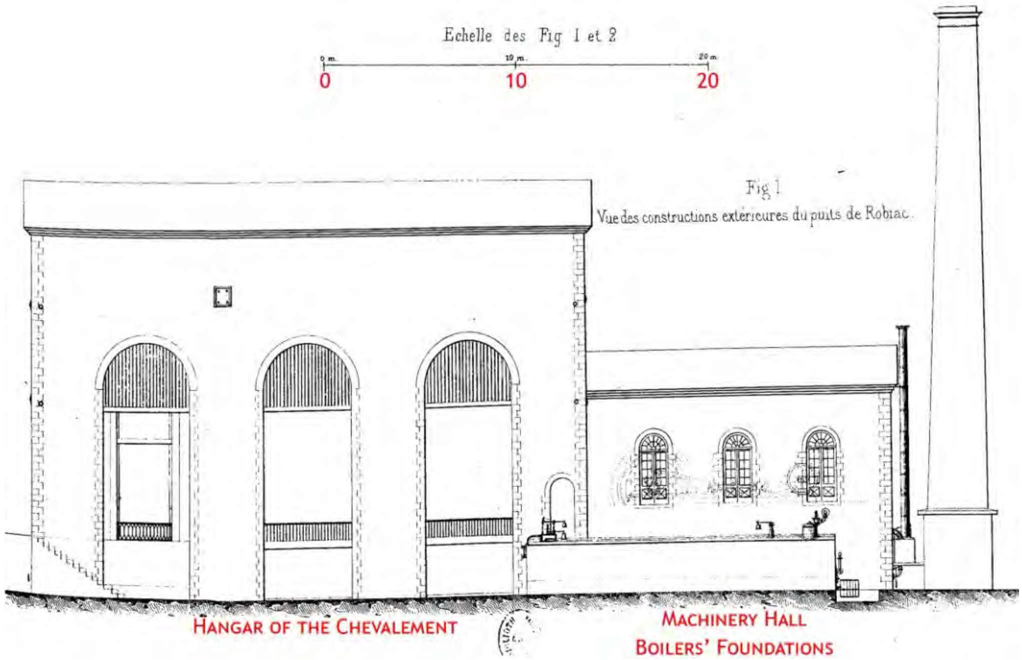



Figure 15. Main façade. *Atlas de la Société de l'Industrie Minérale*, 1868, planche XX.

Still from the Nord – Pas de Calais basin we may confront another pit, coeval of Robiac, to the Sardinian case: the n. 4 pit in Courrières mine is in fact a stronger example of the linguistic simplification and the persistence of a massive presence of masonry in French – Belgian mining architecture, although combined with metal elements. The plan features a sort of L – shape with a marked separation of its volumes and functions: starting from the left we find subsequently the garage, the pit hole, the hall of the machine, the tanks, the boilers and the chimney; all of them are visibly separated through walled sections, i.e. thick masonry that divides the whole building into independent and isolated compartments.

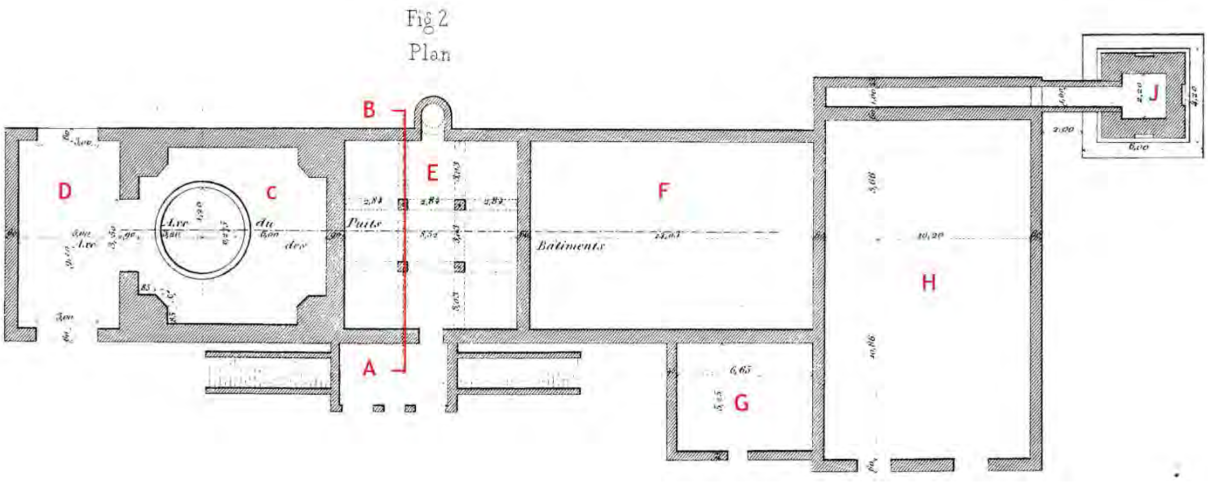



Figure 16. Plan of Courrieres pit. *Atlas de la Société de l'Industrie Minérale*, 1870 – 1871, planche VII.

The pit itself is a circular hole partly surrounded by a wooden headframe, with a 4 m diameter, placed inside a rectangular frame measuring 3,05 x 2,15 m intended for the extraction. The short sides contain both two tracks extending from axe of the cages: these are interrupted in order to place a false track (*faux guidage*) to let the wagons in and out at the ground level[3]. The building of the *chevalement* C is placed in a rectangular building measuring 9,20 m x 8,50 m built in a 0,90 m thick masonry; the latter is reinforced in the four corners by heavy pillars sustaining the headframe: this allows to better enlighten the perimetral structure of the headframe when elevating the base of the pit. The access is extended into a small covered building D in which the wagons move and turn in the ground level, forming the level of the water. Between the access and the machinery there is a barrack E constituting in the lower lever a hall, measuring 9,09 x 8,52 m, covered by a iron plank, sustained by beams carried by four cast – iron pillars. Two stairs next to a stairway link to the access of the pit and to an adjacent platform that extends to the building of the machinery. This hall F measures 14,03 m x 9,09 m and contains the extraction machine. Another building G contains the tanks for the water, connected in the next building to the boilers in a hall H measuring 16,52 x 10,20 m where there is also a chimney J to collect the vapours. Each building is built in bricked masonry of various thickness and tiled roofs, excepted for the walls fencing the head gear and the cages: the head gear is totally made of oak wood, with four struts measuring 0,50 x 0,50 m at the base and 0,40 x 0,40 m at the top and cast iron planks distributing the stress on the four masonry pillars, which are crossed by iron tie rods in order to prevent the deflections. The struts are connected to each other by three rows of transversal elements and Saint Andrew crosses; in the highest section there are crosspieces measuring 0,50 x 0,50 m forming the top and sustaining the pulleys.

[3] Evrard, A. L'extraction et le roulage a l'Exposition Universelle De 1867. *Bulletin de la Société de l'Industrie Minérale*. Paris: Dunod Ed., tome XV, 1870 – 1871, pp. 243 – 246.

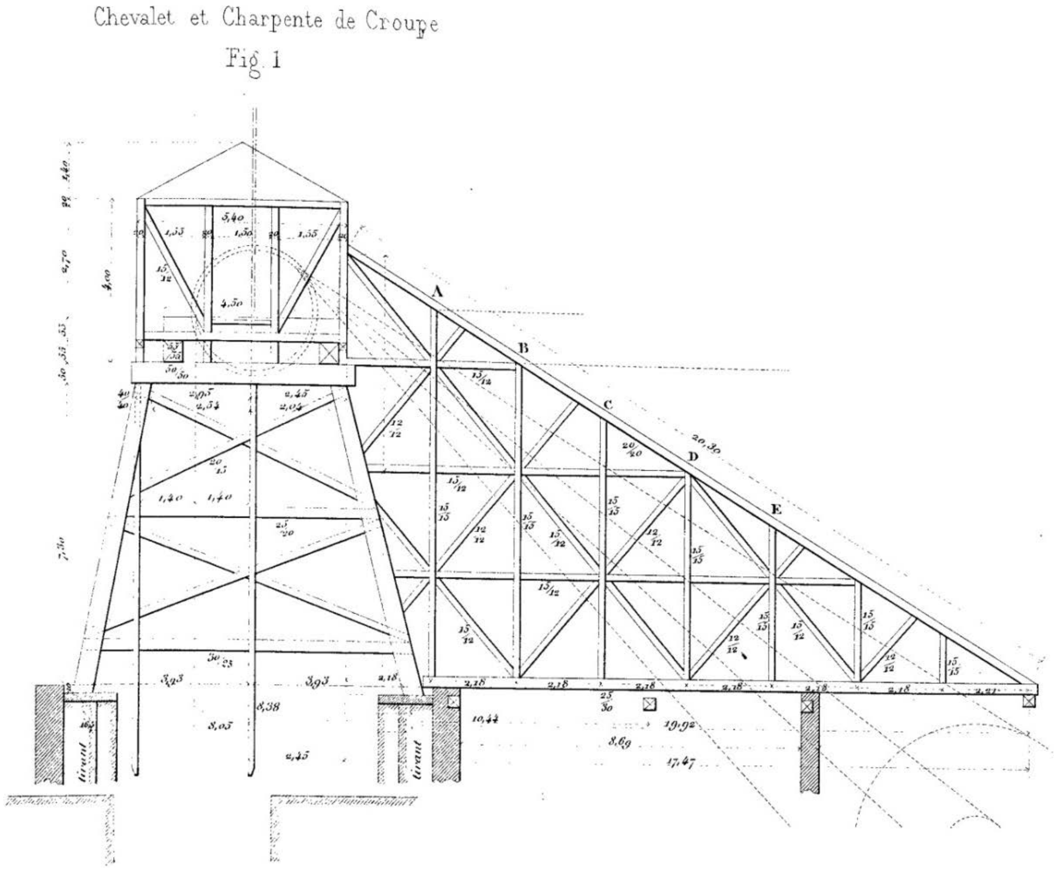



Figure 17. Section of the wooden headframe. *Atlas de la Société de l'Industrie Minérale*, 1870 – 1871, planche VIII.

The covering protection elevates the *chevalement* up to 14,80 m high over the masonry pillars and to 20 m over the level of the coal. The structure bearing the frame of the cages is eloquently described as a system of beams and vertical elements, jointed and repeated linearly: the stakes (*estacades*) are made of double T beams measuring 120 mm and 6,25 m long, placed every 1,04 m and fixed by five double bearings laying on wooden crosspieces, 120 mm high, which are sustained by small metallic pillars. The latter features a sort of rough, stylized capital – column system, since the upper part bearing the wooden beam lays on a second trapezoidal capital that constitutes a unique piece with the metal pillar sustaining the whole stake. There is therefore a multiplicity of levels that composes this structure, whose complexity is evident in the technical drawings: the pillars constitute the lowest level, surmounted in order by a first trapezoidal capital, sustaining in turn a secondary perforated capital bearing the wooden beam, which finally carries the metallic joints and the double T iron beams. This system, finally, might be considered a sort of frame protecting the descending and ascending movement to and from the pit hole and therefore inaccessible, keeping the extractive function strictly separated from its environment and from the rest of the building.

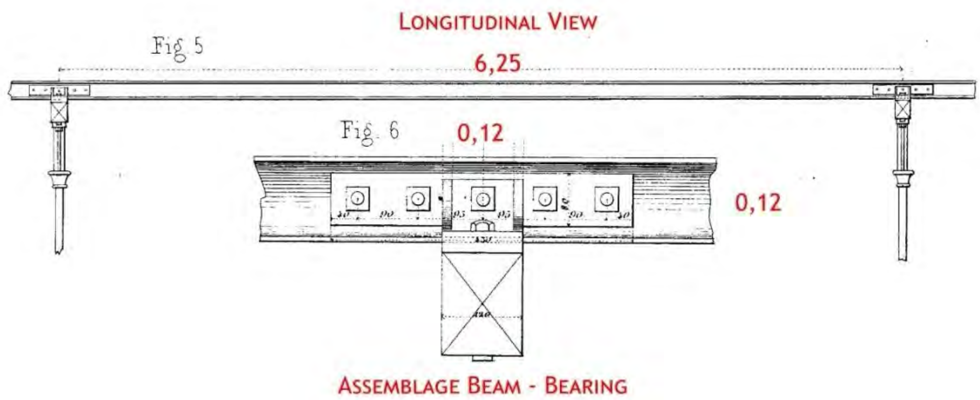



Figure 18. Detail of the assemblage of iron beam and bearing. *Atlas de la Société de l'Industrie Minérale*, 1870 – 1871, planche VI.

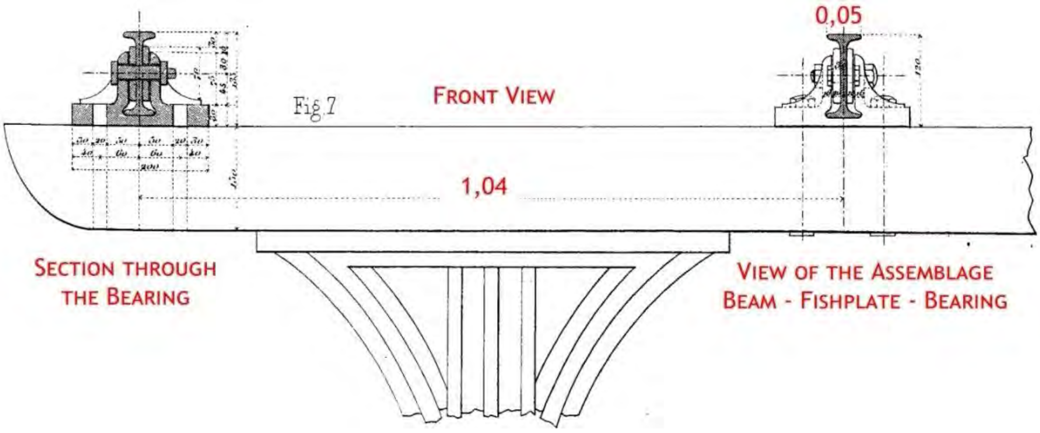



Figure 19. Front view of the assemblage. *Atlas de la Société de l'Industrie Minérale*,1870 – 1871, planche XII.

Another important insertion of metal components is traceable in the barrack E, where we find a vertical partition of the volume due to an iron plank carried by four cast – iron pillars, displaced in a span of 3,03 m from the masonry and between them. These last are maybe the only perceivable decorative elements in the whole building: we find in fact a high basement, containing a reminiscence of Greek torus both in the base and in the upper end, sustaining a strongly tapered, cast – iron column ending with a thin Doric capital that features nothing but an elegant slim physiognomy. The lightness of the metal columns is counterbalanced by the massive presence of the masonry, whose thickness is 0,90 m on the left (since it is the masonry of the building of the pit headframe) and 0,60 on the right, and by the laying system above. Also here in fact, as like as in the stakes, we find a layered composition of metallic and wooden elements: in detail, this system consists of a vertical structure (the basement, the column and the capital) surmounted by a main iron beam, 0,25 m high, penetrating in the masonry and laying on wooden blocks; this girder contains in turn a row of 0,16 m high double T iron beams, placed at a span of 1,01 m from each other, supporting bricked vaults of 0,11 m height covering the area. Above this structure, there is another metal plank, 0,05 m high, that sustains an additional layer consisting of wooden beams, measuring 0,12 x 0,20 m. The final level features iron planks disposed over the beams, creating the floor of the upper room.

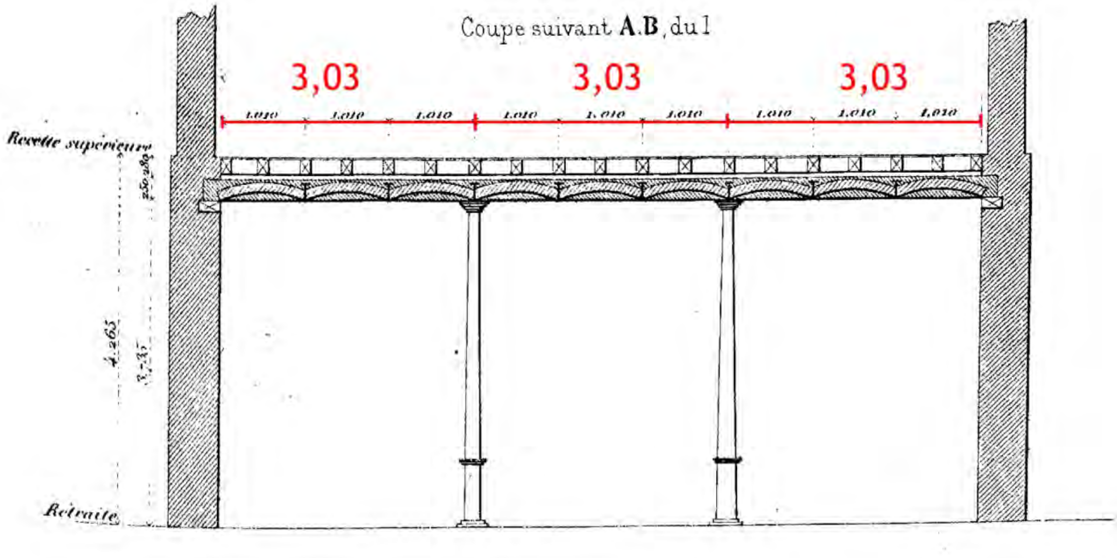



Figure 20. Section A – B through the pillars in the barrack. *Atlas de la Société de l'Industrie Minérale*, 1870 – 1871, planche VIII.

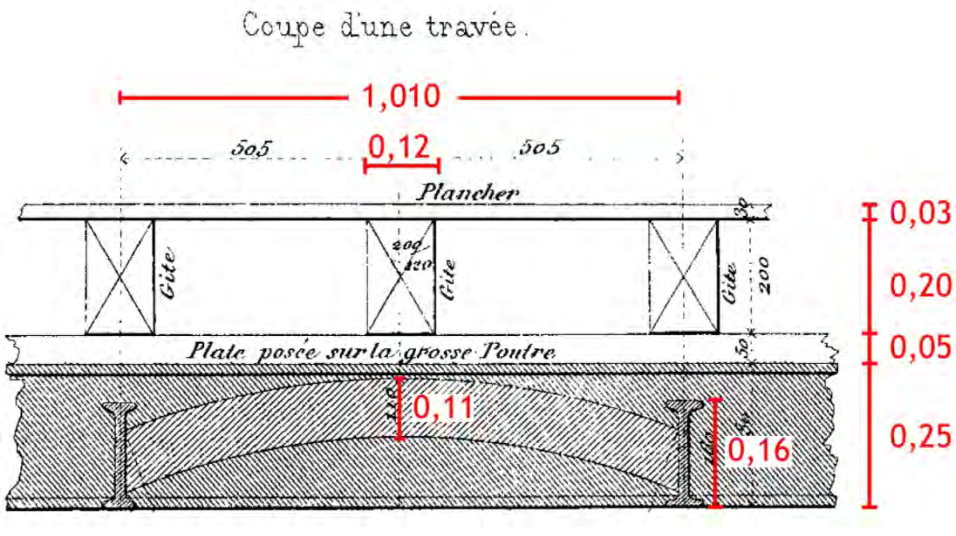



Figure 21. Detail of the layers in the barrack. *Atlas de la Société de l'Industrie Minérale*, 1870 – 1871, planche VIII.

A final consideration about the linguistic and constructive approaches must be credited to the composition of the façade: from the outside the building testify clearly the presence of massive wall sections, underlined evidently by the heavy responds corresponding to the extension of the inner walls towards the outside. The decorative intent is reduced here to the basements and to the frames surrounding the arched openings, which follow a certain rhythm that however does not express any functional relation or importance to the observer. Moreover, the accents of an Eclectic combination between Neo – Renaissance arches and Neoclassic elements are mostly referable to the main level and do not suggest a lighting of the masonry sections but, on the contrary, its reinforcement and powerful presence. The emerging volume of the stairway also remarks this impression due to the false arcades that follow the inclination of the ramps, counterbalanced by the real openings leading to the tank room G that pierce the masonry. In Sella Pit in Monteponi mine, on the contrary, we see that the Eclectic language, expressed through the Neoclassic and Neo – Renaissance formalism in the main front, gave to the building an impression of a balanced magnitude, lighted by the long and elegant series of arcades, pilasters and frieze that enriched the whole composition, evoking both a celebration of its function and the mastery in the use of heavy and light elements.

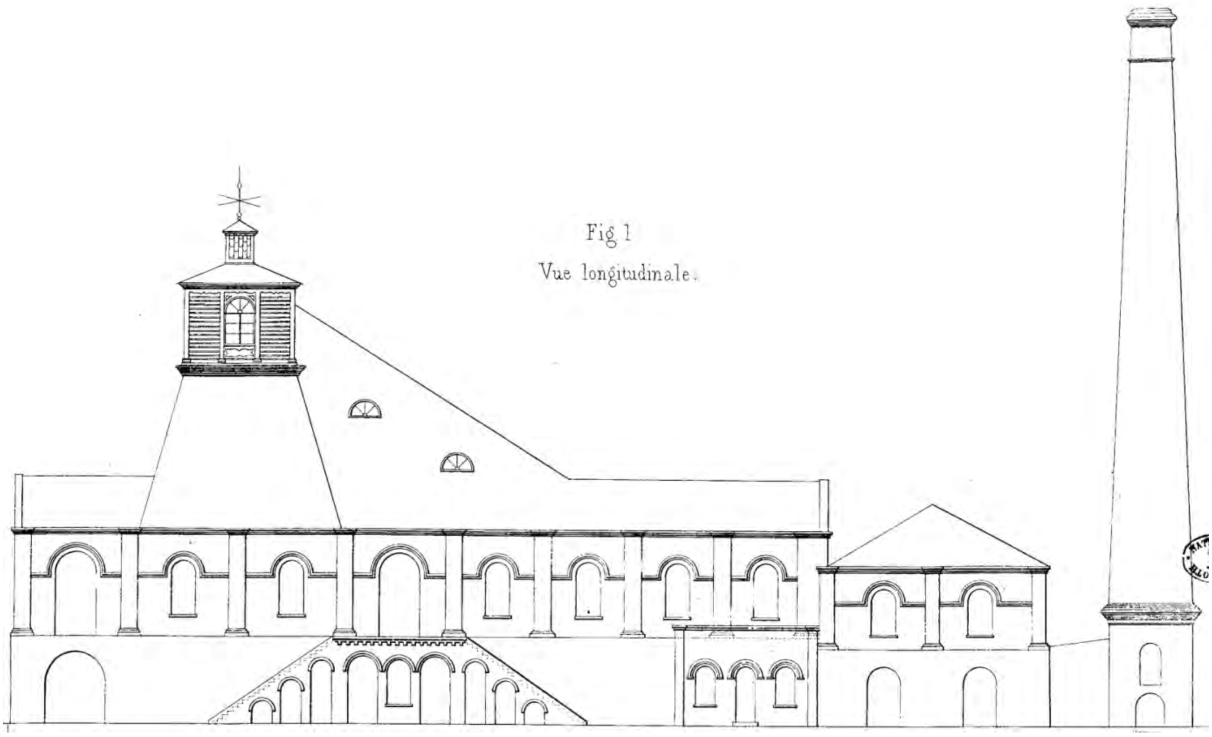



Figure 22. Main façade. *Atlas de la Société de l'Industrie Minérale*, 1870 – 1871, planche VII.

## Formal and structural features of the mining facilities in Almadén mine

To conclude the overview of the constructive and linguistic affinities and differences between the mining heritage in Monteponi and in the other referring European sites, we aim to present one of the oldest buildings of the Almadén mining compound: the San Teodoro Shaft. Although the former building does not exist anymore, since it had been demolished and replaced by a new mining shaft in 1960s, it is possible to trace the main characteristics of this facility thanks to the drawings and plans stored in the Archive of the Almadén Park.

The first drawing– presumably dating to 1860s or 1870s – features the project of the house of the 40 HP steam machine for the shaft. This building recalls the same features that we saw above in the later examples of mining facilities in the French – Belgian region, since it is characterized by a sobriety in the architectural languages and in the dimensions that, however, might relate to the Vittorio Emanuele Shaft in Monteponi for the linguistic and volumetric control. Although the decorative apparatus is less intense than in the Sardinian building, we may consider it as well as celebrative since it features the same linguistic expedients that in Vittorio Emanuele shaft contributed to enhance the halo of a "mining temple": the main difference clearly consists in a more modest conceive of the small fronts, which show each an arch whose springers base on Doric pilasters and contain themselves other arched openings of smaller dimensions. The architectural impact of the lateral fronts – where there is the access to the building – relies on the triple articulation in height of the high arcades containing the double level of openings: the decoration is clearly synthetic but evokes the same aulic imposition that we saw in the Sardinian buildings and constitutes the frame for the regular rhythm of the arched windows. Another linguistic and structural expedient is represented by the use of a basement as a podium to elevate the building, clearly highlighted by the baseboards all along the perimeter of the building: the main level is connected to the ground level through a stair that is perfectly balanced between the modular width of the openings. The basement also allowed to ventilate the lowest floor as we may see thanks to the use of small, arched doors and windows, which are underlined by frames presumably made of bricks. Lintels, windowsills and springers create therefore a dialogue with the arched elements that pierce the façades – which thus are the main fronts – and underline the partition of the surfaces, creating a motif of recessions that would have been probably enhanced by the natural light and shadow. In the minor fronts there is also an indication of the structural existence of – presumably – wooden beams that might suggest the presence of trusses: whether these are timber or metallic is uncertain to say, but confronting to the other buildings of the mine the first hypothesis is preferable, since the introduction of metallic structures started in the 1910s and 1920s, e.g. the building of the machinery of *San Aquilino* Shaft and the workshops. The static is therefore still based on the bearing masonry, which is going to last as the main structural elements along with the trusses during the further decades and until the 1940s, as testified by the warehouse of the mercury dating back to 1941.

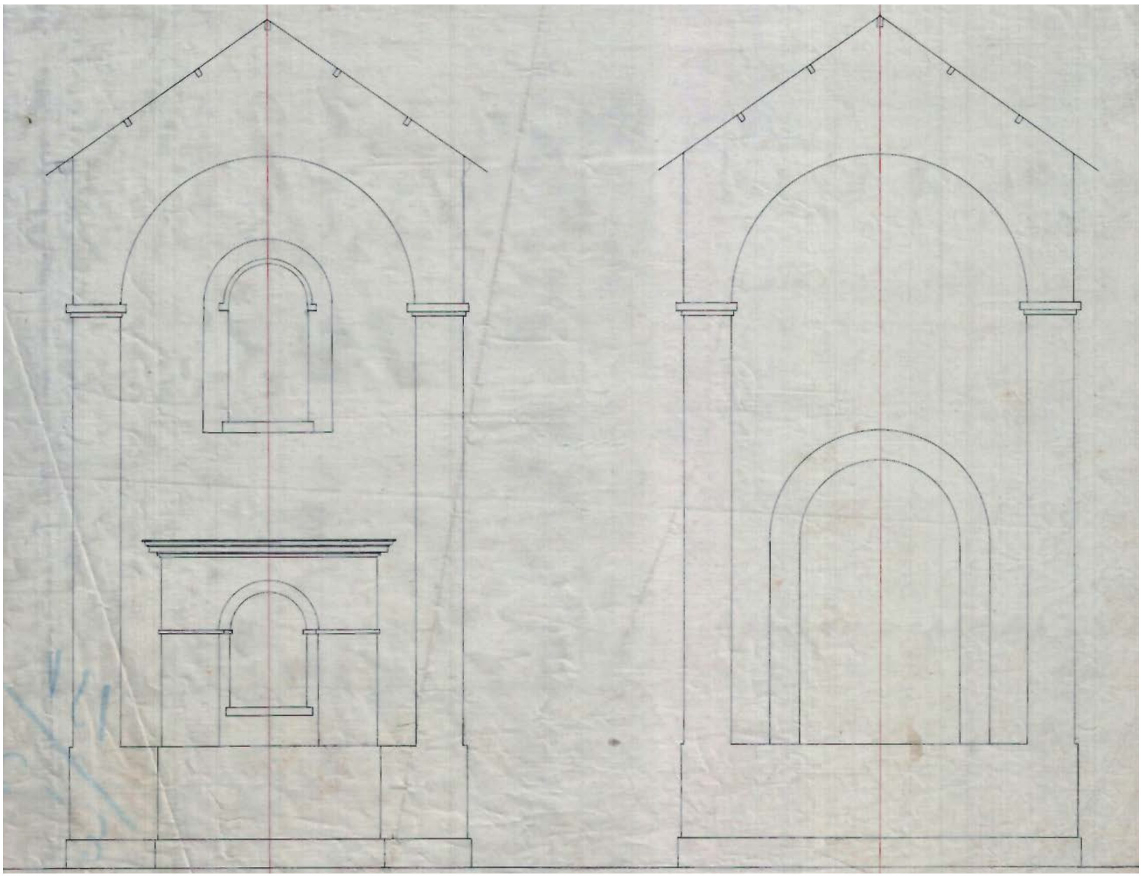


Figure 23 Minor fronts of the former San Teodoro shaft. Source: FJV-098/1 Almadén Mines Historical Archive.

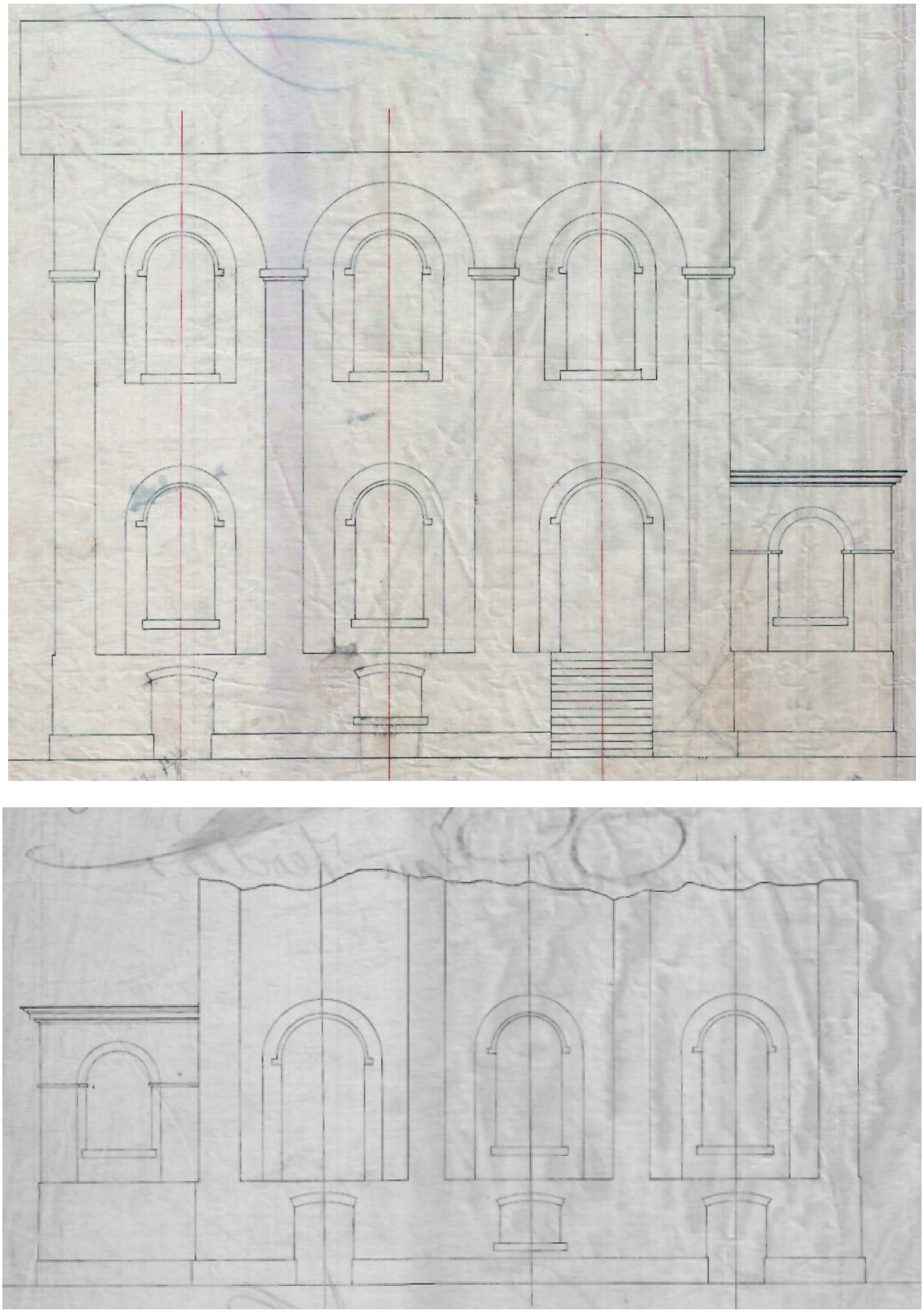


Figure 24 Lateral fronts of the former San Teodoro shaft. Source: FJV-098/1 Almadén Mines Historical Archive.


Figure 25 The former storage of mercury, now the Museum of Mercury. Source: www.parqueminerodealmaden.es

The building of San Teodoro Shaft was replaced in 1920 by another building, still containing the extracting machinery linked to the pit: the new volume featured a strong expressivity of the formal language thanks to a decorative apparatus based on the application of bricked motifs and stylistic features, clearly derived from the Modernist architectural culture. Contrarily to the former project, this building contains a metal structure combined to a 0,45 m thick, bricked, bearing masonry, which contains multiple openings. The main one is the great gate allowing the access for the rods connecting to the metallic headframe: its importance is underlined by the double frames, by the ogival oculus on the top and by the use of a crenellation under the pitched profile of the roofing, fit between the frames running along the façades. Despite the aulic presence of decorative expedients and motifs enriching the walls, the presence of the steel structure is confirmed through the visible pair of double T pillars standing in the span of the main door and the drawings of the main front – where the foundations identify the use of steel plates and triangle brackets – and in the general plan.
The amortization of this double structural presence relies in the strong formal use of brick faces, frames, a classic basement, Doric lintels and motifs that conceal the possible use of a metallic frame, recalling the image of a mid - Nineteenth century, Eclectic building.
Unfortunately, the house of the machinery and the pit was demolished and replaced by a new metal headframe in 1962, which *de facto* erased every trace of the past connotation and of the Modernist features of this building.

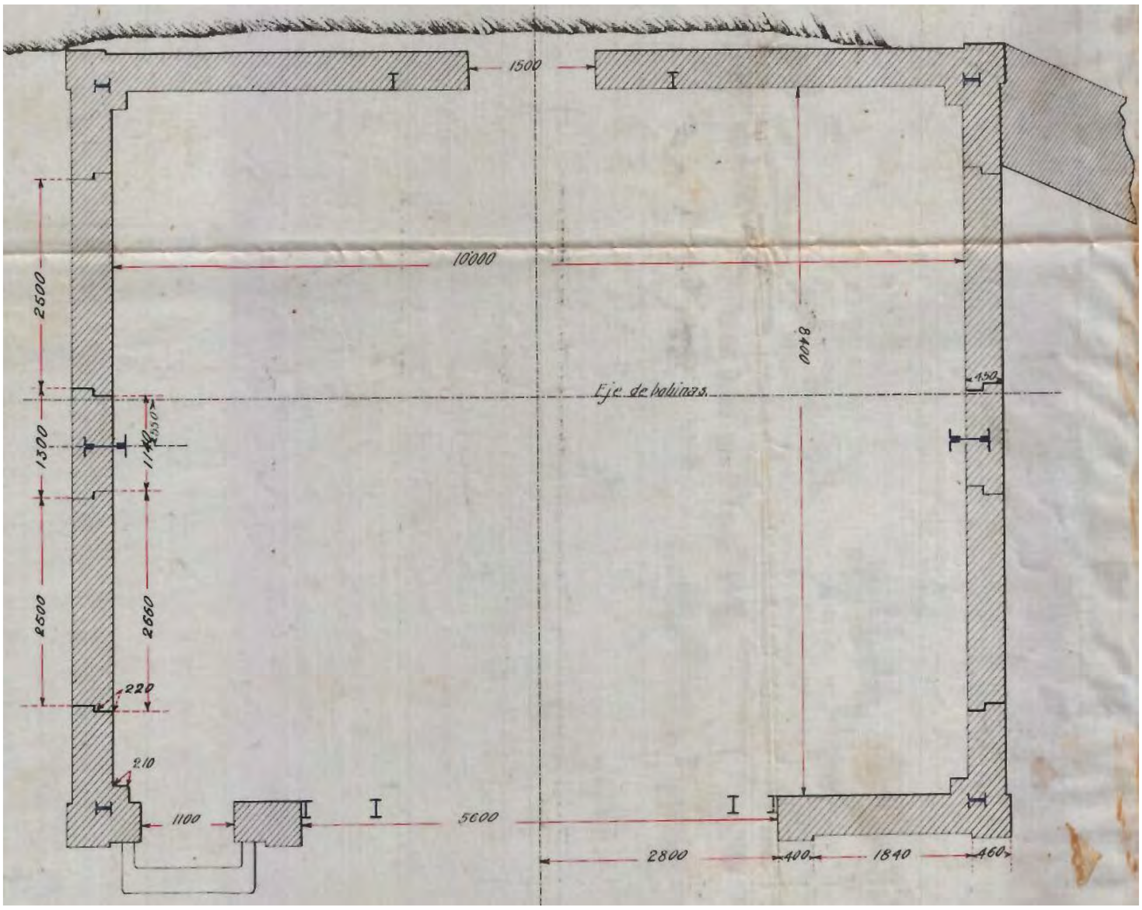


Figure 26. Plan of the 1920s San Teodoro building. Source: FJV-098/1 Almadén Mines Historical Archive.

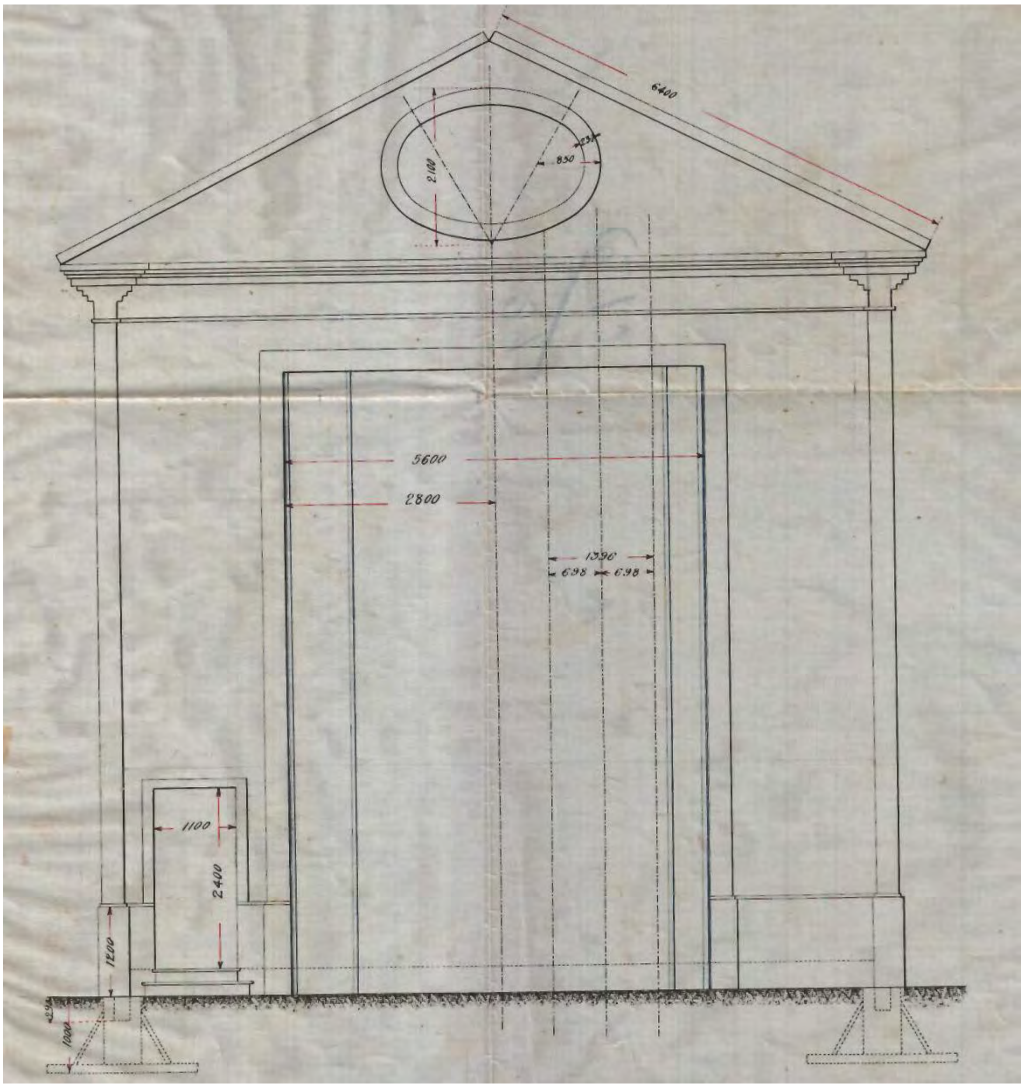



Figure 27 Main front of the 1920s San Teodoro building. Source: FJV-098/1 Almadén Mines Historical Archive.

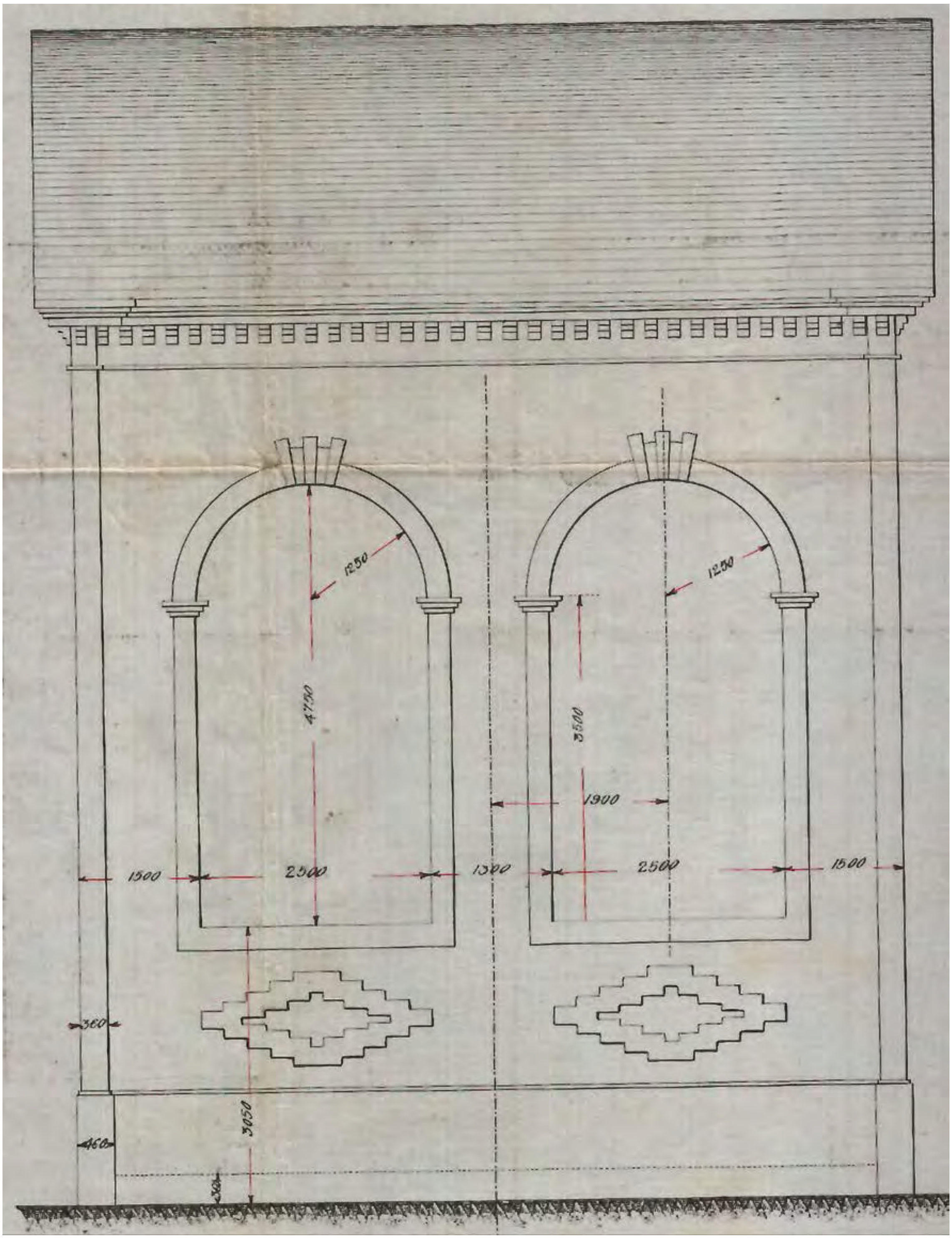



Figure 28 Lateral façade of the 1920s San Teodoro building. Source: FJV-098/1 Almadén Mines Historical Archive.

## Final considerations

In order to take the results of this part of the dissertation, after the investigation of the linguistic and structural features of the mining building of the 19th century in Europe, we may trace the parallelisms and common characteristics that link reciprocally the Sella Shaft and the other facilities.

In a first instance we may assert that the bearing masonry represents a constant element in the whole building panorama of the mining heritage of the 19th century: we see in fact that in every given example the walls with a structural function are both a component of the building scheme and a mean to divide the spatial composition. The functional separation is in fact a common feature in the analyzed cases, since the whole building housed different but complementary facilities that may be linked to each other or kept separated. In Sella Shaft this condition is presented through the triple articulation of volumes: the wings containing the forges, the foundries and the mechanical workshops and the main tower containing the machinery, the carpentry and the access to the pit. In the other cases the partition frequently involved the house of the machinery, the workers' rooms, the headframe and the transporting / distribution services in order to distinguish and remark the various pertinences and the competences of each sector.

The analysis of the metallic elements offers another interesting aspect regarding the conceive of the mining architecture of those decades: we see in fact that the presence of iron structural components is often reserved to the most important sections of the buildings or those where there is a need of spatial freedom – such as in the workshops, the house of the machinery, the headframe and so on. In Sella Shaft this occurs in the lateral wings, where the Polonceau trusses display along the whole length allowing to free the floors, while in the central volume we find the huge system of iron beams and girders sustaining the pumps. In the other pits the metallic elements are reserved for the same purposes, such as in the Grand Hornu and Courrieres; in the first case the use of metallic components is brought to a high celebrative intent that could be observed in the finishing of pillars, railings, capitals and arcades in order to underline the fundamental role exerted by the machinery, which becomes therefore the core of the mechanization in the exploitation process.

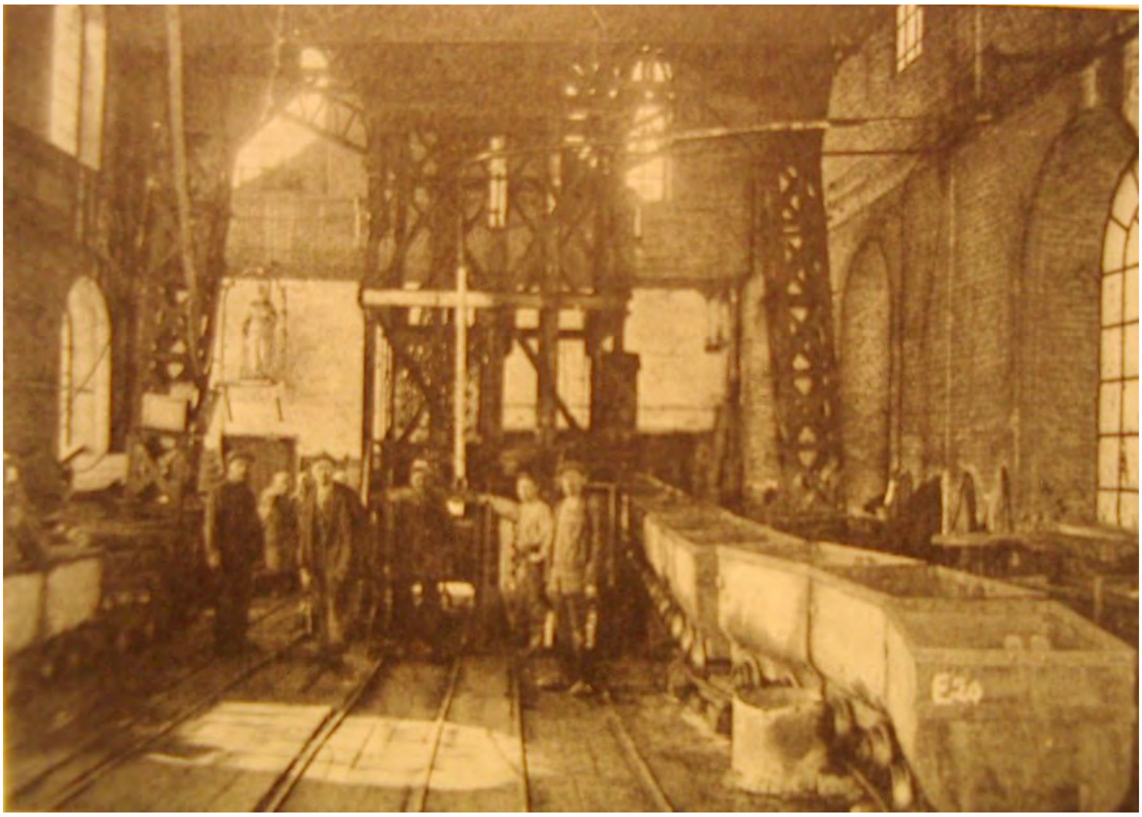


Figure 29 Gables of the Shaft n. 7 (Société Civile des Usines et Mines de Houille du Grand-Hornu). Source: http://les-charbonnages-borains.skynetblogs.be/hornu/

Moreover, the abacus of the building elements features a variety of profiles and declination of the design of the girders that offers an idea of how the studies and researchers on metallic structures had amplified in the mid of the century: double T beams, girders, riveted parts, assembled beams, pillars and reticulated girders represent the materialization of the attention paid for the structural balance, in accordance to the permanence of masonry and bearing walls, which however are mainly relied to the perimeter of the buildings. The partitions are in fact frequently avoided in order to achieve the best possible circulation inside and outside the facility and to allow the installation of further plants and machinery when occurred. Finally, we must remember that along with the masonry, there is also the permanence of timber components, mainly in the roofing (beams, trusses and purlins)and in the sections of the headframes but also in the slabs, where they are linked to iron beams and vaults to create the floorings.
Roofing is another common feature in this scenario: pavilion and pitched roofs are in fact based in each building on metallic or timber trusses and feature in some cases openings and skylights to let the light flood in, such as in the case of Sella Shaft and in Grand Hornu, where the circular oculus (or bull's-eyes) are placed just below the eaves.

Natural illumination is supplied through the openings on the main walls, which are always characterized by two elements: the semicircular – or arched – profile and the presence of frames, headstones, windowsills and arches that fit the windows creating a rhythmical partition in

the façades, frequently embossing or recessing the surfaces with a plastic alternation of lighted and shadowed parts.
The repetition of these openings and frames create thus a movement in the fronts that suggests a complex co – penetration of structural and accessorial components, highlighted through an apparently endless display of hollows and filled parts.

The linguistic formalisms, to conclude, are therefore a mean always used in the mining buildings of this period and feature the influences of different stylistic approaches that we might recollect all under the Eclectic vision of the whole building process: where structural parts are combined inside through articulated solutions of various materials (cast – iron, iron and timber) we find an explicit counterbalance consisting of multiple, decorative and bearing – simulating elements (such as pilasters, buttresses and arches) jointly with frames, cornices, crenellation and so on that compose the aesthetic scenario where the industrial function is exerted and pursued.


Figure 30 External view of Shaft n. 7 in Grand – Hornu. Source: http://les-charbonnages-borains.skynetblogs.be/hornu/

PART 6

# REHABILITATION

# OF THE

# EUROPEAN MINING HERITAGE

## Introduction

This chapter first analyzes the European experiences of valorisation and reuse of the mining sites, previously described in the second part of this dissertation. The purpose of this section is to present different approaches and methodologies that have been applied during the processes of restoration and acknowledgment of the most important elements of each case, in particular those regarding the installation of new functions in an optic of sustainable development.

The first example, referring to the Tuscan mining heritage, shows the three main sites of Follonica, Gavorrano and Niccioleta: at the light of the characterization of their heritage we may confront the typological features and the stages of intervention, which saw the installation of cultural facilities, didactic centres and museums with the aim to promote the knowledge and the divulgation of the historical and architectural values belonging to this mining centres. The case of Gavorrano shows also a variety and a complexity in the reclamation and the reuse of the majority of its buildings, thanks to recovery plans that interested the extractive cores, e.g. the quarries, and the existent facilities: these programs or recovery consist mainly of reclamation of soils, reparation and restoration of damaged structures and of the installation of new functions such as theatres, exposition halls, mining heritage museums and touristic dwellings and services.

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The second case presents the recovery of Almadén's mining heritage is presented through the projects of adaptation and reuse of the most important facilities, in particular the creation of visiting routes, didactic centres, adaptation of the galleries for the public, a museum, a mining archive. The preservation of the architectural elements is also relevant since the actors aimed to keep the features testifying the historical evolution of the site, e.g. the mining fences (the *Cercos*), and the technological apparels, such as the ovens, which express an high level of technical advancement and the evocative meaning of the mining scenario.
The final part illustrates the UNESCO acknowledgment procedures to enlist Almadén's mining heritage in the World Heritage List in virtue of its historical, technical and cultural values.

The chapter dedicated to the recovery of the mining heritage in North - Pas de Calais - Wallonie presents a focus on two important examples of restoration and reuse of the mining heritage for cultural and social purposes: the *Fosse Delloye* case, converted into a Historical Mining Centre in Lewarde, one of the most important researching centre on mining heritage and archive in Europe; the other case is the *11/19* site in Loos – en – Gohelle that has been turned into one of the most important research centre on the sustainable development thanks to the researching projects on the environmental recovery, the sustainable energies, the promotion of sustainable enterprises and economical activities with a peculiar care for the respect of the natural and industrial heritage of this site.

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## Follonica and the tower of the former *Ilva*

The area of the former Ilva of Follonica constitutes an important productive complex bound to the chain of cast iron, situated in the heart of the city. Its configuration is analogous to an industrial citadel, nestled in the urban settlement and characterized by a building stratification dating from the era of the Grand Duchy of Tuscany[1]. The first elements of this core are the melting furnaces, which after various modifications and alterations have given to the complex the form of a large masonry block mixed with bricks and stone on irregular layers, with 10 outlets on the front alternated with the vents of the galleries connected to the central tunnel. The mouths are surmounted by the crucibles from which the material by means of a loading plane was thrown and from which the process of smelting and refining started. In the Nineteenth and Twentieth centuries, during the Grand Duchy of Leopold II were made the ovens *San*

[1] Maciocco G. Il patrimonio minerario moderno. In Preite, M. (Ed.). *Masterplan. La valorizzazione del paesaggio minerario*. Florence: Tipografia editrice Polistampa, 2009, pp. 83-84.

*Ferdinando*, *San Leopoldo* and *Maria Antonia* with which particular systems of blowing for the melting of cast iron were employed[2].

The access to the industrial area of the former Ilva is constituted by an imposing railing in cast iron and iron that offers an interesting testimony of the varied artistic production of the factory at its apogee. The project of the fence dates back to 1840 by Carlo Reishammer, who set it up on four lintelled columns holding a hexyl perforated and ornamented arch, on which stands the dolphin-shaped Savoy Kingdom's[3] coat of arms. The flame of cast iron that exits from a torch of the same alloy recalls the nature of the production of the area while the cornucopias evoke the aspirations of wealth and productivity of Nineteenth century period, certainly among the happiest in the industrial history of Follonica. The separation of the Royal Foundries from the town is therefore entrusted to this element of division, beyond which it may be observed the articulated geometry of the *Leopoldina* planimetric setting that diverges from the most ancient ruins and from the Nineteenth century renovations. Among the best architectural specimens preserved in the area the dry geometries of the Grand-ducal Palace, built in 1845 on the ruins of the Arsenal and used as a Prince's secondary residence[4], may be admired.

[2] Ibidem, pp. 83-84.

[3] Turcheschi, F. Le Fonderie di Follonica. In Preite, M. (Ed.). *Paesaggi industriali del Novecento. Siderurgia e miniere nella Maremma toscana*. Florence: Edizioni Polistampa, 2006, pp. 67-68.

[4] Ibidem, p.69.

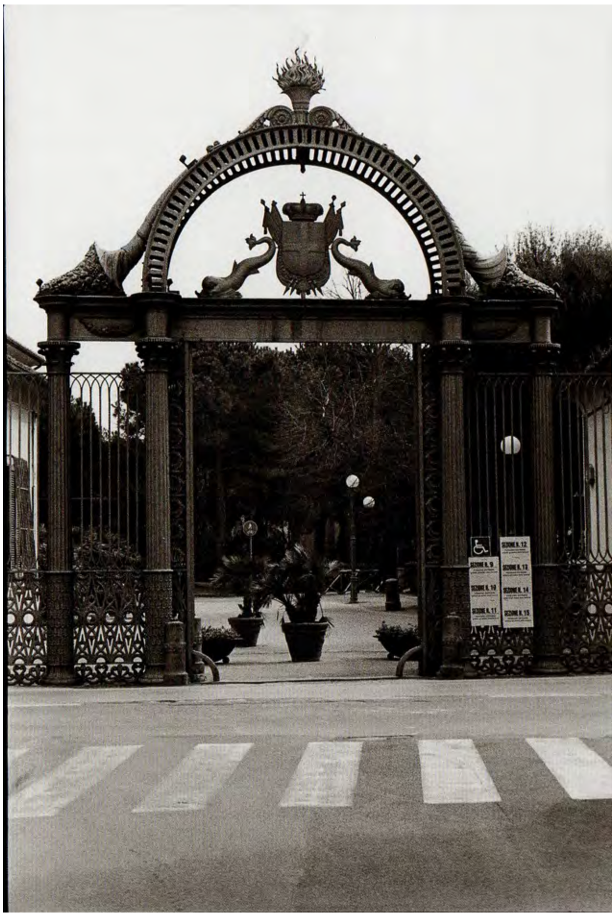


Figure 1. The access fence to the *magonale* paddock.

Source: Preite, M. *Paesaggi industriali del Novecento,* 2006.

*Public Library*

The edifice of the Public Library is part of the complex of industrial archaeology of the former Ilva and was built by Grand Duke Leopold II of Lorraine in 1838 as a mechanic workshop, on the remains of the furnace of the Seventeenth century and of the Mill. The structure contained vaults supported by columns made of cast iron and was almost destroyed by the bombings during the Second World War; it was then rebuilt after the war with a Neoclassic language faithful to the original source. The clock tower dated back to 1838 and stands on the Eighteenth-century building initially used as a church and then transformed into a residence for the Grand Duke until the completion of the Grand-Ducal Palace[5].

[5] Ibidem, p. 70.

Figure 1. The Clock- Tower. Source: Preite, M. *Paesaggi industriali del Novecento*, 2006.

Upgrading and aggrandizement works of the ground floor were carried out in 2004, followed in 2009 by the adaptation of offices and meeting rooms on the first floor. The intervention has mainly focused on the containment of the thrust of the arches drift on the ground floor and on counteracting the drifts that have caused some obvious cracks in correspondence of the roof. The reinforcement intervention on these lesions provides the building chaining related to the most impressive split-ups through the positioning of carbon fibres on the façade and through the insertion of chains which contribute to counteract the thrust[6].

*Redevelopment of the former* Leopolda *foundry.*

The recovery plan for the ex – Ilva area among the various interventions provides the recovery of the building of the foundry n. 2, according to a project respectful of the archaeological - industrial physiognomies of this complex and a sight of reuse as a place of entertainment , compatible with the preservation of the historical value of the site together with the marked distinction of the new intervention in respect to the existing. The project strategy is consequently based on the anti – camouflage between ancient and modern with a dialectic between the parties which would not prejudice the cultural value of the building complex.

[6] Preite, M. (Ed.). *Masterplan. La valorizzazione del paesaggio minerario*. Florence: Edizioni Polistampa, 2009, p. 127.

This is a building constructed during the Lorena family period with an evident archetypal ambition, starting from the large arches that divide up the main prospect and the glazed screen, in perfect dialog with the hydraulic tower where the single and paired openings are arranged on four fronts. A volume in the form of a small temple with classic pediment and a rear blind oculus bears the inscription dated 1834[7].

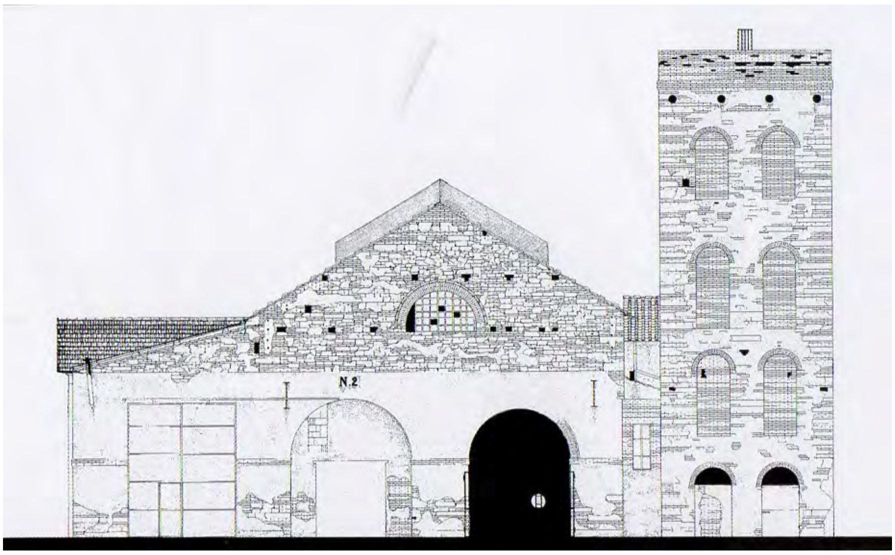



Figure 2. n.2. Grand Duke Foundry Prospectus Source: Preite, Paesaggi industriali del Novecento, 2006.

*San Leopoldo* furnace dated back to 1835 and it is the first structure to be inserted into the Ex Ilva site. It was designed by the French engineer Henry Auguste Brasseur and in 1840 a second furnace for the cast iron was added, paired to the previous one and named *Maria Antonia*[8]. In addition to the spaces devoted to the machinery, including ovens, rockers, cylinder pistons, lathes and planers, there was also a room of the models of foundry that hosted also the school of drawing and decoration. At the end of 1850 the furnaces complex was enlarged and equipped with new steam machinery and hydraulic lifts for the movement of charges from the veins and the coal to the embouchements. Subsequently, "*between 1907 and 1910 the furnaces were smashed and today the great space covered by roof trusses and metal sheet retains few traces of the former rich industrial production*[9]", whose restoration has opted for the conversion of this space into a convention centre and a theatre.

[7] Turcheschi F. Le Fonderie di Follonica. In Preite, M. (Ed). *Paesaggi Industriali del Novecento. Siderurgia e miniere nella Maremma toscana.* Florence: Edizioni Polistampa, 2006, pp 71-74.

[8] Ibidem, p.72.

[9] Ibidem, p.73.

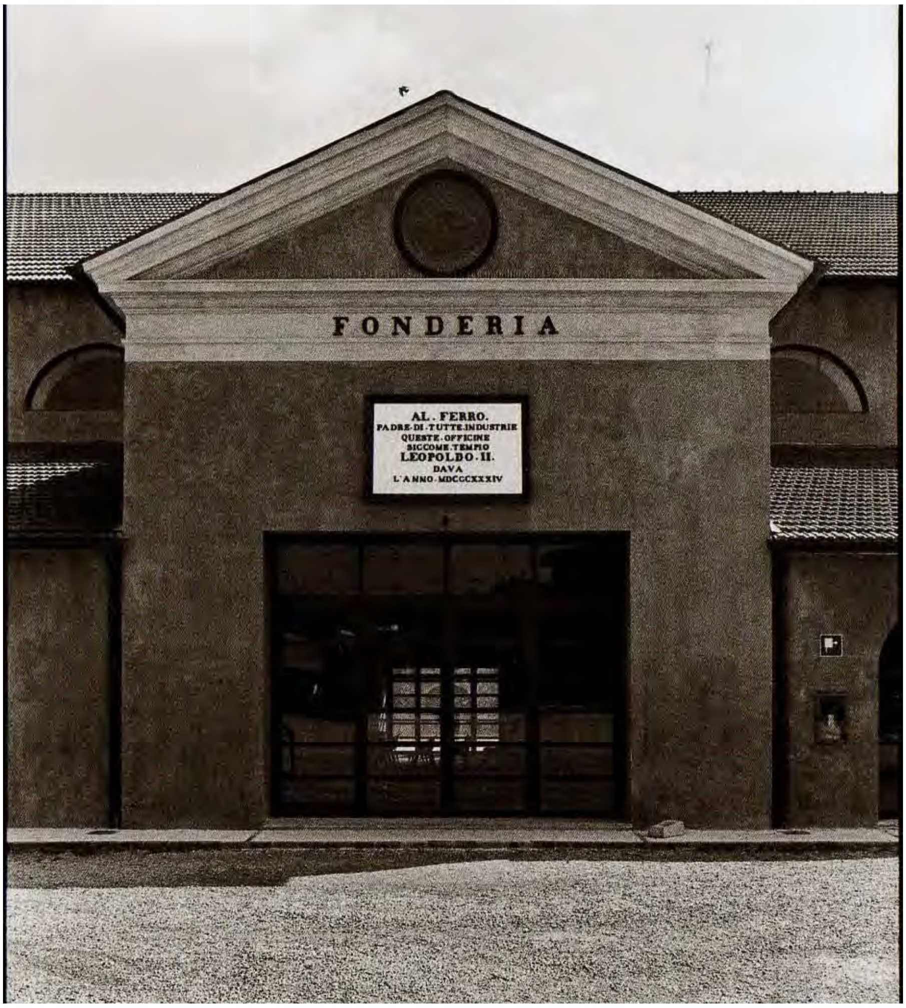



Fig. 3. n.2 Grand Duke Foundry's main façade. Source: Preite, M. Paesaggi industriali del Novecento, 2006.

The project for the redevelopment of the *Leopolda* has been conceived by Vittorio Gregotti and completed in 2014. The sequential scheduled and programmed interventions were: the realization of a new plant of the air-conditioning system for the multi-purpose halls, through the installation of the technical rooms into the former *Magazzino delle Terre*[10]; the realization of the movables and fixed grenades, letting the use of half of the building as exhibition spaces and the other as the hall for projections; the total recovery of the entrance hall has seen the introduction of the new food & beverage area and the toilets for the public as well as the realization of accessory spaces outside the main building; the roofing of the building were completely insulated with new insulating layers to improve thermal performance; outside the blocks of ancillary services were housed in a new building of three floors above the ground, that contains the dressing rooms, bathrooms and classrooms test [11].

[10] Preite, M. (Ed.). *Masterplan. La valorizzazione del paesaggio minerario*. Florence: Tipografia editrice Polistampa, 2009, p. 131.

[11] Ibidem, pp. 131 – 132.

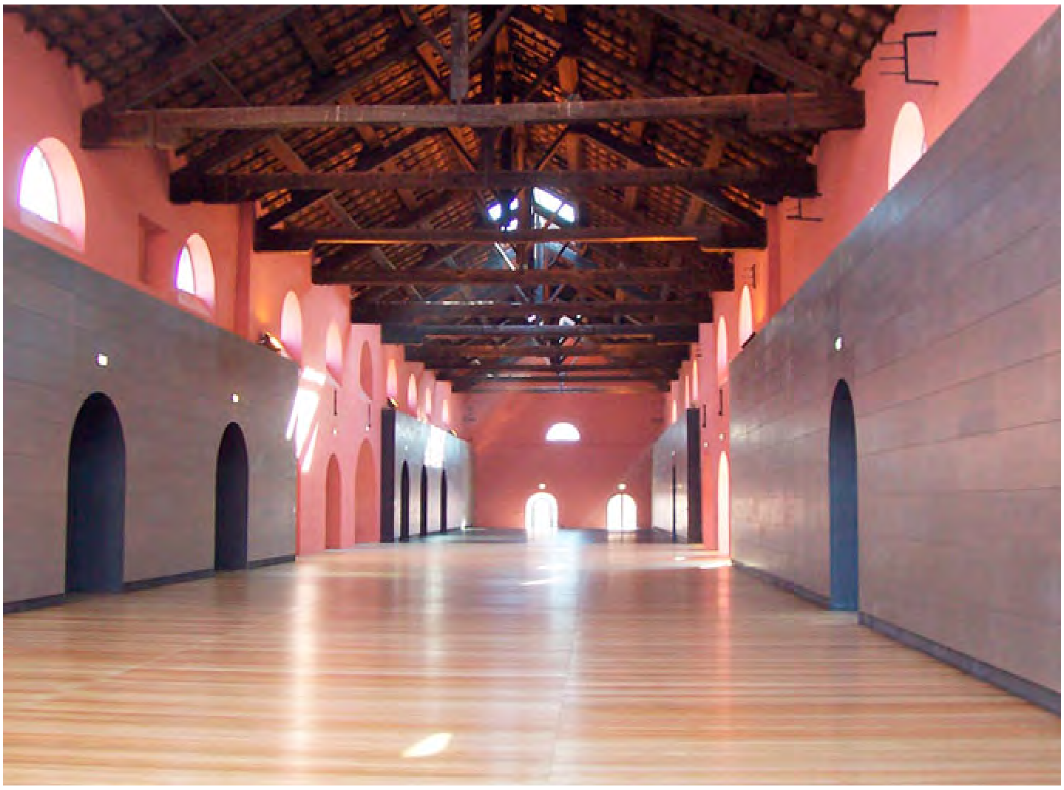


Figure 4. Inner sight of the Leopolda after the restoration. Source: Italstrutture.

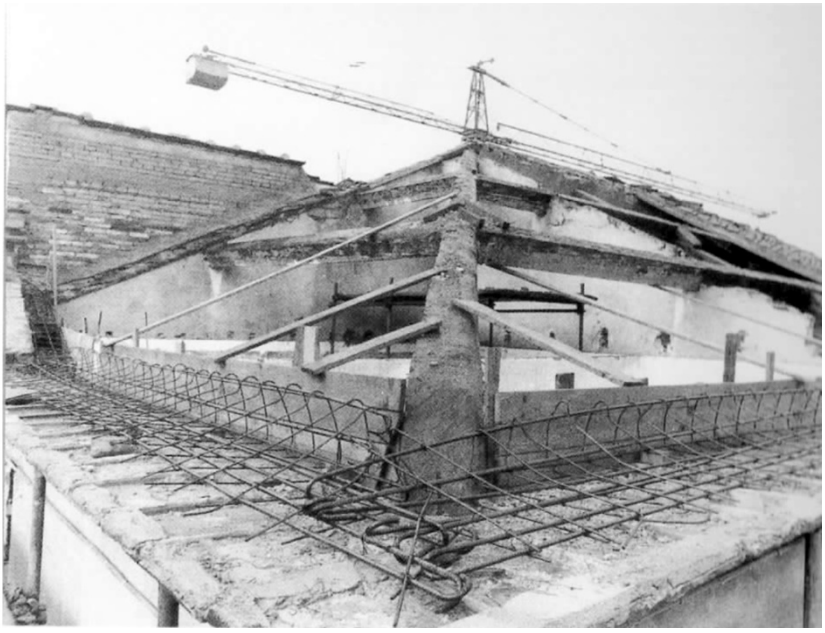
*Recovery of San Ferdinando Furnace*

The Furnace, called *San Ferdinando* in 1835, represents the most ancient core of Follonica's ex Ilva, temporary collocated between 1546 and 1618 related to the first buildings. It was rebuilt after the Seventeenth century demolition and throughout the 1600s and 1700s it suffered some adjustments and expansions, although the main innovations were introduced during the Nineteenth century.
The ironworks was in fact dismantled between 1805 and 1806 for being converted into a melting furnace on Boury's plan[12], but only three years after it was definitively demolished and rebuilt as its dry-stoned walls couldn't ride out the temperatures reached during the fusion. The 1817 – 1818 edification appraises the new rounded shape with significant dimensions (8 m high and 2 m wide in correspondence of furnace embouchement) and the powering through floating-wind turbine machines. Once obsolete, it was abandoned in 1888 for being definitively dismantled between the 1907 and the 1910. The furnace cellar was exploited as supply rooms for samples and sanitary facilities for workers, while the top floor was converted into craftsman accommodation, but in the '50s it versed in a very poor condition.
However, we must wait up to 1984 to assist to the first effective attempts of recovery; the original furnace structure was greatly arched and double volume, but the various modifications, together with the slabs and charges addition, subtractions of supporting arches and the engraving of the

[12] Franchina, L. *Follonica - Ex Ilva. Il recupero del Forno San Ferdinando*. S.l.: s.n., 1998, p. 5.

furnace embouchement, made its statics seriously compromised, with a consequent severe out of plumb[13].

From 1981 to 1986 the covers and the parties to consolidate were carefully restored: for the roofs it was necessary to bind the supporting base of the wooden roof warping by curbs in reinforced concrete and metal chains of connection to the beams themselves; some embedded flats in concrete are anchored to the wooden beam by means of screws, ensuring the transmission of transverse thrust to the load-bearing masonry; the latter was made homogeneous and collaborating through specially modelled curbs; to counteract the tires thrust tie rods of round iron are inserted at the level of the last floor and at the level of the eaves, which are mutually connected by means of plates in such a way as to cancel the bulging of masonry walls toward the outside; the wooden floors have been restored and reinforced to adapt to new operating loads by 6 inches wide ribs in reinforced concrete and equal to the overall height of the floor, placed in the upper part of the wooden beams; hidden works have been completed in order to absorb the strains of compression of the composite beam while the traction is absorbed by the wooden beam; the mixed beam was performed by the connectors in round iron anchored to the beams through resins and embedded in the concrete[14].



[13] Ibidem, pp. 7 – 9.

[14] Giorgi, M. Opere di consolidamento e di restauro. In Franchina, L. *Follonica - Ex Ilva. Il recupero del Forno San Ferdinando*. S.l.: s.n., 1998, p. 9.

Figure 5. Reinforcement and restoratiing interventions of the oofs. Source: Franchina, L., 1998.

In 1989, after an unsuccessful attempt to start the archaeological excavations with an English expert of industrial archaeology, excavations started to bring back to light the vestiges of San Ferdinando furnace, which represent an important piece of ex Ilva's industrial heritage, albeit with times and procedures slowed down[15].

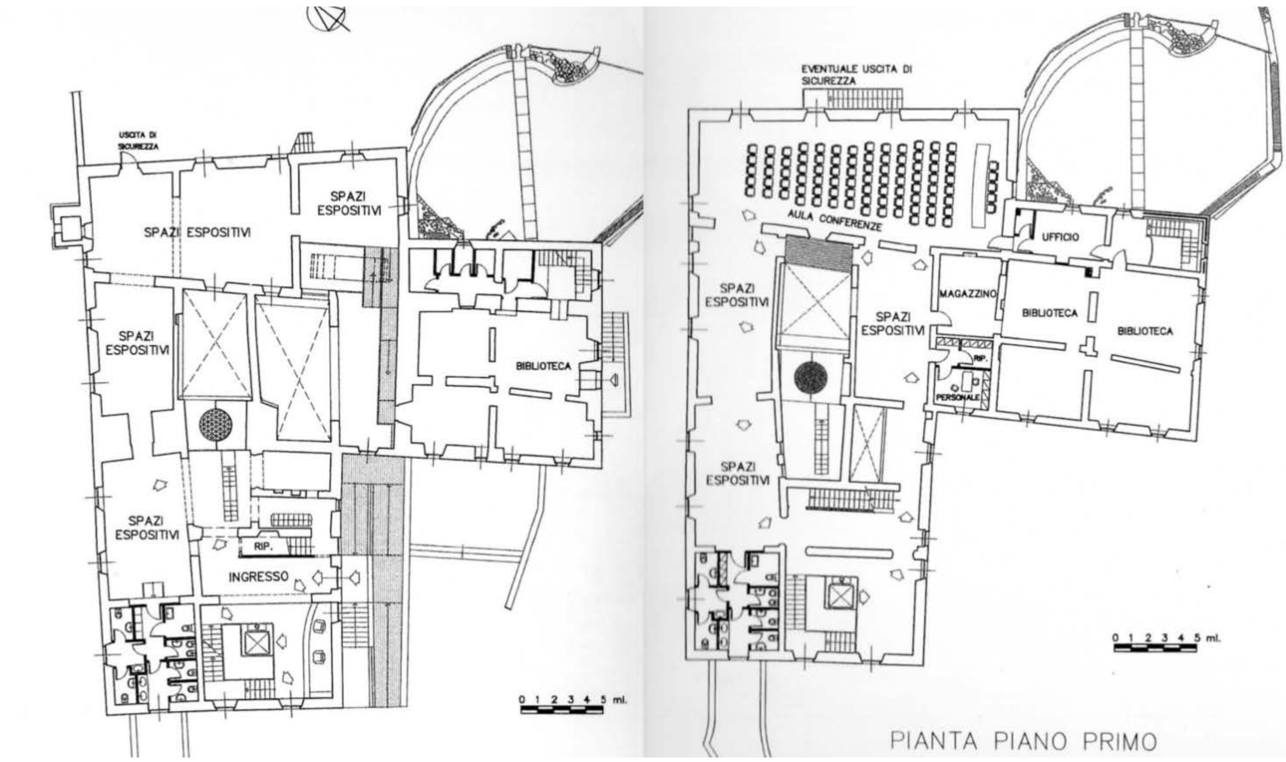



Image 6. Planimetries of the projects for the furnace recovery.

Source: Franchina, *Il Recupero del Forno S. Ferdinando*, 1998.

[15] Franchina, L *Follonica - Ex Ilva. Il recupero del Forno San Ferdinando*. S.I.: s.n., 1998, p. 7.

*MAGMA: the Museum of Cast Iron Arts of Maremma.*

The restructuring and enlargement of the "Museum of iron and cast iron" inside the *San Ferdinando* furnace foresee the realization of the old part of the building as an archive and consultation rooms[16]. The ancient carbonyl, back to its original size with the elimination of the floor built at the beginning of the Twentieth century for the dwellings, will host the distribution node while the underground part remains as ruin and accessing path to the furnace and the blower. A greater part of the machines will be rebuilt and it will be proposed during the exhibition itinerary with the renewal of hydraulic systems for loading the ovens.[17].

Image 7. Follonica. Magma Museum from the outside.  Source: Magma Museum.

Image 8. Follonica, MAGMA Museum, interior. Cast iron hall. Source: Magma Museum

[16] Ibidem, p.128.

[17] Ibidem,  p. 128.

## The recovering and enhancing interventions of Ravi Marchi

The first step that has affected the Ravi Marchi area for the recovery of the structures is the consignment from the survey of the area and of the elements falling within it by the scope of identifying the roles and the physiognomies in respect of the entire productive cycle of the mine.

In this phase it was thus found a silo built in masonry belonging to a broader complex, identified as the old Ravi Marchi washery, with a surface of about 18 m x 18 m and descending toward the street with a jump of altitude of about 12 m. The building had however a hardly recognizable configuration because after the dismantling of the floors, installations and covers were invaded by the inert material and vegetation. The predominant absence of the structural part has caused the progressive decline of the wall hangings and of the plasters and the opening of the slits and injuries, which affect seriously the static behaviour[18].

The first attempt of recovering the structure has removed the invading vegetation in order to free the most compromised masonries: these were cleaned, plastered and reconstructed in the missing portions by means of carrying on a sew-unstitch work; for an additional protection a layer of cocciopesto – *Opus signinum*, a waterproofing material dating back to the Roman construction and made of small pieces of tiles, mixed with mortar, and beaten down with a rammer – has been added in the terminal parts to avoid the stagnation of the water[19].

In addition to the old washery, the premises of the carpentry, the brick-vaulted tanks, the open-air tanks and the remains of the hydraulic systems as the drainage channels and similar were recognized.

The accessory parts – such as the lime kiln, whose foundations have collapsed causing the instability of the cup in granite in which they prepared the lime – suffered the same fate as the old washery: the recovery project has affected the walls collapsed, the renovation of the roof and the cleaning and consolidation of stoned strata.[20]. The static instability and the structural problems were also present in the tanks and in the stairs of connection with the high level, invaded by the vegetation and flopped in numerous points, in addition to the buried *dorr* (i.e. the tanks with a circular plan that collected the processing sludge) and in the new washery, that has a strong lead out due to lack of counterbracing structures[21]. The crane room was compromised by slits and lesions in structural parts and buffering. Finally, the absence of a proper system for water management has contributed to make ever more urgent action of safeguarding for this mining heritage, put even more at risk from its position within the watershed of a river basin[22].

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[18] Fantini, D. La miniera di Ravi Marchi. In Preite, M. (Ed.). *Paesaggi industriali del Novecento. Siderurgia e miniere nella Maremma toscana*. Florence: Edizioni Polistampa, 2006, p. 170.

[19] Ibidem, p. 172.

[20] Ibidem, p. 174.

[21] Ibidem, p. 171.

[22] Ibidem, p. 171.

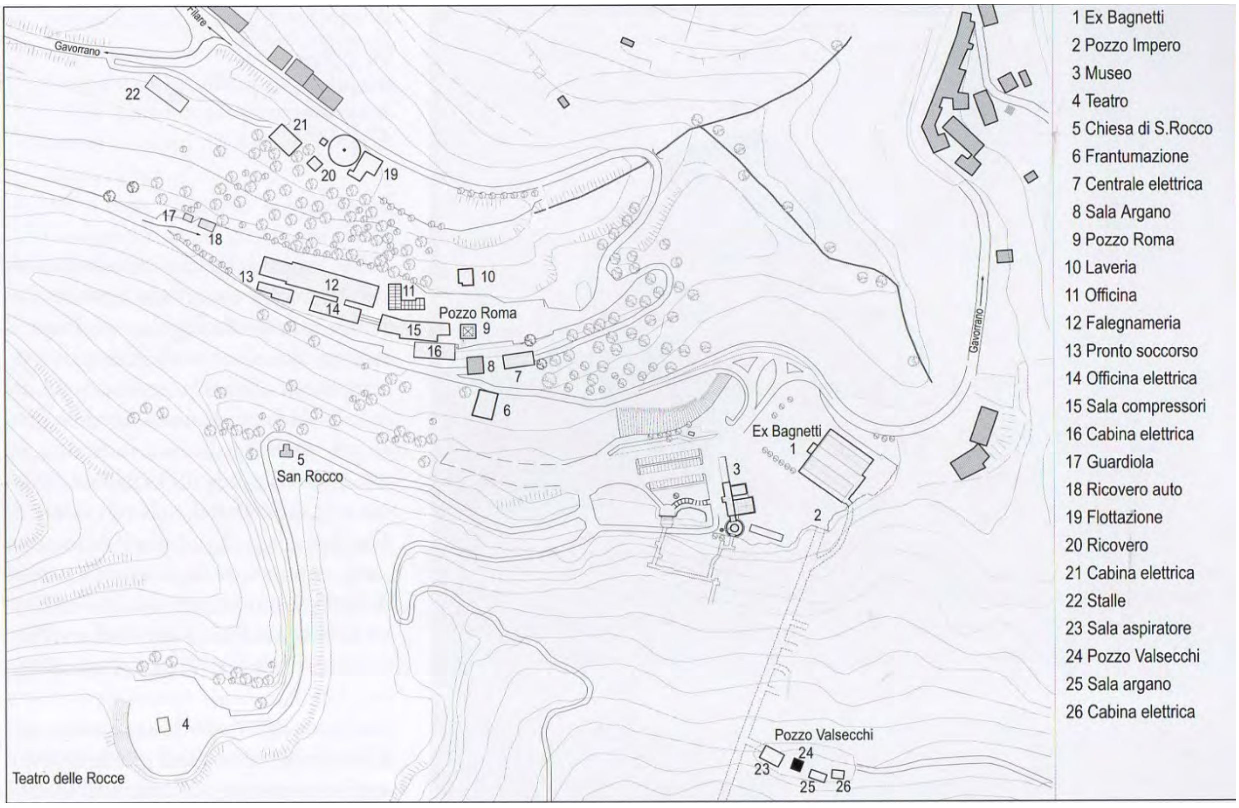


Figure 9. Gavorrano mine plan Source: Preite, *Paesaggi industriali del Novecento*, 2006.

*The new washery*

The new washery has been equipped with a water regulation system to restore the old washing process of materials and with a path of gangways and ramps for visiting all the washery levels up to the highest part, retracing thus the procedure followed by the minerals when the washery was running.

A complex system of ramps connects through a tunnel the great portal to the stair-tower that allows access to the penultimate level, which opens on the surrounding landscape and the entire mining complex. A further ramp leads to the intermediate level of the washery and Vignaccio shaft crane hall, until reaching the opening to the shaft ramp. The latter is left free from obstructions and high vegetation in order to not obstruct the view on Monte Calvo.

The room of the crane was used as a staging point and protected by a skylight in iron and glass; from this level it continues toward the new shaft through an old concrete staircase put in safety up to the base of the castle, where a copper canopy protects the visitors and at the same time recalls the rusted structures, now removed. The old railway tracks of the carriages visually lead toward the room of the hoppers and the conveyor belt, whose path leads back to the inlet opening ramp where the old railway transport of the minerals laid open[23].

The vertical connections are ensured by steeled flat elements which support the floors and the steps by a regular grid of parallel bars made of steel that reflect those of the safety fences. These elements were painted with beige epoxy enamels to approach and to merge the more possible

[23] Carmassi, G., Carmassi, M. A Musealizzazione di Pozzo Vignaccio, Pozzo Ravi e della nuova laveria (lotto 1). In Preite, M. (Ed.). *Masterplan. La valorizzazione del paesaggio minerario*. Florence: Tipografia editrice Polistampa, 2009, p. 146.

with wall changing and with the rocks, creating a geometrical pattern that overlaps the random and incongruous masonry and of the existing orography. This coloration was also chosen for some slabs which make up the paths between the structures made with specially coloured reinforced concrete[24] [25].

The structures in stone and masonry were consolidated and integrated into the more compromised parts with inserts made of reinforced concrete, designed in such a way as to be the less invasive possible, while the diggings conduit to liberate and consolidate the partially buried structures have offered the possibility to realize an over 12 meters high steel cor-ten containment structure that follows the original trend of the new washery coverings [26].

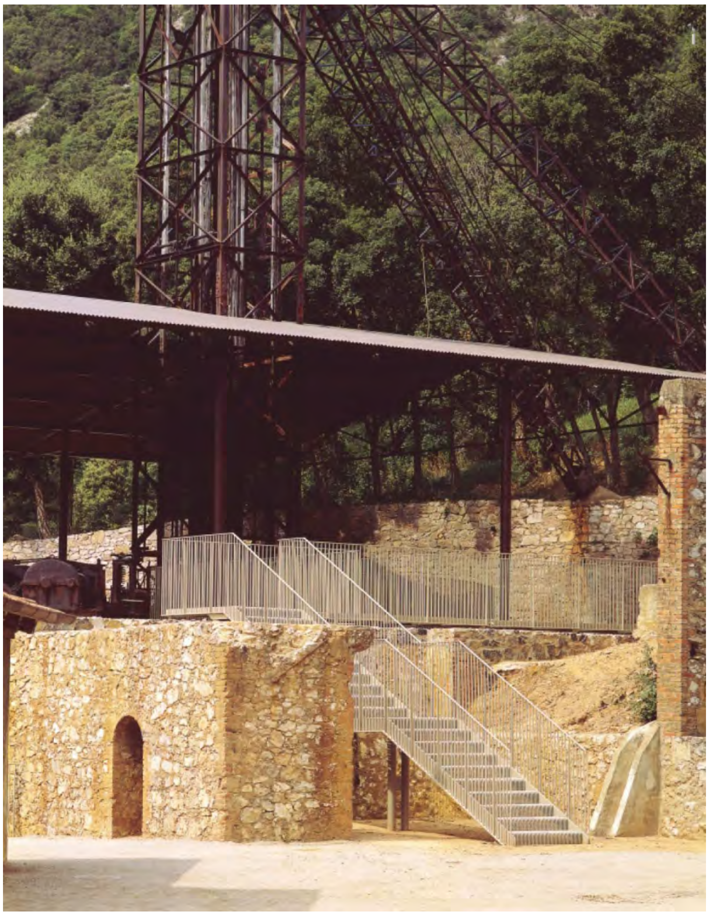

Figure 10. The path and the metal mounting overlying Ravi shaft.

Source: Pieri, E. Costruire in Laterizio 99, 2004.

[24] Ibidem, p. 146.

[25] Pieri, E. Recupero del Parco Archeominerario a Ravi di Gavorrano (GR) 1999 – 2001. *Costruire in Laterizio* n. 99 (XVII), pp. 16 – 21.

[26] Fantini, D. La miniera di Ravi Marchi. In Preite, M. (Ed.). *Paesaggi industriali del Novecento. Siderurgia e miniere nella Maremma toscana*. Florence: Edizioni Polistampa, 2006, p. 172.

*The Dorr*

For what attains the models of interventions in the higher part of the mining site, the *Camassi* architecture firm involved in the projects have focused mainly on the great *Dorr*, bringing it back to its authentic function as water tank. In fact, once overcome the access zone, channelled around the ramp where the public services and conference rooms are, we arrive to the lime furnaces and to the floating tank decanters: beyond them, the great round *Dorr* was filled up again with water and bounded by a ring at the perimeter on which a suspended iron walkway and a larch cube – containing the illustrative panels and the useful information for visiting the mine – fly over. This wooden casing is imposed on the *Dorr* as a nestled stilt inside the water tank, like a cubicle which overlooks the surrounding valley through a narrow slit.[27].
The mining castles were recovered, put in safety in tottering parts and painted with special colours for preserving the existing oxidation layer; the canopies in asbestos were replaced and anchored to the profiles through iron on metal trusses, maintaining the original aspect of the covers.

Figure 10. A view of the Dorr. Source: Pieri, E. Costruire in Laterizio 99, 2004.

[27] Pieri, E. Recupero del Parco Archeominerario a Ravi di Gavorrano (GR) 1999 – 2001. *Costruire in Laterizio* n. 99 (XVII), 2004, pp. 16 – 21.

Figure 11. The route of water gauges and water pool which surrounds the new *Dorr*.

Source: Pieri, E. Costruire in Laterizio 99, 2004.

*Parco delle Rocce - Museum of the Mining Heritage*

The visitors' path runs along the museum gallery, leading directly from a reinforced concrete conic volume covered in zinc-titanium, enlightened inwards by a skylight: inside a series of illustrative panels and a scale model explain the past history and the possible future of the mine. From here starts the path inside the old powder keg or *riservetta* (the ancient storage of the ammunitions), in which an outlet, identifiable by the lowered arch engaged in a stonework masonry, has been opened. The visitor is conducted through the gallery in various rooms, dedicated to individual aspects of the mining life, reconstructed through dioramas and accompanied by sound, video and lights that contribute to recreate the sensations and the aspects of the miners' life[28], including the *lampisteria* (in the past, warehouse for the custody and maintenance of the lamps) and the descending cage similar to that of Impero Shaft. The former *riservetta*, i.e. the gallery opened to visitors, exhibits a three elbows pattern with a niche designed originally for the venting of gas in case of explosion and is equipped with a stove and ventilation paths dedicated to the carriages for the transport of explosives near the tunnel of Impero Shaft.[29]

Once the visit is over, two buildings connected by a loggia allow to return to the entrance area, declared by the central canopy and the frame that access the reception centre and offices, and the wooden pergola that returns from the forecourt exit[30].

[28] Pedrolli, A. Parco delle Rocce - Museo Minerario. In Preite, M. (Ed.). *Masterplan. La valorizzazione del paesaggio minerario*. Florence: Tipografia editrice Polistampa, 2009, p. 137.

[29] Ibidem, p. 136.

[30] Ibidem, pp. 134 – 135.

*Parco delle Rocce – Open air theatre*

The *Cava delle Rocce*, i.e. the quarry source of filling material for the underlying galleries, was converted into a theatre: the semicircular shape of the site was in fact naturally modelled to accommodate a stage and a forum for events. Starting from the material survey, which highlighted the massive calcareous nature and the clayish and more unstable one of the strata, they opted for the removal of the softest parts to ensure that the calcareous front would house and sustain the theatre, thus incorporated inside the quarry. The tiers are made with the stone used for the safety works, while the theatrical scenes are naturally offered by the panorama on Gavorrano.[31]. The accessorial structures of the theatre, as wardrobe, baths and warehouses have been created in a block in reinforced concrete below the tiers of seats and the connection with the back side of the stage was ensured by a gallery that acts as a corridor for the artists. The stage was made on a metallic volume clad in wood, fitted with wheels for moving on rails embedded in the level audience and thus responding to the needs of spaces for the public. The inlet and outlet are marked by cor-ten elements constituted respectively by a 120 meters long wall and a height of between 0 and 4 meters, acting as a guide for the spectators toward the audience and at the same time which contains the rocky wall overlying, and from a stair of 30 meters rising on a rock which leads to the exit of the theatre.[32].

Figure 12a. A nocturnal view of the Theatre.
Source: http://www.comune.gavorrano.gr.it e www.teatrodellerocce.it

[31] Fantini, D., Focacci, G. Parco delle Rocce – Teatro all'aperto. In Preite, M. (Ed.). *Masterplan. La valorizzazione del paesaggio minerario*. Florence: Tipografia editrice Polistampa, 2009, p. 139.

[32] Ibidem, p. 139.

Figure 12b. A nocturnal views of the gallery of the Theatre. Source: http://www.comune.gavorrano.gr.it e www.teatrodellerocce.it

*The Park's Gate*

The construction of the Park's Gate was completed in 2013 resulting with the recovery of the *ex Bagnetti*, which were built by Montecatini group in 1962 in Impero Shaft Square as dressing rooms and bathrooms for the workers. The rectangular plant consists of two floors and a central double-heighted gallery, cheaply and soberly wrapped, identifiable in the plaster-pinched frames which contour the openings and in the metallic windows typical of the coeval industrial buildings. The inclined pitched frames that compose the structural part of the building were left to view in both the main fronts, stressing the presence of large glazed surfaces and ribbon windows arranged immediately below the gutter level for the entire building length.
The choice to allot this building as a gate of the Park and reception centre is primarily solicited by the central position inside the "System Ravi" that allows to introduce the visitors in the first moment of discovery and reading of the quarry site: through the presentation of thematic areas ranging from geology and from georesources to the Montecatini productive report with historical materials, oral testimonies of miners and illustrations that explain the evolution of mining landscape of Gavorrano. This place is then become the fulcrum of cultural activities and promotion of National Technological and Archaeological Park of the Metalliferous Hills of Grosseto, as well as its own headquarters and relative Directional Centre.[33]

[33] Maremma Local Action Group, Comune di Gavorrano (Eds.). *Museo del Parco Minerario delle Colline Metallifere*, pp. 6 – 7.

Figure 13. Historic view of ex Bagnetti edifice, to date Park's Gate. Source: Region of Tuscany GAL FAR Maremma.

The works of rehabilitation, directed by Gabriella Maciocco and Leonardo Brogioni[34], let almost 1150 m$^2$ on two levels devoted to visitors and conference centre to spread out.
The Central Gallery is set up on the ground floor, by enclosing the inner court with glassed and metallic barrel vault, hosting the informative panels dedicated to the Metalliferous Hills Park, the Info Point, the touristic and administrative offices, the media library and an area related to the typical food exhibition.
On the first floor, lean out on the gallery thanks to a continuous platform, is detached the conference centre, with the conference hall realized in the former locker rooms, fitted to all *Parco delle Rocce* activities[35].
In the square in front of the new entrance canopy, which has replaced the original one composed of two in reinforced concrete T-shaped frames arranged side by side in parallel, a contemporary work of art dedicated to Gavorrano mines was installed.

[34] Maciocco, G. Recupero dell'edificio Bagnetti per la realizzazione della Porta del Parco. In Preite, M. (Ed.). *Masterplan. La valorizzazione del paesaggio minerario*. Florence: Tipografia editrice Polistampa, 2009, p. 141.
[35] Ibidem, p. 141.

Figure 14. Roofed gallery and new entrance after the restoration.

Source: Toscany Region GAL FAR Maremma.

*Recovery of decantation tanks*

The recovery project also completed the reinstatement of the old hydraulic system related to the water-cycle, which directly links the visitors to the settling tank and to the *Dorr*: a recycle plant with new passageways systems let the rainwater to channel from the building roofs and from the external areas and to convey in the restored tanks, finally arriving by gravity to the tanks of the inlet zone. Here the ticket office is placed in a cylindrical volume which welcomes the visitors with an entirely cor-ten covered structure, which recalls the ferruginous colour of the mining structures[36]. The coverage of the ticket office is formed with an inclined wall in zinc-titanium. A concrete wall, illuminated by an all-light neon, creates a sort of guide and path between the high and the low square, accompanying the visitors in the output path after the visit to the open air structures.

[36] Fantini, D., Saragosa, C. La musealizzazione dell'antica laveria, delle vasche di decantazione e dell'ex fornace di calce (2° lotto). In Preite, M. (Ed.). *Masterplan. La valorizzazione del paesaggio minerario*. Florence: Tipografia editrice Polistampa, 2009, p. 147

## Niccioleta mine and the plants for the mining treatment.

Until 1962 the Niccioleta plant was divided into two sections: the first, that of comminution, treated highly sulphated minerals, while the second enriched the poorly minerals to make them suitable for the production of sulphuric acid in Scarlino's factory. The sector of high-grade ores crushing contained a series of mortars and wet screeners for the progressive reduction of the sections. In the second compartment was employed a battery of sieves in water, separating the useful mineral from the sterile, and a final system of flotation which recovered fine particles of pyrite through the dewatering of waste[37]. This enrichment plant was decommissioned after 1963 when the Society used the new Scarlino plant for the production of sulphuric acid, of iron pellets and pyrite, but keeping active to crushing.


Figure 15. The plant of the sulphuric acid of Casone (Scarlino). Source: Preite, *Paesaggi industriali del Novecento*, 2006.

[37] Ibid, p. 202.

## Recovery works of Niccioleta mine

*Recovery of former warehouses and infirmary*

The restoration project of the former stores and infirmary – a linear complex characterized by volumes at different heights and extension – started from an indispensable phase of remediation and commissioning of the buildings security. The poor condition required immediate remediating actions on the walls and on the infrastructure facilities, already obsolete and unrecoverable. The constructive features of this edifice represent a synthetic building technology, which includes pitched roofs, a large glazed surface, grit floors, embossed corners and wooden trusses. The degradation, observed when the works started, was attributable to poor sun exposure, to the vegetal invasion and to the structural and material deterioration, which have been solved through new timber roofing and slabs, synthetic drainage, demolition and rebuild of the compromised horizontal strata, new floors and plasters and the replace of the former windows and old plants by new ones in order to improve the thermal behaviour[38]. Once completed the restoration, the former infirmary and warehouses have been converted into Centre of Documentation and Archives of mines that contain all the documentation on the metalliferous hills.

The old weight has been converted into a technical room at the service of the new complex.

[38] Martinozzi, S. Recupero degli ex-magazzini per la realizzazione di un Archivio e centro di documentazione. In Preite, M. (Ed.). *Masterplan. La valorizzazione del paesaggio minerario*. Florence: Tipografia editrice Polistampa, 2009, p. 150.


Figure 16. The main service buildings (numbers refer to the general plan).

Source: Preite, *Paesaggi industriali del Novecento*, 2006.

Figure 17. The archives before the restoration. Source: www.massacomune.it e www.ilgiunco.net

Figure 18. The archives after the restoration. Source: www.massacomune.it e www.ilgiunco.net

*Restoration of the former mining manager's house*

The former Directorate house was built in the 1950s and it features a three storey structure in traditional masonry, concrete and iron-concrete floors. The restoration of this building relating to structural problems has rehabilitated the masonry and the plasters, the moisture remediation and restoration of the roofs. The internal layout has been studied to realize a hostel–guest house for visitors of the Documentation Centre with an exhibition space and a cultural centre that will be structured on three levels: the laundry and storage in the basement; reception and services for the guests on the ground floor; the first floor contains the conference room, the collective and study rooms[39].

[39] Martinozzi, S. Recupero della palazzina della ex direzione della miniera per la realizzazione di un ostello. In Preite, M. (Ed). *Masterplan. La valorizzazione del paesaggio minerario*. Florence: Tipografia editrice Polistampa, 2009, p. 150.

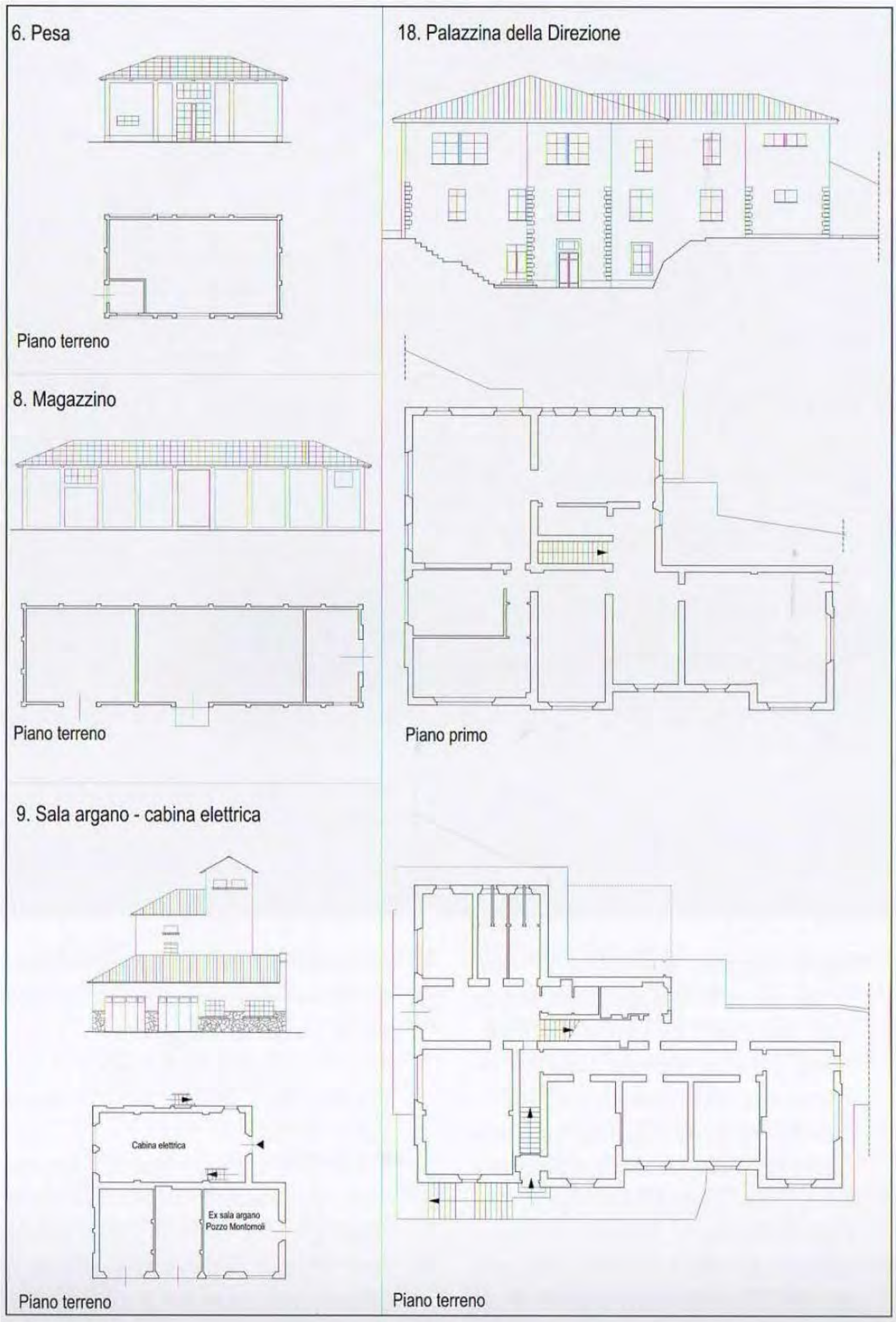


Figure 19. The main service buildings and the Directorate (numbers refer to the general plan). Source: Preite, *Paesaggi industriali del Novecento*, 2006.

### The recovery of Almadén's mining heritage

In 2003 – after the closure of the *El Entredicho,* Las Cuevas and Almadén mines and its intense metallurgical production – coinciding with the European political and environmental measures culminating in a ban on mercury sales due to its highly polluting properties, the majority of mining activities related to the extraction and processing of mercury ceased.

The recovery and renewal program of the Almadén Mines therefore implied complex socio-economic, environmental and safety relations for the activation of projects, under the protection and guidance of the central and regional government. In the end the actuated measures were[40]:

a) For the safety and the environment:
   - guarantee of quality of surface and underground waters for waste drainage.
   - Stability of long-term waste and erosion of the structures that remain on site.
   - Restoring the landscape.
   - Maintaining health and safety conditions (closure of the excavations access, monitoring of environmental conditions in Almadén neighbourhood).
   - Environmental remediation to enable the development of recreational and tourist activities.

b) In socio-economic field:
   - Modernization, expansion and diversification of existing economic activities.
   - Improvement of infrastructure in the area.
   - Improving professional training for work in the installation of alternative industrial activities.
   - Implementation of the Consensus Platforms enabling social acceptance of changes promoted.

The creation of the Mining Park of Almadén with the rehabilitation and adaptation of all its mining and industrial heritage for cultural purposes, hitherto ignored by the mining companies, is one of the key – actuations carried out within this development program, supported and motivated to and from the companies after the closure of those which had been considered until then the main livelihood sources[41].

[40] Ibidem, p. 224.
[41] Ibidem, p. 225.

## Almadén Mining Park

The recovery of the Almadén mine for its conversion to a Mining Park has been a great opportunity to integrate the assets of the mining complex goods with an innovative and totally renewed space. The total cost of the project was 12 million euro, to which were added € 20 million when considering the burden on the environmental recovery[42]. The opening at the end of the works of the Park was held on January 16th, 2008 in the presence of the President of Castilla - La Mancha José María Barreda Fontes and the Minister of Industry Tourism and Trade Joan Clos Mateu.

The main considerations underlying the project of the Park were:

- The installations of the mine were well preserved and they did not suffer any decay, neglect or vandalism and they still preserve elements of great historical value.
- The geological value is worldwide unquestioned.
- In the historical development of Spain and Latin America the Almadén mines have played a key role in forming for a long time the only source of wealth for the Almadén population.
- Being one of the few mines whose exploitation has lasted for over a thousand years, it was a test of advanced technologies produced in the metallurgical and mining field, making it therefore a technological platform for exchange in the world, not only with the American Viceroyalty but also with European countries.
- The Almadén mines integrate a complex asset connected with the local population and its production and housing facilities, forming a social cultural important framework[43].

The Almadén mining complex is composed by different spaces in which have developed several activities that have concurred to mercury extraction and processing of mercury and by which important historical passages might be crucial.

The areas of greatest interest in respect of the rehabilitation project were:

1. The underground area of the Almadén mine composed of the following assets[44 45]:

- the underground mine of the *Castillo* Mine and the *del Pozo* Mine;

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[42] Ilustre Colegio Oficial de Geólogos, *Tierra y tecnología – Revista de Información Geológica*, n. 29 (1° semestre), 2006, p.3.

[43] Mansilla Plaza, L., *Metodología para la valorización del patrimonio minero industrial de Castilla - La Mancha* Doctoral Thesis, Montes Tubio, F. P., Almarcha Núñez – Herrador, M. E., University of Cordoba. Cordoba: University of Cordoba Publishing Services, 2013, p. 236.

[44] Mansilla Plaza, L. El Parque Minero de Almadén. *Her&mus*. P*atrimonio cultural en Castilla – La Mancha: entre la diversidad y la innovación*,volume III, n. 1, January – February 2011, pp. 19 - 20.

[45] Mansilla Plaza, L., *Metodología para la valorización del patrimonio minero industrial de Castilla - La Mancha* Doctoral Thesis, Montes Tubio, F. P., Almarcha Núñez – Herrador, M. E. University of Cordoba. Cordoba: Editing Services of Cordoba University, 2013, pp. 236 - 239.

- the Gallery of the Convicted to hard labours and the internal galleries;
- the *Baritel* (capstan) of *San Andrés*.

In these areas galleries dating from the period between the Sixteenth and Twentieth centuries have been adapted to show off visitors the different mine exploitation systems as well as various galleries used as emergency exits. The *Pozo San Teodoro* machinery, dating back to the Twentieth century, and the duct of wooden transport of *Pozo San Aquilino*, dating from the Nineteenth century, have been restored and adapted for the descent of the visitors inside the mine. On the other hand, the musealization checked under a faithful and historic rigor has allowed the reproduction of machinery such as the crane in *Pozo San Andrés* and the homonymous winch, the Eighteenth century pumping systems, the deposits of tools dating to the Nineteenth century etc. thanks to the copious documentation existing in the *Almadén and Arraynes* Mines archives.

2. The mining enclosures (*cercos)*[46]:

In the project of restoring and external use of the two *San Teodoro* and *Buitrones* enclosures, which covered an important role for their dissemination and preservation, a greater number of elements belonging to the mining heritage has been recovered, some of which have been deemed to the most disparate use such as:

- The compressor room, become the Mining Interpretation Centre.
- The stock of mercury which houses the Museum of the Mercury.
- The building of the Mining Company General Management, which now performs the dual function of an administrative centre, and reception of visitors.
- The mine Directorate, now dedicated to illustrating in what manner the mine was managed through its offices, by coeval furnishings and equipment.
- The ancient forge, carpentry, machineries rooms, workshops etc. show the tools and the equipment with which they worked and exploited the mercury until the closure of the mine.
- The mining pits of *San Aquilino*, *San Joaquin* and *San Teodoro*.
- The room of the machine in *Pozo San Aquilino*.
- *Carlos IV Door* dating back to the Eighteenth century which allowed the access to the *Cerco de Buitrones*.
- The *Puerta de Carros* of the Eighteenth century, useful for the entrance and the exit of the mule carriages carrying mercury from Almadén to Seville.
- The mine protection fences with a 3 km long and 4 metres high upper boundary.

[46] Ibidem, p. 239.

- The *de aludeles* or *Bustamante* ovens of the Seventeenth century, still exist for their unique characteristics, which were transported from the mine of Huancavelica in Peru to Almadén.
- The chimney of the *Cermak - Spirek* ovens of 1906, from Central Europe.
- The Pacific – *Herresof* ovens, dating back to 1954, the last to operate in the field of metallurgy of mercury at Almadén.
- The Nineteenth century pottery kilns for brick-making for mine exploitation.
- Urban works within the mining installations for paths and guided tours.

A key aspect of this Mining Park about security is related to the adjustment to the accessibility standards required the construction or rehabilitation, as appropriate, three emergency exits inside the mine, the elevator added, and a signalling system led to the indication of the outputs. It has also installed a fire alarm and fire doors with smoke detectors in all places where there are electrical boxes or wooden parts. Despite being sufficient natural ventilation, a fan in case of emergency to feed the tunnels has been installed[47].

The Park management is carried out by MAYASA mining company, through the Almadén Francisco Javier de Villegas Foundation and a management plan whose performances are summarize in four basic points[48]:

- *Preservation of real estates.* Retrieved on 100% of the works defined in the Master Plan, we have established programs of maintenance work on assets recovered and the study of the rest of the goods that form the complex of the goods of interest in the Almadén mines.
- *Preservation of documentary heritage* It carries through two complementary lines:
    - The Archive reorganization of Almadén Mines, whose funds are grouped into: Old Fund; MAYASA of the Board of Directors; Cartographic Collection.
    - Compilation and research of funds deposited in other archives.
- *Environmental sustainability.* Essential to ensure the preservation of good health and safety of visitors and employees, as well as for environmental monitoring of the remains of mining.
- *Visitors Management.* Inherent to everything related to the program of visits and activities complementary to the Mining Park.

Among the interventions mentioned above we describe in particular the following:

[47] Ibidem, p. 23.

[48] Mansilla Plaza, L. *Metodología para la valorización del patrimonio minero industrial de Castilla - La Mancha* . Doctoral Thesis, Montes Tubio, F. P., Almarcha Núñez – Herrador, M. E. University of Cordoba. Cordoba: Editing Services of Cordoba University, 2013, pp. 244 – 245.

### 1. *Miners' Royal Hospital*[49 50 51]

This is the current headquarters of the *Almadén - Francisco Javier de Villegas* Foundation and it contains the Historical Mining Archive and the Mining Museum. It was the first building restored within the mining architectural complex.

The Royal Hospital is a remarkable impressive building outside of the mining district and it was founded in 1752 by the Superintendent Francisco Javier de Villegas, from whom it takes its name. In addition, it is a magnificent example of political and economic synergy between mining and local business world as the funds needed for its construction were the income from the sale of the adjoining houses to the bullring and the income from the bullfighting shows[52].
It is one of the first hospitals in Spain which made use of a professionalized care system and can be considered as a milestone of the health movement of the Eighteenth century. The building, declared Property of Cultural Interest in 1992, features an L shape that reveals a simple physiognomy and responds to strictly functional criteria and constructive economy[53]. The only representative element is constituted by an exposed-bricked portal with the balcony and the bell tower on the façade. In a niche there is the Figure of the Archangel St. Raphael, patron of Colonial America. The anagram of the Foundation uses its own coat on arms on this portal[54].
The museum area is made up of a room dedicated to the health of the miners, with an emphasis on the typical diseases of the profession; in the other room it shows the lifestyle and work of the miners, with reference to their families, the interests and leisure activities that could access.

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[49] Ilustre Colegio Oficial de Geólogos, *Tierra y tecnología – Revista de Información Geológica*, n. 29 (1° semestre), 2006, p. 4

[50] Cañizares Ruiz, M. C.*Patrimonio minero industrial en Castilla - La Mancha: el área Alamdén- Puertollano*. *Investigaciones Geográficas*, n. 31, 2003, p. 96.

[51] Hernández, Á., Feraud J. *The Almadén Mining Park: an example of both recreational, educative, scientific, environmental and territorial approach for revitalizing a closed down mining basin*. In Proceedings of International Meeting on Post Mining – Apres mine, Nancy, 6 – 8 February 2008.

[52] Ilustre Colegio Oficial de Geólogos, *Tierra y tecnología – Revista de Información Geológica*, n. 29 (1° semestre), 2006, p. 4.

[53] Sumozas García-Pardo, R. *Arquitectura industrial en Almadén: antecedentes, génesis y repercusión del modelo en la minería americana*. Sevilla: Universidad de Sevilla, 2007, pp. 86 – 89.

[54] Peris Sánchez, D. *Paisajes Industriales de Castilla – La Mancha*. Madrid: Bubok Publishing S.L., 2013, p. 246.

Figure 21. The *Real Hospital de Mineros de San Rafael* in an historical photo.

Source: Mi Pueblo Almadén on issuu.com


Figure 22. The actual Mining History Archive. Source: Parque Minero de Almadén.

## *2. The historical archive.*

The historical mining archives, located in the Eighteenth century complex of the Miners' Royal Hospital of San Rafael, collect all documents related to mining exploitations and those which were scattered and fragmented in various national archives. The building was declared of Cultural Interest in 1992 and restoration work began in February 2002, ending in September 2003[55].

The main Archive rooms consist of the reading room, the office of archivists and deposits. These latter are distributed in two levels with a total area of about 325 square meters, while in an annex of about 220 square meters building houses the documentary collection of Mining Company MAYASA[56].

Thanks to the work of archival reunification to promote the study and knowledge of these mines it has been possible to recover this documentary heritage and to order it into five sections[57]:

- Old Fund (XVIII century- 1918);
- *Almadén and Arrayanes* Society Board of Directors (1918-1982);
- *Minas de Almadén y Arrayanes, SA*. (1982 -...);
- Cartographic collection;
- Library with a current volume of 2,667 linear meters.
- In May 2016 the Governing Council of Castilla - La Mancha has approved the Archives Declaration of Almadén and Arrayanes Mines as Item of Cultural Interest (BIC) in the Collection category. The Declaration has taken hold since the proposal made in 2014 by the Company Mining of Almadén and Arrayanes SA (MAYASA)[58].

## *3. Visit inside the mine*

The open area corresponds to the first level, where distinct parts can be observed: the *del Pozo* mines (Sixteenth - Eighteenth centuries) and *Castillo* (Eighteenth century). The descent is travelled via a lift situated in San *Teodoro* pit by which the visitor descends to the level situated 50 meters deep. On the way, the different steps in which the mine was excavated must be observed: in 1784 the Hoppensack Direction abandoned in fact the subtraction of material excavated, which

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55 Villar Diez, C. *El Archivo Histórico de las Minas de Almadén: un proyecto de Recuperación del Patrimonio Documental*. [n.d.]: [n.d.], [n.d.], pp. 1 – 8.

56 Villar Diez, C. *El Archivo Histórico de Minas de Almadén*. In Proceedings of the VIII Congress of the Asociación Española de Historia Económica, Santiago de Compostela, 13 to 16 September 2005, pp. 155-168.

57 Ilustre Colegio Oficial de Geólogos, *Tierra y tecnología – Revista de Información Geológica*, n.29 (1st semester), 2006, p. 5.

58 See: Mining Park of Almadén in the Press Room.
http://www.parqueminerodealmaden.es/noticias/detalle.php?referencia=40&idioma=es

caused numerous subsidence, introducing the system to "benches and headboards"; this was to introduce large wooden logs called "*asnados*" to support the vaults of the digging tunnels[59].

Through a gallery known as *Caña Gitana*[60] the visitor is conducted to the *Castillo* mine. In this part of the mine, dug in the early Eighteenth century, the black powder, allowing a speeding up of the excavating operations, began to be used together with wooden wagons for the transport of minerals[61].


Figure 23. *Cana Gitaña* Gallery. Source: Parque Minero de Almadén.

The almost vertical arrangement of cinnabar veins required to continuously deepen the excavation through realizations of pits: the main shaft of the *Castillo* mine, until it was replaced with the *Pozo San Teodoro*, was the *San Andrés,* which started from the first level down in depth up to the fourth. For its use an underground capstan, which required the excavation of a large circular hole covered by an impressive dome of brick and stone, was installed.
On top of the *San Andrés* pit there is a big bricked arch to support the walls of the pit, a method which later has been developed in an exemplary manner by the director Diego Larrañaga since

[59] Hernàndez Sobrino, A. El Parque Minero de Almadén. *De Re Metallica* n. 2 march 2004, p. 57.

[60] Cañizares Ruiz, M. C. The touristic attraction of the most important mercury mines in the world: the mining park of Almadén (Ciudad Real). In *Cuadernos de Turismo*, n. 21, 2008, pp. 19 – 20.

[61] Ilustre Colegio Oficial de Geólogos, *Tierra y tecnología – Revista de Información Geológica*, n. 29 (1st semester), 2006, p. 6.

the year 1800 with the name *mamposterìa*[62], namely "brickwork support": it consists in the use of high, wide and very thick bricked arches that support the rocks after removing the vertical layers of cinnabar.


Figure 24. The *Baritel* (capstan) of the *Pozo San Andréas*. Source: Parque Minero de Almadén.

By accessing the *Pozo San Aquilino* the visitor passes further in the ancient access to the mine of the bankers of Függer, dating back to the Sixteenth and Seventeenth centuries, and the route continues in the *Socavòn* gallery (Seventeenth century), used until the Twentieth century, which together with more ancient galleries offers the possibility of studying the reservoir from geological and mineralogical point of view through quartzite layers, volcanic breccia, black schist, cinnabar red etc.

Always inside the well there is another important expedient introduced by German technicians at the end of the Eighteenth century: the staircase façade, which increased the security of the miners in a considerable manner from the moment that allowed to separate vertically the mine in two parts, one for the transport of the mineral and one for the transport of personnel; this was therefore no more forced to climb and descend into the well hung to the baskets through belts or ropes[63].

[62] Hernández, Á., Feraud J. *The Almadén Mining Park: an example of both recreational, educative, scientific, environmental and territorial approach for revitalizing a closed down mining basin*. In Proceedings of International Meeting on Post Mining – Apres mine, Nancy, 6 – 8 February 2008.

[63] Sumozas García-Pardo, R. *Arquitectura industrial en Almadén: antecedentes, génesis y repercusión del modelo en la minería americana*. Sevilla: Universidad de Sevilla, 2007, p. 141.

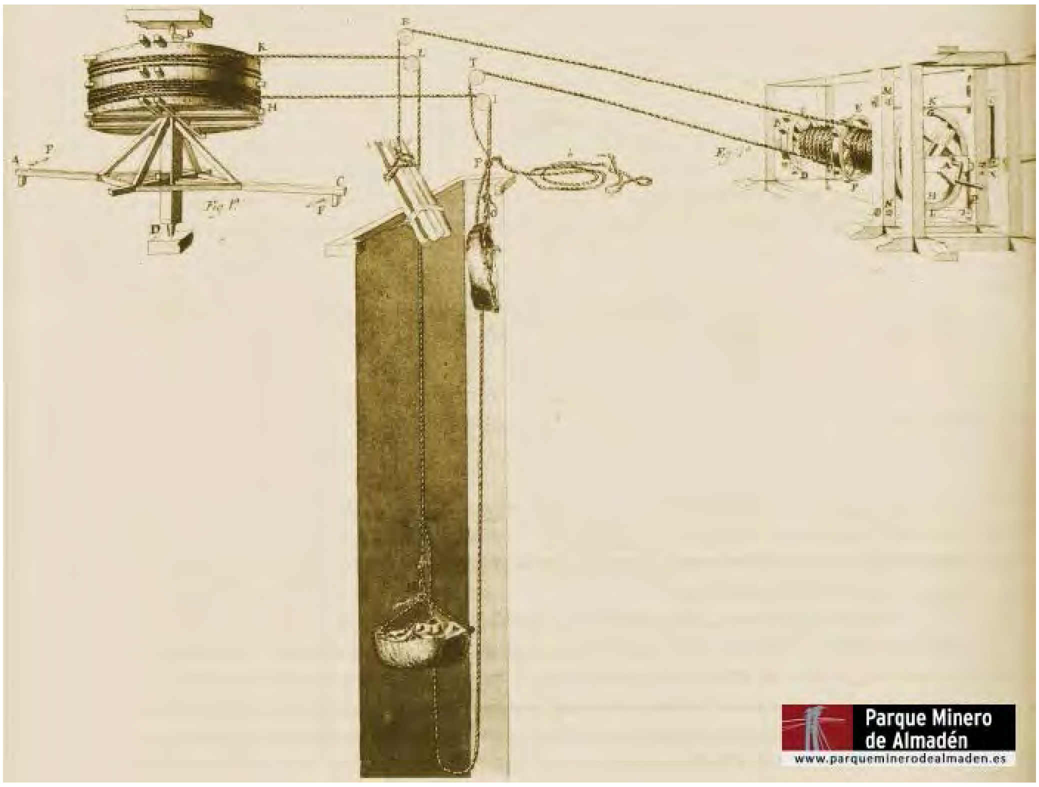


Figure 25. *Malacate* operative diagram, namely the crane driven by mules for the movement of men and minerals.

Source: Parque Minero Almadén.

The visit ends with the lathe *de Castro*, where it was recreated in 1754 the Gallery of the Convicted that connected the mine directly through an underground tunnel to the Royal Prison of Forced Labourers, preventing that they could go outside the mine. The gallery had an entry in the prison and continued northeast until it encounters the *Mina del Pozo* tunnel, leading directly the prisoners to *San Teodoro* fence. The prison, which no longer exists as it was destroyed in 1969, was replaced by the Polytechnic Universitary School[64].

[64] Ilustre Colegio Oficial de Geólogos, *Tierra y tecnología – Revista de Información Geológica*, n. 29 (1° semestre), 2006, p. 7.


Figure 26.The Jail of Hard Labourers in a vintage photo. Source: Parque Minero de Almadén.

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Figure 27. The Prisoners' Gallery. Source: Parque Minero de Almadén.

### *4. Museum of Mercury*[65]

In 1941 the original storage of mercury was converted into the *Museum of Mercury* and its original functions have been moved in the installations of the *de Las Cuevas* mine, 7 km far from Almadén. The building has a ground floor and a basement floor, where the rooms dedicated to the geological, metallurgical, scientific and historical related to Almadén mines are located[66].

The central patio of the building, which was covered with a large skylight, is dedicated to the geology of the mines, which is exposed by means of graphic panels; there are also several specimens of minerals, fossils and rocks that are exposed within several glass cases contained in the patio itself.

In other rooms it is explicated the evolution of the kilns for mercury in Almadén Dock via the scale models of the Arab *xabecas* ovens, the oldest, of ovens or *de aludeles* Bustamante – of which is also preserved an original building with twin ovens – and the Pacific ovens, used until the closing of the plant in 2003[67].

The other room of the museum is dedicated to the science of mercury, where they show the characteristic properties of the metal.

The basement is dedicated to the mining history with its most important episodes, such as the discovery of amalgamation of mercury and silver in Colonial America.

Figure 28. Mining Museum in the Park. Source: Parque Minero de Almadén.

[65] Ilustre Colegio Oficial de Geólogos, *Tierra y tecnología – Revista de Información Geológica*, n. 29 (1° semestre), 2006, pp. 7 – 9.

[66] Cañizares Ruiz, M. C. El atractivo turístico de las minas de mercurio más importanted del mundo: el Parque Minero de Alamdén (Ciudad Real). In *Cuadernos de Turismo*, n. 21, 2008, pp. 19 – 20.

[67] Carrasco Milara, J. *El Parque Minero de Almadén.*In Acts of the 6 th International Meeting Actuality in Museography, Bilbao 17 – 20 june 2010, ICOM – España, p. 98.

### *5. Cerco de Destilación* or *de Buitrones de Almadén* and *Carlo IV Door.*

The *Cercos* play a key role within the architecture industry and mining of urbanism in Spain and in the case of the Almadén de *Cerco de Buitrones* architecture is an excellent demonstration of mining fences[68]. It is in fact a wall, directly linked to *San Teodoro* mine, which separated the metallurgical zone where they produced the mercury from the mining area where cinnabar was extracted, in order to ensure control and prevention of theft and accidents in working areas.
Within the *Cercos* it could only be accessed via the well-guarded portals, which were usually closed at night to prevent theft and demarcated areas were constantly under vigilance against any act of escape or loss of the mineral[69].


Figure 29. The *Cerco de Buitrones* represented by Simoneau in 1719.

Source: Memoires de l'Academie Royale des Sciences, p. 478_pl 23

From the doors to the fences, in addition to the mining workers, all the necessary materials (quarry stones, sand, lime, timber, etc.) used to pass by. To the other side it detaches the driveway and mule paths on which the transport of mercury, before the arrival of the railroad, was carried to Seville and to be shipped to the silver mines of colonial America.
Among the most famous and important elements of architectural quality and identity value in the Almadén Park there is the Gate of Charles IV, located in the ovens enclosures: the remind on Neoclassical and Italian architecture here is mingled with hints of French military architecture, for the presence of the crowning gable, admittedly Bourbon, to which a crusade shield is

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[68] Sumozas Garcia-Pardo, R. *Arquitectura industrial Almadén: antecedentes, génesis y modelo en repercusión of the American minería*. Sevilla: Universidad de Sevilla, 2007, pp. 135-137.

[69] Ilustre Colegio Oficial de Geólogos, *Tierra y tecnología – Revista de Información Geológica*, n. 29 (1° semestre), 2006, p. 9.

applied. The inscription on the sides bears the date 1786 since the beginning of the works, which ended in 1795.[70]

The construction is made of brickwork, combined with limestone in the eardrum, in the shield and in the inscriptions dedicated to Charles IV. The portal is constituted by a segmental arch remarked by pillars and Tuscan columns made entirely of bricks.[71]


Figure 30. The exterior of the *Puerta de Carlos IV*. Source: Parque Minero de Almadén.

[70] Cañizares Ruiz, M. C. Patrimonio minero-industrial en Castilla-La Mancha: el área Almadén – Puertollano. *Investigaciones Geográficas*, n. 31, 2003, p. 95.

[71] Sumozas García-Pardo, R. *Arquitectura industrial en Almadén: antecedentes, génesis y repercusión del modelo en la minería americana*. Sevilla: Universidad de Sevilla, 2007, pp. 135 – 137.


Figure 31. Interior sight of *Puerta de Carlos IV*. Source: Parque Minero de Almadén.

Restored by the Institute of Spanish Historical Heritage in 2004 with a cost of about € 90,000, the Gate of Charles IV plays a high-self celebration of the mine and it is an excellent example of the Bourbon industrial architecture because of the architectural quality of its construction. To this end, the comments of the Secretary of the Royal Academy of History, Prof. Antonio Bonet Correa are worthy to be mentioned:

"*Buildings like the Almadén Plaza de Toros, the Gate of Charles IV, the Mining Academy and de aludeles ovens are works worthy of being placed in the scale of architectural values like a temple or a Neoclassical building from the same era*."[72]

On the other hand, the Academy of Mines, founded in 1777, also called Mining School, was the first in Spain to train mining engineers and later became the School for master builders. The building is characterized by a bricked Neoclassical facade, on two floors, which suggested a step forward in the modernization process in the Enlightened Spain and it is a clear example of how the academic character which had distinguished the sciences hitherto was transformed to give way to a much more pragmatic conception of the mines.[73]

[72] Ilustre Colegio Oficial de Geólogos, *Tierra y tecnología – Revista de Información Geológica*, n. 29 (1° semestre), 2006, p. 10.

[73] Sumozas García-Pardo, R. *Arquitectura industrial en Almadén: antecedentes, génesis y repercusión del modelo en la minería americana*. Sevilla: Universidad de Sevilla, 2007, p. 45.

## *6. Safeguard of historical mining ovens*

### *Historic connotations*

· *Xabecas* ovens

The use of advanced techniques for cinnabar distillation in Almadén certainly dates back to the times of Roman colonization; however, we have more precise information about the configuration of furnaces for the extraction of mercury from cinnabar ore for the period of the Arabian conquest, during which there were introduced the *xabecas* ovens used until the Seventeenth century. The descriptions of the Arabian ovens can be found in the work published by Maffey and Rua Figueroa[74] in 1543 within the Mineral Bibliography: the name comes from the term j*abeca* or *Jabega*, which means great fishing or flute network and it suggests a certain verisimilitude to the ovens' structure.

The oven consisted of four vertical walls that form a sort of rectangular body and of a cylindrical vault that acted as a cover. In the vault and along the walls there were three rows of openings for a total of eighteen, twenty or twenty-four so that they correspond six, seven or eight in each row, giving to the oven the form of a flute or a large fishing network. In the holes conical shaped jars in the role of crucibles were collocated and sealed with mud to avoid the loss of fumes through the holed vault. Then the pieces of ore, large like nuts, were trickled into the crucibles leaving a void at the top of three fingers in height to be filled with sifted and pressed ashes (*hormigo)*. Shell shaped mud tops finally covered the holes, sealing the borders with a paste of a mix of mud and ashes (*larax*) in order to avoid the loss of mercury during the process, whole the sharp lower end of the jars was protected through a layer of mud[75].

The operations were conducted in a manner that the charge was terminated at sunset and the cooking began putting in the oven six stoves through the opening, in order to form a mound on the bottom of the chamber. The air required for combustion came through the door and the flames, heating the jars, climbed to the chimney located on the opposite side. However, it is possible that in *xabecas* ovens there was no chimney and that the flames would retreat to exit through the fuel introduction port.

[74] Anònim. Minas. Tomo II, num. 3503, p. 398. See: Escosura y Morrogh, L. *Historia del tratamiento metalúrgico del Azogue en España*. Madrid: Ed. Imprenta y Fundición deM. Tello, 1878, p. 22.

[75] Ibidem, p. 23 – 24.

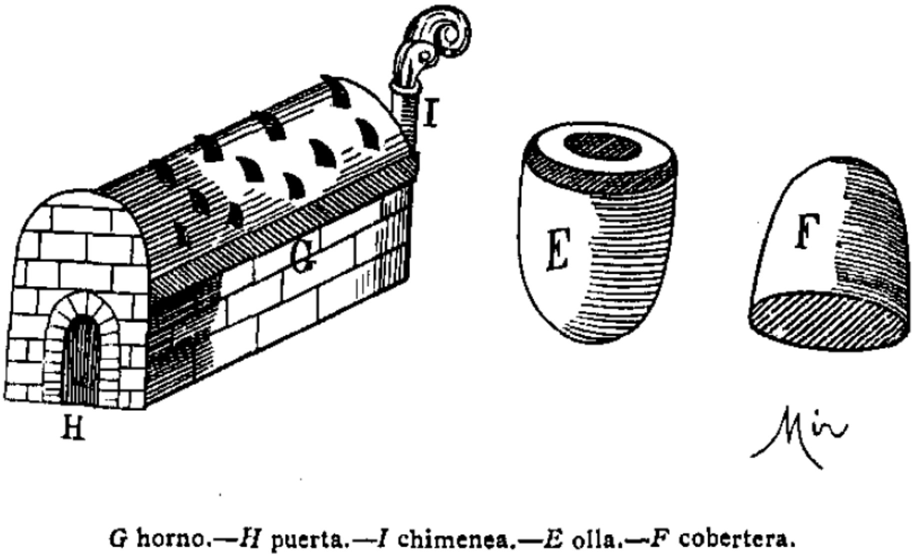


Figure 32. Drawing of *xabecas* ovens and cooking pots.

Source: Escosura y Morrogh, Historia del tratamiento metalúrgico del Azogue en España, 1878.

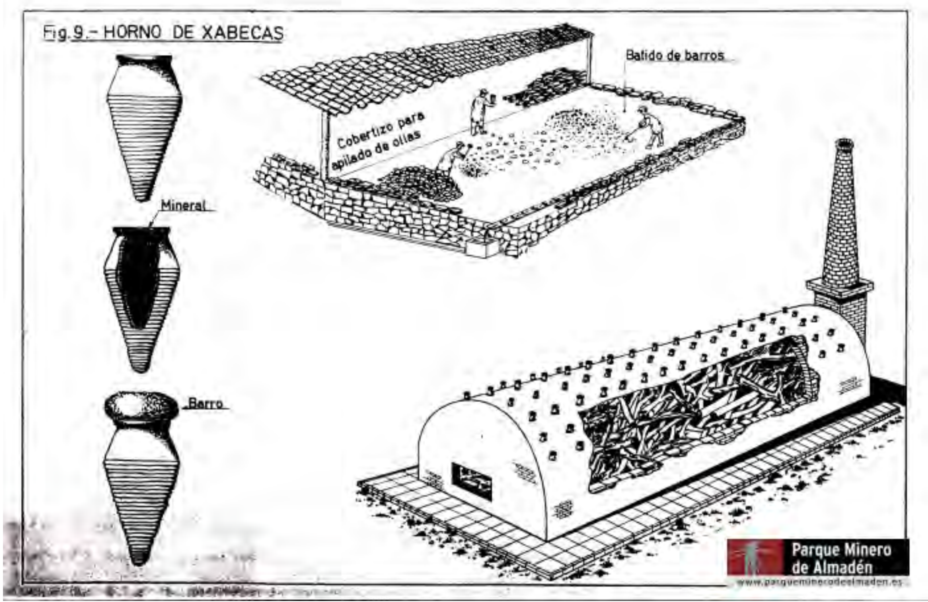


Figure 33. Illustration and insight of de *xabecas* ovens. Source: Parque Minero de Almadén.

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· *de aludeles* or *Bustamante ovens*

In 1633 the doctor Lope Saavedra Barba, who practiced in Huancavelica, invented a system for the extraction of mercury, analogous to those used since ancient times for firing bricks, tiles and ceramics[76]. Inside, they were cylindrical in shape with a network or a grid of bricks at mid-height, with the difference compared to traditional ovens that they were not open at the top and

[76] Ibid, p. 45.

ended at the dome, at whose centre there was a hole closed by an earthen tile called *cambusto, capellina* or *capirote*.
The ovens had a lateral aperture at the network height that was used to introduce the charge, and which was closed during firing. The mineral was placed on top of the network and the wood was placed down through a slit that remained constantly open to allow the entry of air required for combustion of the firewood and the desulphurisation of the mineral[77].
The products of combustion and the air crossed the network, circulating around the pieces of cinnabar and – mixing with the sulphur dioxide gas and with the mercury vapours, formed by the decomposition of mercury *sulphide* – exiting out from the furnace through a lateral hole. From this hole started the condenser, consisting of several tubes or *de aludeles* open at both ends and inserted one inside the other, filled with water up to a certain height and placed above an inclined plane or terrace, from which the water flowed and irrigated the tubes on the outer side.
In the ovens of Saavedra Barba the air served as a desulphurizing and consequently the ash and the jars were suppressed; the manpower requirements were saved and fuel consumption got reduced; it also managed to completely decompose the mineral that was introduced into the furnace, eliminating the washing of mercury and of distilled vermillion, and above all it gained the valuable benefit of increasing the production of mineral that could be treated in a single oven. Finally, by adjusting the air flow inside the oven so that the gases and vapours would go up with a certain rhythm and a reduced speed towards the tubes, a complete desulfurization of cinnabar was obtained and the ascent of the whole mercury vapours toward the capacitor[78].
In Almadén the introduction of the furnaces designed by Saavedra Barba was in 1643 thanks to Juan Alonso de Bustamante, from whom the ovens inherited the name.
In the Cerco de Buitrones the two most important kilns were those of *San Carlos* and *San Sebastian*, whose structures maintained the original covered cylindrical shape of a flattened or lowered hemisphere. The grid or network over which the ore was loaded was made of bricks and was supported by three arches of the same material. The bottom part of the network was the vase (*vaso*) and the bottom of the fireplace was known as *caldera*. In each furnace there were three doors and a chimney: the door of *cargadero*, or of the mineral filling in the oven, was located in one of the sides at the level of the grid and it went up to the dome's springers. The door, in front of which there was a staircase or a bridge, was called the *boca* or *boquete* or stoker's door, formerly known as *buitron* and it was used for the introduction of the fuel inside the furnace.
In the vault forming the lintel of this door was set the chimney from which the smoke came out that had not found an outlet in the grid and in the French mining etymology corresponds to the *chéminèe d'appel*. The third door finally was called *anillo* and it was a simple circular hole in the dome top that was used to load the minerals placed over the network and by the stoker to came out after he had entered the furnace from the door of *cargadero*. During this operation the *anillo* was closed with a plate said *valvula*. At the springers level of the dome there were also six

[77] Tejero-Manzanaresa, J., Garrido Sáenza, I., Mata Cabreraa, F., Rubio Mesasa, M. L. La metalurgia del mercurio en Almadén: desde los hornos de aludeles a los hornos Pacific. *Revista de Metalurgia* n. 50(4), october – december 2014, pp. 5 – 6.
[78] Escosura y Morrogh, L. *Historia del tratamiento del Azogue Metalurgico en España*. Madrid: Ed. Imprenta Fundición y de M. Tello, 1878, p. 46.

radial openings called *ventanillos* by which the fumes, gases and mercury steam in the rooms of the upper part come out[79].

The inclined plane at 11° was made up of two parts or nearly equal levels: the first, downward sloping and called *Plan de cabecera*, or "head plan", began at the level of the upper rooms and ended in the irrigation channel called *quiebra*; the second running from the irrigation channel (*quiebra*) up to the arches was *called Plan de rabera*, that is "tail plan"[80].

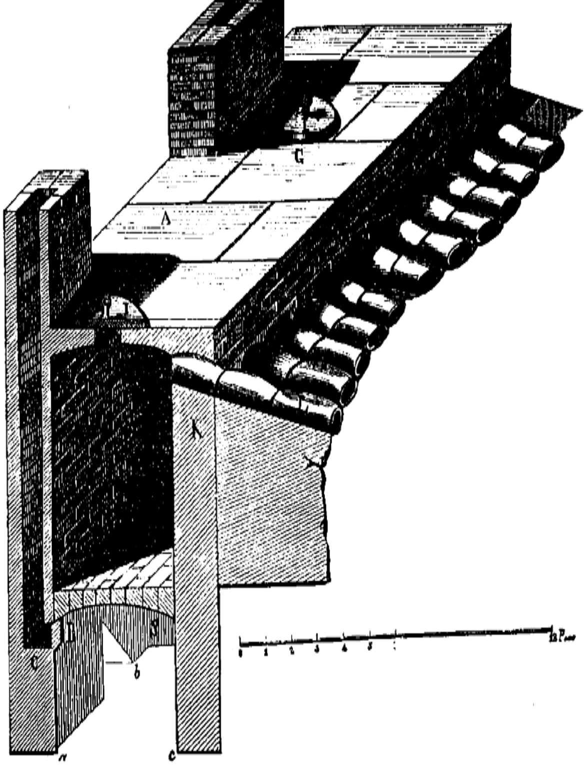

Figure 34. Section of *Bustamante* oven.

Source:Escosura y Morrogh, Historia del tratamiento metalúrgico del Azogue en España, 1878.

Next to the ovens there were other rooms: two deposits or dryers, one behind the arches and the other above the volume in which the chimneys opened; two fuel tanks, several stairs, two washeries and a deposit at the end of the subsequently irrigated canal[81].

[79] Ibidem, pp. 77 – 78.

[80] Ibidem, pp. 79 – 80.

[81] Escosura y Morrogh, L. *Historia del tratamiento metalúrgico del Azogue en España*. Madrid: Ed. Imprenta y Fundición de M. Tello, 1878, pp. 67 – 68.

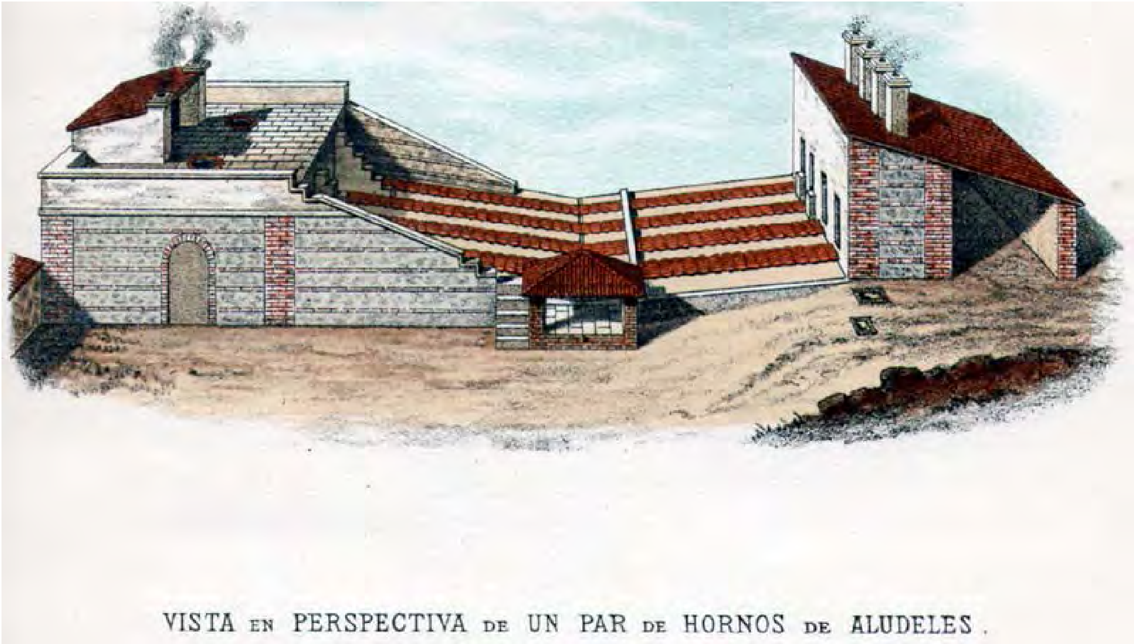


Figure 35. Copy illustration of de aludeles ovens.

Source: Escosura y Morrogh, Historia del tratamiento metalúrgico del Azogue en España, 1878.

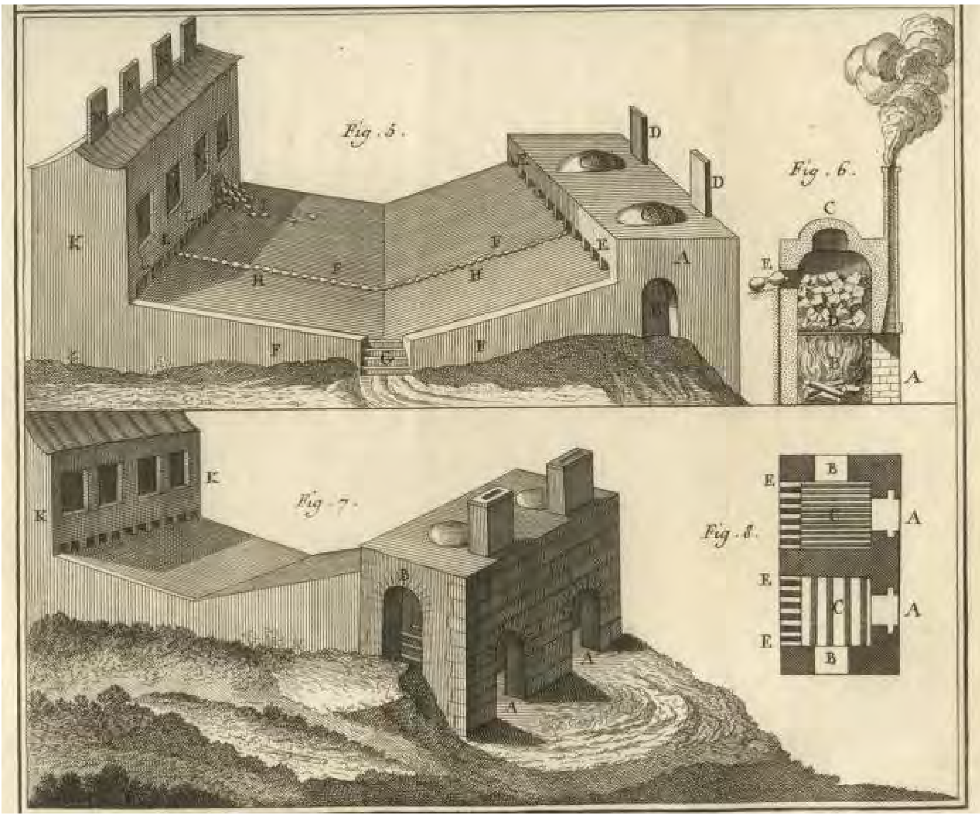


Figure 36. *Bustamante ovens*: illustrative drawings by Jussieu, Anonymous of 1768, table 177.

Source: Recueil de Planches sur les Sciences, les Arts Liberaux et les Arts Méchaniques avec leur Explication. Vol. 6.

- Idrija furnaces or "rooms"

In 1806 for the first time the *San Carlos* and *San Luis* ovens, based on the model of the Idrija ovens, originating in the namesake Slovenian mine, were introduced: they were made without channels and equipped with a condenser room and vessels or ovens larger than the *de aludeles* ones. The two Almadén furnaces were designed and built by the Director of the mines of Almadén Diego de Larrañaga, who was interested specifically in studies on the metallurgy of mercury [82].

The system of the furnace rooms consisted of a central cylindrical vessel – in which the ashes were placed at the bottom – the hearth and the collection of the mineral, which had to be previously reduced with a hammer to a size appropriate for the treatment. The vessels had a capacity equal to two and a half times that of the *Bustamante ovens*.

Unlike *de aludeles* ovens, the holes in the central vessel communicated with a series of six rooms placed on both sides of the vessel, in place of the mud channel. These rooms communicated among them through windows placed alternately at the bottom and at the top to force the mercury gas to realize a large zig-zag like a serpentine. At first, they were manufactured entirely of refractory bricks and after they were coated with mortar of Portland cement to facilitate the slippage of the drops of mercury. The lower part was shaped like a truncated inverted pyramid from which the mercury was collected, then led through a small channel to a pool. Finally, the last room was much higher because of acting as a chimney, while the walls of all the rooms were extremely thick to retain heat for a long time and the rapid cooling observed in the first two rooms was due only to the extraordinary expansion which the mercury gas undergo inside so high-capable rooms. The vapours in this type of ovens in fact travel 32 meters far, 16 metres on each side, with a height of 84 meters without counting the elevation of the last chamber.

The figure below represents a profile of the two planes of *cabecera* (descending) and *rabera* (ascending) of *San Carlos* oven and the monitoring points along the channels A, B, C and D are located at a distance of:

- 0,46 m from the outer wall of the room to the point A;
- 3,96 m from A to B;
- 4,42 m from B to C (centre of *quiebra* irrigation canal);
- 8,58 m from C to D.

[82] Tejero-Manzanaresa, J., Garrido Sáenza, I., Mata Cabreraa, F., Rubio Mesasa, M. L. La metalurgia del mercurio en Almadén: desde los hornos de aludeles a los hornos Pacific. *Revista de Metalurgia* n. 50(4), october – december 2014, p. 6.

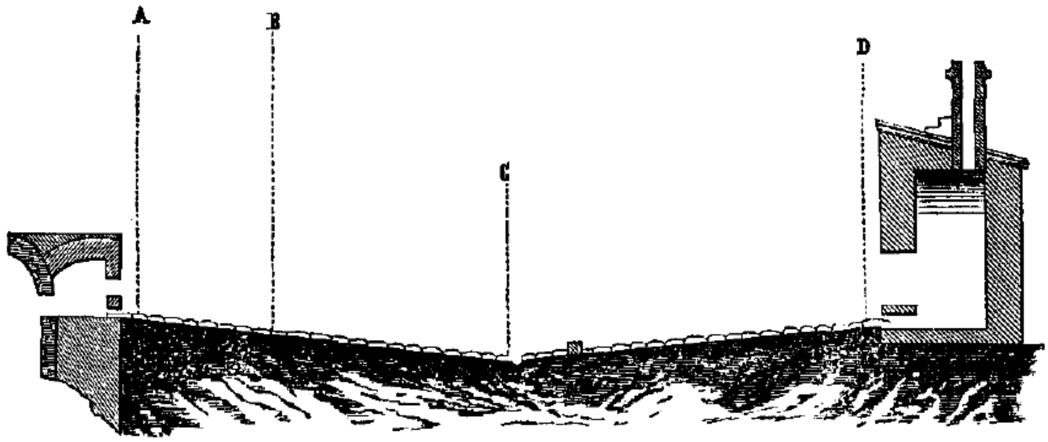


Figure 37. Profile of *cabecera* and *rabera* of San Carlos oven . Source: Escosura y Morrogh, *Historia del tratamiento metalúrgico del Azogue en España*, 1878.

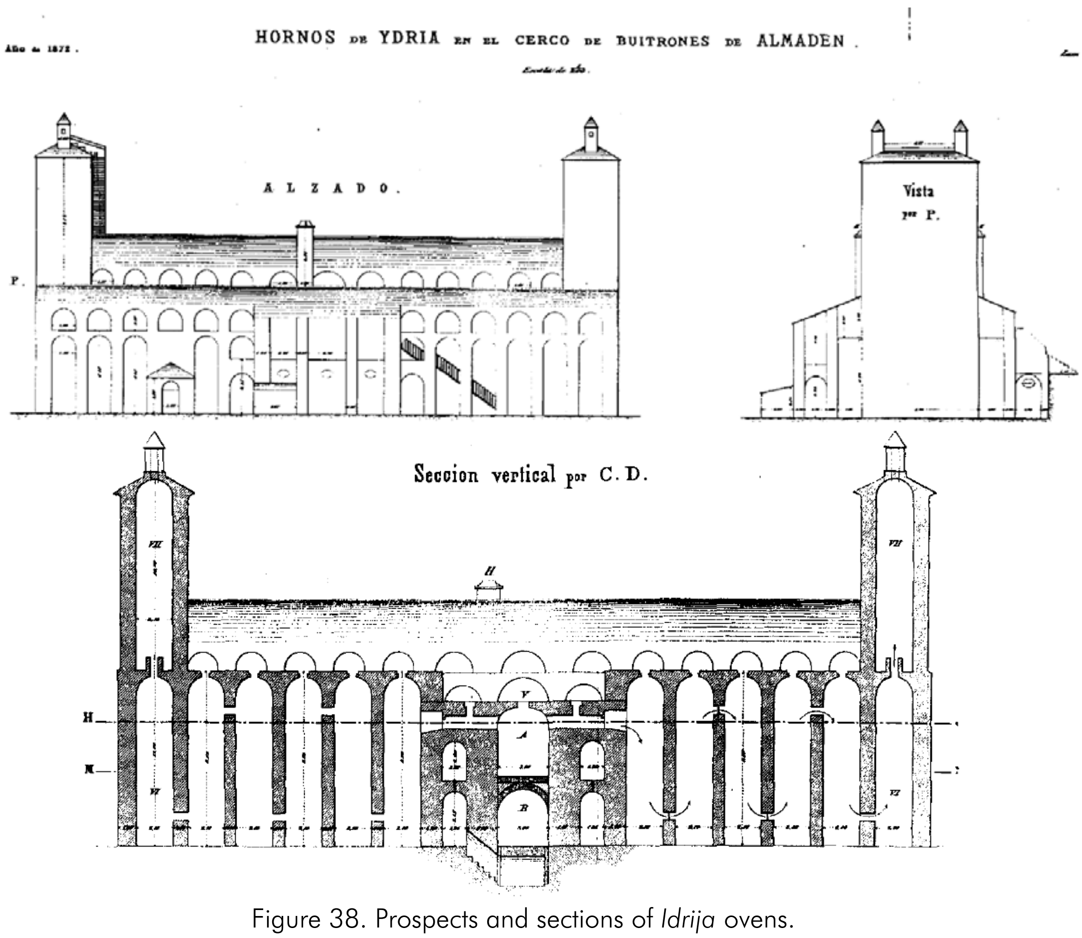


Figure 38. Prospects and sections of *Idrija* ovens.

Source:Escosura y Morrogh, Historia del tratamiento metalúrgico del Azogue en España, 1878.

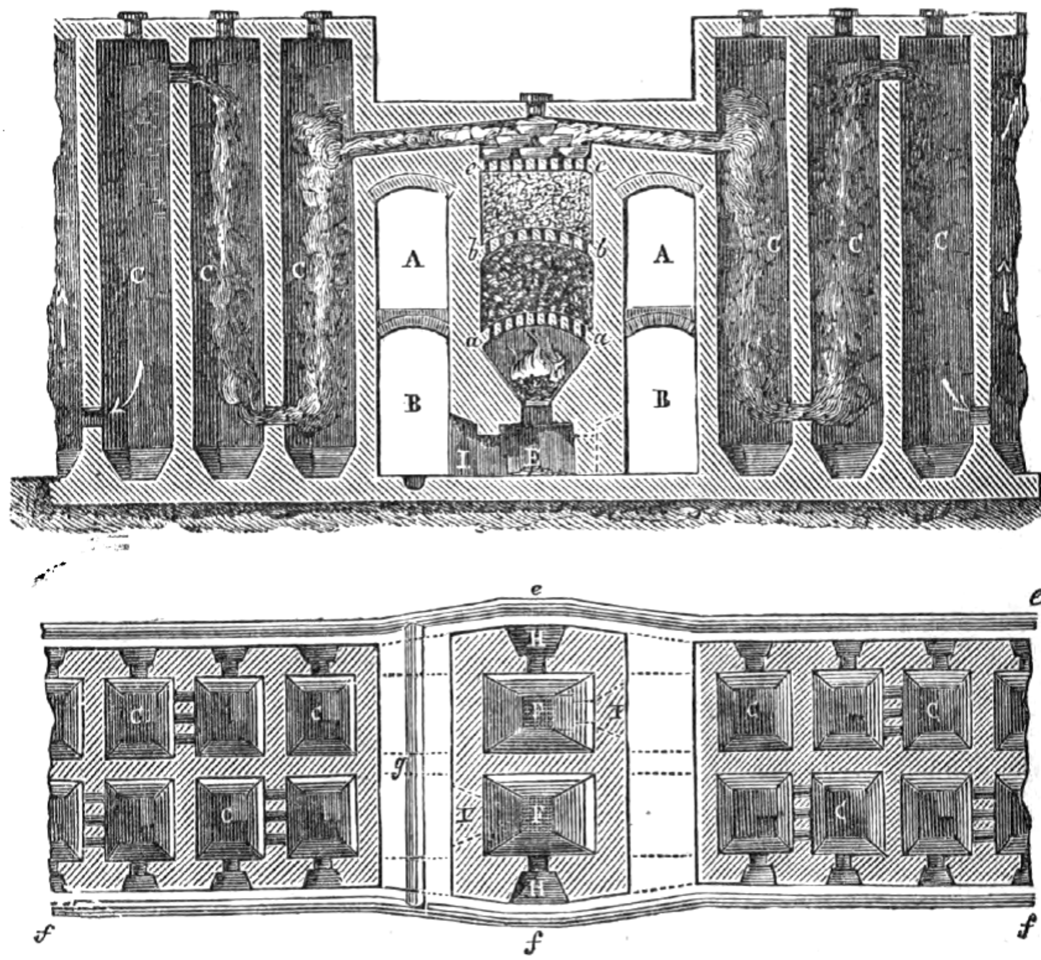

Figure 39. Idrija oven illustrated by Rafael Saez y Palacios in his *Treatise on Chemistry Inorganic Theoretical and Practical*, published in Madrid in 1869.

The substantial changes in *Idrija* oven compared to Bustamante essentially concern the part in which the mercury condenses. The *Idrija* oven consists of two coupled ovens: the entrance to the furnace *H;* the furnace *F;* the plane of the ashes *E;* the vaults *aa* on which the mineral is placed*, bb;* the condensation rooms *CC* and the deposits *g* in which the mercury flows, from which a conduit that leads to a common storage starts. The upper openings of the rooms are closed with plugs sealed with mud during the operations and they are opened to cool the furnace more easily in order to be able to enter to pick up the sooty part mixed with mercury that is deposited in the walls[83].

The Idrija ovens generally had a diameter of 3 m and a height of 7.50 m, which is divided into two parts or compartments by a grid of parallel arches, separated by a space equal to its width and joined by means of great size bricks to form the network on which the ore was loaded[84].

[83] Saez y Palacios, R. *Treaties on Inorganic Chemistry Theorical and Practical, Madrid*: C. Bailly – Bailliere, 1869, pp. 174 – 175.

[84] Tejero-Manzanaresa, J., Garrido Sáenza, I., Mata Cabreraa, F., Rubio Mesasa, M. L. La metalurgia del mercurio en Almadén: desde los hornos de aludeles a los hornos Pacific. *Revista de Metalurgia* n. 50(4), october – december 2014, p. 8.

- *Pellet* furnaces

In 1867 the French engineer Emilio Pellet made an agreement with the Minister of the Treasury Barzanallana to install his invention for the extraction of mercury that reduced considerably the losses during the firing process[85].

In 1869, following the proposal by the management of the mines in Almadén to adapt one of the existing Idrija ovens or building a new one to carry out a control test with Pellet furnaces, the French inventor turned on his first oven in the *Cerco de Buitrones*: the comparison tests between the Pellet furnaces and those of *Idrija,* however, turned out a total failure and called for a duration of several years, affecting also the *Bustamante* ovens [86].

In the document sent to the Superintendent José de Madariaga in March 1870 by José de Monasterio y Correa, Inspector General of Mines, it was stated that Pellet's system required a cost four times higher than the chamber system and therefore the adoption was anymore suggested. Nevertheless, the Pellet ovens remained in use in the distillation processes, as it can be seen in the plans of the ovens of 1924, and were demolished only in 1928[87].

- *Livermore* furnaces

In 1887 a new furnace already used in Asturias and Idrija, called Livermore or canal system was installed in Almadén. This technology was introduced by E. C. Livermore in the Redington Mine in California in 1874[88]. In Almadén three types of ovens worked in the nineties of the Nineteenth century[89]: two for the treatment of major minerals and the third for the tiny ones. The first two types differed among themselves for using *aludeles* in one case and a large section in the other rooms, or Idrija ovens.

The *Livermore* system, belonging to the third type of Almadén ovens, is described by Oyarzábal[90] as similar to those used in California. They consisted of an inclined plane from 6 to 9 meters wide, divided throughout the longitude and along its inclination by a 30-cm high wall that formed different channels of 16 cm in width from which the oven takes its name. At the end of the inclined plane existed a hopper for supplying the mineral in the channels; in the lower

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[85] Escosura y Morrogh, L. *Historia del tratamiento metalúrgico del Azogue en España*. Madrid: Ed. Imprenta y Fundición deM. Tello, 1878, p. 137.

[86] Tejero-Manzanaresa, J., Garrido Sáenza, I., Mata Cabreraa, F., Rubio Mesasa, M. L. La metalurgia del mercurio en Almadén: desde los hornos de aludeles a los hornos Pacific. *Revista de Metalurgia* n. 50(4), october – december 2014, pp. 6 – 7.

[87] Ibidem, pp. 6 – 7.

[88] Schnabel, C. *Handbook of Metallurgy*, Vol. 2. New York: MacMillan and Co. Limited, 1898. Op. Cit. In: Manzanaresa-Tejero, J., Garrido Sáenza, I., Cabreraa Mata, F., Mesasa Rubio, M. L. The metallurgy of mercury Almadén en: desde los hornos de los hornos aludeles Pacific. *Revista de Metalurgia* n. 50 (4), october – december 2014, p. 8.

[89] Ibidem, p. 8.

[90] Oyarzábal Zabalabe, E. Reseña descriptiva historica y de las minas de azogue de Almadén. Almadén: Històrico Archivo de Minas de Almadén, 1883. In Manzanaresa Tejero, J., Garrido Sáenza, I., Cabreraa Mata, F., Mesasa Rubio, M. L. The metallurgy of mercury Almadén: desde los hornos de los hornos aludeles Pacific. *Revista de Metalurgia* n. 50 (4), October-December 2014, pp. 8-9.

part another wall was disposed in perpendicular direction and separated by a distance equal to the thickness of the mineral layer that descended through the channel. The hearth stood a little higher than the second floor and in front of the first, in such a way that the gases of combustion touched the mineral in the opposite direction to that of its journey.
The condensation system was formed by a thin-bricked room with iron sheet floor in the part closest to the oven and of slate from Villar del Rey in the farthest, arranged in such a way that the air could circulate and that no condensation of mercury formed in the bottom. This was inclined to pour the liquid metal inside a channel. The second part was formed by a wooden and crystal chamber, which communicated with the chimney through which the gas came out. In these furnaces, also, the distillation was continued: once the mineral was loaded with a uniform thickness and sufficiently exposed to the calorific action of the combustion gases, a certain amount was retired in the lower part of the channel in order to let the charge in the space from the removed portion: this operation allowed the hopper to charge again a quantity of mineral equal to the removed scoria.

The Livermore ovens remained in use to Almadén until 1907, along with the *de aludeles* ovens and the Cermak-Spirek and Spirek[91].

## Awards and honours

The Almadén Mining Pak originated from the initiative of the Mining Society of Almadén to preserve and organize the preservation and enhancement of its assets: the final act of this process was the Declaration of Good of Cultural Interest in 2008 by the Council of Culture of Castilla - La Mancha against the mining complex of Almadén, already proposed in 2007[92]. This act is accompanied by the approval of the Historical Centre Protection Special Plan of Almadén (PECHA) by the Municipality, which concludes the cycle of institutional acts of recognition and protection of the mining industrial heritage in this site.

Internationally, the increased importance of the Spanish case is reflected in the nomination for the UNESCO World Heritage Site in conjunction with two other mining sites, deeply linked to Almadén's industrial past: the nomination in fact is entitled "*the binomial Mercury and Silver in the Intercontinental Camino Real*: *Almadén, Idrija and San Luis of Potosi (Mexico)*.

The criteria for the approval of the registration request by the States of origin are provided in the dossier of analysis and conclusion of the UNESCO accreditation procedure, which approved the nomination for World Heritage Site in June 2012. Some of these criteria are reported as follows:[93]:

· Integrity and Authenticity

[91] Ibidem, p. 9.
[92] Carrasco Milara, J. *El Parque Minero de Almadén*. In Proceedings of the 6th Encuentro Internacional Actualidad en museografía, Bilbao 17 to 20 June 2010 ICOM - España, p. 101.
[93] UNESCO Advisory Body Evaluation (ICOMOS) Document, pp. 344 – 345.

The property shows traces of its mining function from the Sixteenth and Seventeenth century and it consequently testifies the mercury exploitation, its processing and transportation as well as the significant urban and architectural elements of the development of the mining city of Almadén. The property is part of the urban and mining landscape that evokes its history, linked in the beginnings of the Mercury Route to Seville and then to the Americas.

The vestiges of mining activity illustrate the evolution of the techniques of exploitation of mercury and its processing until the Twentieth century. A sufficiently significant number of elements of tangible evidence have been preserved to represent its history with consistency and integrity.

The present urban planning is noticeably close to that of the Eighteenth century. Some houses have been changed and other buildings were destroyed, as the home of the Superintendent of the mine and the Prison of the Convicted to Hard Labours.

The presence of underground mining elements dating from the Sixteenth to the Seventeenth century has been authenticated. A pair of *Bustamante* ovens, whose technical design dates to the Fifteenth century, has been restored by the Spanish Historical Heritage Institute in accordance with the principles of the Venice Charter and the restored parts are clearly identifiable. The functions of some urban buildings have been modified from their original purpose and have been the subject of some substantial alterations, such as the *Retamar* Castle, but most have a high level of architectural authenticity[94].

· Criteria under which it is proposed for inclusion

The property is nominated on the basis of criteria II, IV and V:

> *Criterion II. exhibition of an important interchange of human values, in a span of time or within a cultural area of the world, on developments in architecture or technology, monumental arts, town planning or landscape configuration.*

This criterion is justified by the Member States since the fact that the trade and transport of mercury, which became intercontinental since ancient times, generated important, scientific, technological and cultural exchanges. This was the case in the use of mercury in amalgamation processes, which led to the transfer of technical and experts from America and Europe between the Sixteenth and Seventeenth century. The use of mercury in silver mines in America gave rise to unusual trade flows and unprecedented financial developments. In the following period the creation of the Academies of Sciences and exchanges of scientists and technical processes, particularly in Europe, created a scientific and professional community known at international level. Mining tradition influenced also the creation of cities containing emblematic as well as singular buildings.

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[94] UNESCO Evaluation Advisory Body (ICOMOS) Document, p. 344.
http://whc.unesco.org/en/list/1313/documents/

ICOMOS considers that the nomination is essentially centred on mercury extraction and that this would only partially illustrate the economic and cultural exchanges relating to it, particularly those related to the development of amalgamation processes in the Americas. However, there were really trading exchanges between the production of mercury sites with a regard to the extraction processes and these started since the earliest times both in Europe and on an intercontinental scale, due to the nature of the mercury market and the specific nature of the technical and scientific problems related to the extraction and use.

*Criterion IV. Being an outstanding example of a type of building, architectural or technological ensemble or landscape which illustrates one or more significant events in human history.*

This criterion is justified by the States on the basis that Almadén and Idrija mines were and remain the largest mines of mercury in the world. As having been closed relatively recently, today they represent the most significant events regarding the exploitation of mercury by man, in terms of mining techniques and impact on the environment, transports, trades and urban and social factors. The extraction processes involving the use of furnaces are specific for mercury and were truly innovative in the period from the Sixteenth to mid-Nineteenth century.

Furthermore, ICOMOS considers that the two mining towns of Almadén and Idrija constitute the most important asset inherited from the extraction of mercury, especially in modern and contemporary times: this double testimony is unique and presents various territorial, industrial, urban and social components of a specific socio-technical system – the metalliferous production industry.

*Criterion V. be an outstanding example of a traditional human settlement, land-use or sea-use which is representative of a culture (or cultures), or human interaction with the environment especially when it has become vulnerable under the impact of irreversible change.*

This criterion is justified by the States on the basis that the nominated sites are an outstanding example of the interaction of man with his environment, which today is vulnerable due to the closure of mines and mercury pollution.

This human intervention gave impetus to social aspects, through a workforce that included workers sentenced to forced labour and prisoners of Almadén, through the hard life of miners and premature considerations on occupational diseases in Idrija. Many elements of the intangible culture are associated with the specific nature of human communities that participated in the exploitation of mines.

ICOMOS considers that the two nominated sites constitute an example of a distinct form of human settlement for the intensive extraction of mercury, reflected in its subsoil, in industrial and urban elements that are specifically recognized under the terms of the criterion IV. The effects of the toxicity of mercury on the environment also express a specific relationship between man and nature and ICOMOS considers the effects of pollution as an integral part of today's property, but criterion V does not feel fully satisfied because only the pollution by mercury is a truly distinctive element in relation to other types of mining uses of the territories.

In conclusion, ICOMOS considers that the nominated property fully meets the criteria II and IV under the conditions of authenticity and integrity and that the Outstanding Universal Value has been demonstrated.

Protection, conservation and management[95]

· property

The mines, the adjacent areas and sections of the Mercury Route identified as starting points are the property of MAYASA Mining Company, as well as the Hospital of Miners and the Chapel of St. Michael, located within the city.
The public spaces and parts of the buildings identified as holders of historical and heritage values are the property of the municipality of Almadén (Castle, home of the Superintendent, Mining Academy, arena). Other elements with historical and heritage value are the property of the Catholic Church and the University (the archaeological site of the Forced Prison).

· legal protection

The settlement of the mining buildings and urban transport is under the legal protection of:

- the Spanish Constitution, which defines the laws and the Statute of the Autonomous Communities (1987);
- the Spanish Historic Heritage Act (16/1985) and its integrations, applications and regional decrees (4/1990 Act of Castilla - La Mancha and 7/2005 Decree);
- Local Territorial Authorities Regulation Act (7/1985);
- Territorial Regulation Act (6/1998);
- the Act of Protection of Natural Spaces (9/1999);
- The new regional law on land use and urban planning (1/2010).

· traditional protection

The dwellings are in most cases private property owned and maintained by the owners. The Catholic Church carries a direct or delegated management of the religious buildings of its competence at Almadén and Idrija.

· effectiveness of protective measures

The additional information provided by Spain and Slovenia clarify how the protective measures for the property and the buffer zones have been incorporated in the Municipal General Plan

[95] UNESCO Evaluation Advisory Body (ICOMOS) Document, pp. 346-349.
http://whc.unesco.org/en/list/1313/documents/

(POM) of Almadén to guarantee the protection of the property. ICOMOS therefore considers that the protective measures at both sites are sufficient.

- Management

The management structures of the Almadén site consist of groupings of several public and private institutions that are responsible for specific aspects of the management of the property or have cultural functions:

- The mining company MAYASA;
- the Foundation *Francisco Javier de Villegas* (FJV) that takes care of the Museum of the San Rafael Royal Hospital, the Historic Mining Archive and the cultural management of the site;
- the Municipality of Almadén;
- the University that manages the historic mining museum and interpretation centre of the mine, located in the Forced Gallery;
- the Almadén Office that promotes cultural and economic activities of the city;
- the Mining Academy of Almadén;
- the Mining Park of Almadén in which the City of Almadén, the Foundation FJV and the Polytechnic School participate.

- current state of preservation

The *Bustamante* furnaces have recently been restored and are in good condition. The remaining two gates of the mining fence have been restored and the identifying elements of the Route of Mercury are clearly identifiable. The monuments and urban buildings are generally in good condition.

## Conclusions[96]

The mining sites of Almadén and Idrija form a coherent whole with complementary components, which effectively illustrate the technical, cultural and social associated with the extraction of mercury. The elements are present in sufficient numbers to make satisfactory their interpretation. These are the two most important sites were to be preserved against the activity took place, in terms of produced volumes, historical duration and completeness of the evidence provided. The integrity is then largely satisfied.

In both sites the presence of mining infrastructure both underground and on the surface, of technical artefacts related to mining extraction, energy requirements and materials (hydraulic energy and in particular timber) and their use in furnaces for the extraction of mercury, its

[96] UNESCO Evaluation Advisory Body (ICOMOS) Document, pp. 351-352.
http://whc.unesco.org/en/list/1313/documents/

transport and storage are authentic. This is also reflected in urban and monumental elements and for the testimony of the miners' living and working conditions.

In addition to the candidature for the World Heritage List, the Almadén Mining Park has received the following awards[97]:

- 1st Regional Tourism Award of Castilla - La Mancha for the most innovative initiative of the Tourism Sector in 2006;
- *FITUR 2009 Award* for Best Active Tourism Product in the category of Culture;
- Regional Sustainable Development Award of Castilla - La Mancha for the restoration project of the landfill in *Cerco de San Teodoro*;
- Award Finalist 2010 *RegioStar* for the best and most innovative European projects funded by FEDER funds.

[97] Carrasco Milara, J. *El Parque Minero de Almadén*. In Proceedings of the VI Encuentro Internacional Actualidad en museografía, Bilbao 17 to 20 June 2010 ICOM - España, p. 101.

### Some initiatives of recovery and reconversion of the Mining Heritage in HBNPC[98]

With the end of the mining industry after more than a century and a half of intense activity in the whole coalfield a seemingly inexhaustible sense of economic hardship, a social and environmental trauma has developed: the abandoned remains of the production sites were viewed with a rejecting approach by the local communities that identified the worsened status of things with the unsustainable unemployment and industrial disintegration of such a vast territory. Even the preservation of the historic memory of the industrial sites of the Nord – Pas de Calais was in the early years of dismantling a tricky question, difficult to manage both by institutional actors and by the people of the mining area[99].

The turning point occurred in 1974 with the decision by the Companies of the Nord – Pas de Calais basin to create the first Historical Mining Centre (CHM), prompted by the desire to keep alive this memory because after 250 years they had come to the awareness of the risk of the disappearance of an important page in the history of the Basin and of the entire region: with the exception of the remaining miners and individual testimonies in the following decades there would be no more evidence of the mining past of the area and all the negative consequences of the industrial decline would continue to prevail in common sense. The second reason addressed then the issue of the industrial landscape and remnants of mining facilities: what sense would have made keeping the wastes from excavations, the slag, machinery and swamps in a such inconsistent and scattered manner, without a place in the territory where the historical significance and identity values of these objects could be collected, kept and explained to the communities?

Finally, the promoters of this initiative aimed at creating a place of safekeeping and conservation of archives of materials and testimonies related to the coal mines objects[100]: hence then the will of the mining Companies to leave a will of their activities, in the form of a built and documentable object, to future generations that would inherit this industrial heritage.

Since the end of the Eighties started thus a promotion of a not insignificant number of initiatives, related to the conservation and the enhancement of the mining heritage that formed the first "critical mass" including:

- *Concerted Research Program in the field of Environment and Human Activities (1994)*

Developed by an initiative of the Nord – Pas de Calais Regional Council promoted by the regional scientific community, it is a State – Region agreement funded by FEDER[101]: the

[98] Houillères du bassin du Nord et du Pas – de – Calais: the coal basin of Nord – Pas de Calais [A/N].

[99] Melin, H. Loos-en-Gohelle, du noir au vert. *Multitudes* 2013/1 (No. 52), p. 60.

[100] [Sd] Un centre historique minier. In *Relais*, (HBNPC-Douai), n ° 56, janv. 1974, p. 15. Op. Cit. in: Thbaut, L. A monument of archeology industrielle: le centre historique minier des Houillères du Nord - Pas de - Calais à Lewarde. *Revue du Nord Numéro spécial: Douai et le Douaisis*, tome 61, No. 241, Avril-juin 1979. pp. 500-502.

[101] It corresponds to the European Regional Development Fund (ERDF) for research and innovation, the digital agenda, support for small and medium-sized enterprises (SMEs) and the economy with low carbon emissions. See: http://ec.europa.eu/regional_policy/it/funding/erdf/

interdisciplinary program brings together 80 researchers, examines the links between human activity and the environment in an industrialized territory since ancient times. The search path is based on three main axes: pollution analysis, geological-hydrogeological and socio-economic approaches. The main objectives of the program are to improve the knowledge and state of the art and the reinforcement of the scientific potential of this territory; at the same time the program takes advantage of a certain amount of favourable local resources as the improvement of knowledge in terms of transference of contaminant agents in the area, the reflection on the possibilities of treatment of pollution thanks to the use of the vegetation (phyto – decontamination), exchanges with regional and local actors[102].

- *Pole of competence on " contaminated sites and soils" (1995)*

It was created after the establishment of the Public Funding Nord – Pas de Calais as a place of interaction and exchange between different actors, such as government services, local communities, investors, associations and research laboratories for remediation and reclamation of polluted sites in the mining area. By this, the Pole has therefore proposed many solutions for the environmental problems resulting from pollution, initiatives for training and improvement of knowledge and the development of the researchers' skills as essential contributors in decision – making in the field of land reclamation and pollution of soils[103].

- *Standing Conference of the Mining Basin (1996) and implementation of the Mission of improvement and development of the Mining Basin (2000)*

This initiative, which is shared by the County Council, aimed at the opening of a debate on the emerging need for a shared project for the mining land management to guide the communities towards the exit from the doldrums consequent to the closure of the mines. In fact, the democratic participation has promoted a more complex knowledge and structured the possibilities of the territory, favouring therefore a better genesis of improvement projects: the first phase in 1998 has produced *de facto* the so-called White Book, whose projects were further explored in the second phase of the next year, in order to promote a global vision of development and interaction between those involved.[104] This initiative was then connected in the Agreement of the Interministerial Committee for the enhancement and development of the territory in December 1998 and led to the creation of the Mission Bassin Minier promoted by the State and by the Region.

In the years 2000 – 2001 a further step was taken in the path of territorial planning of the mining basin through the promotion and creation of two centres of research and enhancement on industrial goods, become immediately focal points in the preservation and dissemination of knowledge of the historical – cultural values of the main mining sites. They focused mainly on

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[102] Chautard, G., Zuindeau, B. enjeu durable des territoires d'une reconversion industrielle de tradition: the exemple du
bassin minier du Nord - Pas-de-Calais. *Espace, populations, sociétés, numéro thématique Les populations des bassins of industries lourdes*, vol. 19, No. 3, 2001 p. 335.

[103] Ibidem, p. 335.

[104] Ibidem, pp. 335-336.

Lewarde and Loos - en - Gohelle sites, which respectively house the Historical Mining Centre (CHM) and the Research Centre for Sustainable Development and are designed as multi – purpose containers oriented both to the issues of environmental recovery than to those of cultural divulgation, of study and research and on touristic and leisure purposes to be practiced in the whole territorial extension of the mining basin.

*Fosse Delloye*: from the extractive site to the Historic Mining Centre (CHM)of Lewarde

In 1973 the choice of the *Fosse Delloye* in Lewarde for the insertion of a research centre on the mining basin has resulted from several factors: firstly, at the time of the decision by the HBNPC, the site was about to be dismantled and all mining activities had stopped; secondly this complex was among the most representative of the mining and manufacturing architecture from the industrial past of the region, linked in particular to the economic recovery after the First World War[105]; finally, the architectural, formal and constructive signs imprinted on this heritage by the *Compagnie d'Aniche* are among the most relevant for their elegance and the oriental taste of the linguistic treatment of mining castles. The site is also located in prime conditions – intact in the state of assets, installations and connections – and it could then offer a good opportunity for conversion: it included the entrance buildings, rooms for the preparation to the work (offices, bath halls, lamp rooms), personnel walkways and storage, shafts and extraction machines, compressors halls, the sawmill and the stables. The roads of the *Delloye* pit also linked 7000 $m^2$ of industrial buildings gathered in a site of almost eight hectares[106], inserted in a central point of the spatial context of the coal basin, in the vicinity of both highways and the headquarters of HBNPC.

In the first phase of installation of the Centre the HBNPC took the leading role: the conservation work and the restoration of the buildings were already undertaken in 1976[107], in conjunction with the definition of the objectives through which it wanted to achieve namely "*the conservation of a site of the period where coal was the main source of energy, the collection of materials and tools, reassemble the documents relating to industrial, artistic and social life of the region"*[108].

In the 1980s they had already made a first exhibition room, reception services for the public and an auditorium. The central point of the project was to achieve an appropriate balance between the installation of services to the public and to fully respect the authentic connotations of the mine: in that sense the exhibition of machineries made in 1986 between the two buildings of mines responds to the criteria of highlighting the architectural parts added to the original and those of immediate comprehension of the buildings and machinery thanks to the transparency of the used materials.

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[105] Debrabant, V. Le cheval de la fosse au musée: the exemple du Centre historique minier. In *Situ* n. 27, 2015, p. 2. Available at: insitu.revues.org/12121

[106] Ibidem, p. 2.

[107] Thbaut, L. Un monument of archéologie industrielle: le centre historique minier des Houillères du Nord-Pas-de-Calais à Lewarde. In: *Revue du Nord numéro spécial: Douai et le Douaisis*, tome 61, No. 241, Avril-juin 1979, p. 502.

[108] Debrabant, V. Le cheval de la fosse au musée: the exemple du Centre historique minier. In *Situ* n. 27, 2015, p. 3.

Figure 18. The Centre Historique Minier in Lewarde. Phot. Couchaux, Denis. © Denis Couchaux.

Figure 19. The glass block which holds the extraction machines. Source: www.voyagerenphotos.com

*The second phase*

This research for integration and independence of the original parts from the new ones is also the basis of the second phase of the works, carried out by the Association of Old Mining Towns after the closure of coal mines: this phase lasted from 1999 to 2009 and concerned the work of architectural renovation and museological installation of the site. The modernization and integration of the collective functions, launched in April 1999, was drawn up by the architectural studio Atelier November[109]and involved the insertion of a new body, superimposed to the

[109] The November study was in charge of the architectural design and museological with the assistance of *Complémenterre* for landscaping. The works were performed by the SEPAC Société d'Équipement du Pas-de-Calais. See: Paris, A. Le centre historique minier de Lewarde. Objectif: accueillir plus, accueillir mieux. In Dorel – Ferre, G. (Ed.). *Bulletin de Liaison des Professeurs d'Histoire-Géographie de l'Académie de Reims*, n. 27, 2002.

conference rooms and the archives located in the underground, connecting the ancient volumes through tunnels.

The first design intent was primarily to set in the historic buildings of the mine all the services of the Mining Centre, i.e. the administration, the ticket office, shops, meeting rooms etc. ... Secondly, there was the need for contractors and designers to offer to visitors the highest degree of authenticity of the site, making it as readable as possible: in this way the removal of added neo – Roman parts in the Eighties, which had masked the internal architecture of the shaft, has helped to bring to light the true nature of the walls and parts of the original levels. The third functional key of the project was the coherence of the centre and the increasing comfort for visitors who, in the mid-2000s, had reached a total of 150,000 year[110].

Finally, the redistribution of the collections in the permanent exhibitions held in the heart of the mine was to make the audience discover not only the mining site but also the scientific, geological and historical heritage of the mining area of the entire Nord - Pas de Calais, as well as the life in mining towns and the urban layout of towns. The visit of the mine then follows the path of the miners, which is the entrance to the workplace from the garages of bicycles, the preparation and equipment area in the rooms of the baths and then in the lamp room,then along the personnel walkway and in cages to reach the work sites – which are the reconstructed circuits of the excavation of tunnels and coal crushing – and those on the surface as the sawmill, the engine room and the stables.

*The creation of the new museum and reception facilities*

A new building houses the entrance hall, a café, a 200 – seat auditorium and meeting rooms. Researchers have available spaces adapted for the best viewing of documentaries of the museum funds, which include 500'000 photographs, 600 films, 7000 books and 2500 linear meters of archives[111].

The restoration of the site has also included the reconstruction of part of the mining railway and the exchange booth.

With a total of more than 4000 $m^2$ of new or restored buildings and 19,000 $m^2$of outdoor spaces retrained, an investment of 7.20 million Euros, the CHM has completed in 2005 the host project to 170,000 visitors a year in excellent and comfortable conditions[112].
For the project of the new reception room, door-input to the site, the architects opted for a transparent volume, made of a metal frame and glass, as opposed to the large glass area of the machines: it marks a clear boundary between the site's industrial history and the contemporary museum of the mine. The hall also houses the temporary exhibition halls, the information centre

[110] Debrabant, V. Le cheval de la fosse au musée: the exemple du Centre historique minier. In *Situ* n. 27, 2015, pp. 4-5.

[111] Paris, A. Le centre historique minier de Lewarde. Objectif: accueillir plus, accueillir mieux. In Dorel - Ferre, G. (Ed.). *Bulletin de Liaison des Professeurs d'Histoire-Géographie de l'Académie de Reims*, n. 27, 2002.

[112] Paris, A. Le centre historique minier de Lewarde. Objectif: accueillir plus, accueillir mieux. In Dorel - Ferre, G. (Ed.). *Bulletin de Liaison des Professeurs d'Histoire-Géographie de l'Académie de Reims*, n. 27, 2002.

for groups and a café; thanks to the modularity of the spatial composition, temporary rooms allow the coexistence of nature and exhibit different sizes in the same area.
The new pavilion also houses the administrative functions and meeting rooms, which are also modular, and the auditorium with 192 seats.

Figure 20. The front entrance of the CHM. Source: www.voyagerenphotos.com

The laboratories are in the north in a new building located near the old woodland park. The symbolic image of the main wood stocks was the main theme of this project, both in terms of its articulation than in the use of materials[113].

The outdoor spaces are integrated in the course and in museological flows, in line with the provisions for the full restoration of the heritage: the boundaries of the site, the openings into the woods, signage, restoration of timber warehouses and differentiated treatment of flooring underscore the link with the mining environment and strengthen the role of the forest as a truly functional part of the identity of the mine. The treatment of the surfaces of old and new buildings using beams of light highlights the architectural and the material values of the industrial heritage within the Centre[114].

[113] Atelier November. Centre historique minier - préfiguration du musée et création de site d'accueil des structures. Source: http://novembre-architecture.com/projet/centre-historique-minier-de-lewarde-59/

[114] Paris, A. Le centre historique minier de Lewarde. Objectif: accueillir plus, accueillir mieux. In Dorel - Ferre, G. (Ed.). *Bulletin de Liaison des Professeurs d'Histoire-Géographie de l'Académie de Reims*, n. 27, 2002

Figure 21. The central block lit up for the night of the museums. Source: www.tourisme-nordpasdecalais.fr

*The museum project*

As for the museographical offer, the Centre hosts a permanent exhibition dedicated to the historical phases of the mine and the entire coal basin, from the Eighteenth to the Twentieth century, enriched by the presence of furnishing that allows visitors to flow quickly through the hall or stopping to deepen their knowledge. Each historical period is emphasized by two emblematic elements: a character linked to the history of the Fosse *Delloye* or the *Bassin minier* – for the Eighteenth century Antoine Delfosse, a miner; for the Nineteenth century the Union Leader Emile Basly and for the Twentieth century Alexis Destruys, mining engineer – and a particularly symbolic object – the church bell created by the Society of Anzin in 1789, the sculpted group "The strike" by the sculptor Corneille Theunissen of 1891 e a big statue of a miner by the artist Janthial of 1955[115]. To make even more accurate the reading of the architectural works and technical instruments used in the normal life of the mine, the permanent exhibition displays models of the main technological innovations for each period: a 1700 steam engine; a model of Magny shafts in the Blanzy basin in Burgundy of the Nineteenth century with a wooden mining pit; finally a model of *Grand-Conde* shafts of the mines of Lens in 1900 with a reinforced concrete *chevalement*.

[115] Paris, A. Le centre historique minier de Lewarde. Objectif: accueillir plus, accueillir mieux. In Dorel - Ferre, G. (Ed.). *Bulletin de Liaison des Professeurs d'Histoire-Géographie de l'Académie de Reims*, n. 27, 2002


Figure 22. Part of the permanent exhibition. Source: www.voyagerenphotos.com

*Fosse* 11/19 to Loos - en – Gohelle: a centre for the research on sustainable development.

The 11/19 site in Loos en Gohelle is one of the most emblematic in relation to the mono – industrial character of the entire coal industry in the Nord Pas de Calais, along with the Arenberg, Oignies and Lewarde sites. In September 2002 the Organization Bassin Minier UNESCO has pursued the application of this mining centre as a World Heritage Site, making a significant research work together with local associations and local actors to inventory and classify the assets that it holds to produce the most possible eloquent file of the historical, cultural, architectural and social development of this region.

The course of rehabilitation of this site, after the closing in 1986, dates to 1988 within the program "Rehabilitation of dismissed industrial areas", which envisaged as a first step to restore the vegetation: while the *terrils* were kept in their original state as mineral deposits, the platform that separates them and the surrounding lands was planted and converted into a green belt that emphasizes the extractive character of the mining slag heaps. Part of the site was also subject to a pre - planting while some lots were reserved for the testing of new fruit, floral and decorative species[116].

[116] Vancaille, M. Caron, JF (Eds.). *Base 11/19 Loos-en-Gohelle site de référence du développement durable*. [Sd]: [sd], p. 3.

Figure 23. Panorama of Loos - en - Gohelle by Terrils. Source: www.euralens.org

*The* terrils *as a memory of places*

Of the 340 hills of waste material from coal mining in the Nord - Pas de Calais in the 70s, about 200 are currently preserved. Most of them were in fact mined to extract shale to be used in the asphalting of the roads, but only recently it was decided to preserve these elements of the HBNPC territory to witness their historic role of waste repositories: in the site 11/19 the slag heaps, or the *terrils,* represent green oases inhabited by different plant species in a context now fully urbanized and serve as habitat for numerous rare species. Thanks to the warm microclimate despite the absence of combustion – which comes on the storage of solar heat by virtue of the black colour – and the lack of fertilizers and pesticides, this ecosystem includes often non - regional animal and plant species that found in the *terrils* an ideal habitat for their survival and dissemination. In Loos - en - Gohelle the original deposits were transferred from their seat at the base of the mining castle through a conveyor belt connected to the structures of washeries, while those coming from the central washery in Vendin - le - Vieil were transported by train[117].

[117] Country of Art and History of Lens - Liévin (Ed.) *Listen to the story of the 11/19*. Lille: The Artésienne, 2012 [?], Pp. 18 - 19. Available at: www.tourism-lenslievin.co.uk


Figure 24. The two *terrils* and on bottom left the site 11/19. Source: Google Earth

*The process to update the perspective of environmental sustainability*

In 1990, to prevent the demolition or the loss of the very high value of 11/19 Shaft, this was bought by the city of Loos – en – Gohelle and in 1992 its metal castles 11 and 19 were enrolled in the Extra Inventory of the Historical Monuments[118].

In 1996 the great project for the site conversion, which became in this way *Base 11/19*, marked a turning point compared to past experiences with the actual start of the first tranche of the works for the improvement of mining structures and territory: the State, the Region, the European Community, the Syndicate of Municipalities of Liévinois, the Department of the Pas de Calais, the Lens - Liévin District and the town of Loos – en – Gohelle agreed to allocate 27 million Euros for the first phase and further agreements between privates allowed the allocation of more than 15 millions of Euros[119]. Works began in 1997 and focused on the roofing and waterproofing of about 16000 $m^2$ of buildings, the opening of a reception centre for the public, the enhancement of t*errils* and their surroundings. For what refers to the road system and the new routes the *CommunAupole* of Lens - Liévin[120] intervened in the realization of roads, parking lots and for the final landscaping configuration; the *Établissement Public Foncier* (EFP)[121]

[118] Vancaille, M. Caron, JF (Eds.). *Base 11/19 Loos-en-Gohelle site de référence du développement durable*. [Sd]: [sd], pp. 4-5.

[119] Ibidem, p. 5.

[120] It is a community of Urban Agglomeration which includes 36 municipalities and more than 250,000 inhabitants in the territory of Lens and Liévin. In 2000 ownership of the site shifted to 11/19 CommunAupole Lens - Liévin. Source: http://www.communaupole-lenslievin.fr/index.php?alias=historique

[121] Literally Public Establishment Foncier: a public institution of an industrial and commercial nature (EPIC) that negotiates and carries out the procedures for the constitution of land reserves upstream of land development projects. See: Établissement Public Foncier Nord - Pas de Calais, founded in 1990 to address the crisis of industrial and urban redevelopment started in the late seventies. www.epf-npdc.fr/

oversaw the terraces and the distribution of new channels and circulation networks in the whole site[122].

The buildings of the 11/19 site, hitherto unemployed, have been restored and requalified: bathrooms and showers kept the "the halls of the hanged " i.e. suspended installations where miners' uniforms hung out to dry back from the quarries; the site also includes administrative buildings, management offices, workshops, condensers halls and so on. All these buildings were connected and placed in the central perspective with respect to the surrounding space through an square opened towards the surrounding neighbourhoods to emphasize the dominance of the mine inside the urban configuration and in the life of the inhabitants in the mining area[123].

The main route of the conversion project was the construction of an Ecopole where the will to safeguard the mining heritage would combine with a durable and sustainable model of development, through the creation of natural areas, biological corridors, study centres and entertainment for the communities of the mining basin. One of the first steps in this direction was the creation in 1998 of the *Chaîne des terrils,* i.e. the chain of *terrils*, for the preservation of the natural and industrial heritage inherited from the now closed mines: the means of intervention look at the participation and education of communities in the development of heritage, proposals for leisure activities and tourism and the development of awareness of environmental issues[124] [125]. Among the initiatives we remind the Permanent Centre for Environmental Initiatives in 2001, the inauguration of the Circuit "From the mine to the Louvre" by bus in 2005 and the interventions of pre – ecological diagnosis of 129 *terrils i*n partnership with *Établissement Public Foncier* of the mining region.

A second intervention by an economic – business matrix is the creation of Jardinerie Delbard in 2000, a cultivation centre and sale point of garden and agricultural products, designed to optimize the use of natural resources (such as collecting rainwater) and the integration of lots and parking with the natural landscape and the architecture of the site[126].

At the base of the initiatives promoted in order to develop the program of improvement and rehabilitation of the site there is an eco – improving chart that integrates the themes of water, energy, waste and sustainable materials and sets the requirements defined by the Program *Haute Qualité Environnementale* (High Environmental Quality), designed by Studio Act Environment[127]: for example, the use of materials from certified origin and risk-free for users and residents of the area; rainwater management by collecting and channeling inside the buildings

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[122] Vancaille, M. Caron, JF (Eds.). *Base 11/19 Loos-en-Gohelle site de référence du développement durable.* [Sd]: [sd], pp. 5-6.

[123] Ibidem, p. 5.

[124] Ibidem, p. 2.

[125] Caron, J. F. Loos - en - Gohelle, villas pilote du développement durable. In Fondation Jean-Jaurès / Observatoire de l'innovation locale (Eds). *Notes* n. 14, février 2014, pp. 5-6.

[126] Perdrigeat, J. *L'écologie en action, 30 ans de développement durable appliqué à Loos-en-Gohelle*. License Creative Commons, 2014, pp. 7-9.

[127] Vancaille, M., Caron, J.F. (Eds.). *Base 11/19 Loos-en-Gohelle site de référence du développement durable*. [Sd]: [sd], pp. 5-6.

to feed the toilets; control of energy consumption with the use of low-consumption bodies and gas condensing for high-efficiency boilers; promotion of green building sites and eco – buildings; promotion of urban transport sustainably fuelled.

Works on buildings have been designed to create a harmonious relationship between the buildings and the surrounding environment, starting with the rehabilitation of the old workshops of the shaft 19 converted into incubators of eco - companies for which the energy management program complies with the directives HQE. Secondly the intervention of the Agency Cd2e has established itself as the only true global player in the renewal of the site thanks to the sharing of environmental experts and has prepared several tools to achieve high quality standards in the management of the *11/19* Base : the creation of activities and new businesses in the environmental sector and sustaining the existing ones for the preparation of a range of services in the field of land reclamation, environmental remediation, international development and partnerships; the development of knowledge and understanding of issues related to pollution and disposal of the materials with the establishment of a research team, called TEAM[128], for the manufacture of recyclable materials, the development of skills for the analysis of the life cycle of materials, the promotion of green sites and remediation of polluted sites, as well as the installation of an energy pole based entirely on photovoltaic through a solar power plant . Within this process of energy and environmental sustainability renewal, the Cd2e implanted in the site a true Theatre of Eco - building to inform and provide concrete tools on low – environmental impact techniques and building regulations: the exhibition includes three levels of study (thermal performance, management of impermeability to air and use of eco – materials), a showroom of materials to present the products and to take note of the technical and commercial properties of the proposed solutions, a lot of didactic tools to teach about the sector technologies, simulate excellent solutions and the real time achievable performances.

Since 2001 in the site of Loos - en - Gohelle there is also another institution of environmental and energy research, the *Cerdd*, or the Resource Centre of Sustainable Development, which operates in six main thematic addresses: climate change, sustainable territories, sustainable power, economic transitions, biodiversity and sustainable urban planning. The Centre's mission is to accompany local, regional and national actors towards new models of society and business, encouraging agreements with stakeholders on the use of best practices, saving environmental resources, dissemination of experience and references practical in the field of corporate sustainability and construction projects.[129].

*The ateliers: incubators of eco - sustainable enterprises*

Since 2008 the *CommunAupole of Lens - Liévin* has chosen to convert an old factory into a business incubator as a centre for the establishment of offices and workshops, thus creating another exemplary piece of the Pole of Reference of Sustainable Development that underlies the

[128] TEAM: Environment Appliqués aux Technologies et Matériaux.

[129] Perdrigeat, J. *L'écologie en action, 30 ans de développement durable appliqué à Loos-en-Gohelle*. License Creative Commons, 2014.

entire recovery program for the site[130]. In this specific case the *CommunAupole* exploited the environmental dimension and the social, cultural and economic values to build the edifice according to the standards of the High Environmental Quality, translating them into practice in the use of sustainable resources such as solid wood, heat exchangers, photovoltaic cells, water management, natural light and summer comfort.
From September 2008 the studios welcome the first business incubator, consisting of four laboratories, ten offices and a large meeting room at the tenants' disposal. The two-storey buildings, with variable surfaces from 25 to 55 $m^2$, feature the ability to group multiple cells to reach a total size of 150 $m^2$ [131].

The transformation of an old workshop into a new efficient and materially composite building had to face with the preservation of the highly industrial and environmental vocation of the 11/19 site, having to opt for volumetric and material choices such to not compromise its coexistence with the existing architectural heritage. In virtue of the functional program and of the urban, the architectural and the environmental analysis the new atelier of ecological architecture assumes a physiognomy faithful to the original building in the ground floor by maintaining the building's original brick façades, and asserted itself with an appendix on the upper floor resting on the porches beneath and covered by Corten steel.[132] This formal and structural choice allowed to gain one more façade over the existing building without falling in the mistake of a “caricature” of a juxtaposed extension, keeping faithful to the *genius loci* through an architecture that plays with the dimension of the complex in a dynamic and contemporary way as a symbol of the renovation of the site.
In this way, once passed the entrance to the site, the excrescence on the first floor becomes a clearly visible signal also thanks to the movement that the new body accomplishes respect to the ancient masonry-built *pied-a-terre*. The offices housed in the complex are flooded with natural light from the façades and the central windows that have the capacity to adapt to the season and the climate in order to manage the overheating in summer and glare: when the temperature exceeds 25° C inside the central window, this is protected by the outer tents that will automatically fold in case of strong winds, while the night in the hottest days the window frames are opened so as to introduce into a stream of fresh air, which helps to cool the building before the resume of the normal daytime activities, and close automatically in case of rain. The ventilation is controlled by the same occupants through the openings in the façades and roofs, as well as the contribution of natural light and heat through external curtains placed in the west façade. Thanks to hygrothermal comfort simulations, it has been possible to study the best solution for the summer behaviour under the least favourable conditions, namely the glazed offices facing to the west: in this way the occupants of the *bureaux* can enjoy the exceptional

[130] Euralens (Ed.). *Livret Euralens No. 3: Quelle dimension métropolitaine pour la 11/19 Base? Compte rendu du Cercle de qualité Euralens du 19 juin 2014*. [sd]: [sd], 2014, p. 15.
[131] CommunAupole Lens - Liévin (Ed.) *Pépinière d'éco-entreprises de la Base 11/19 à Loos-en-Gohelle*. [Sd]: [sd], p. 2.
[132] CommunAupole Lens - Liévin (Ed.) *11/19 Loos - en - Gohelle. Restructuration ateliers en Pepiniere eco-entreprises*. [Sd]: [sd], p. 2.

views that open up the entire mining site and at the same time preserve good thermal and visual comfort conditions thanks to a sensitive architecture, attentive to environmental components.

Figure 25. The business incubator today. Source:www.agencehouyez.com

To optimize the energy consumption related to artificial lighting the Atelier of Ecological Architecture has experienced through the simulations of the daily bright factor specific tools that allowed to reach a daily quantity of natural light equal to 6.7%, which corresponds to the sufficient amount to limit to a minimum of artificial resources. The breakdown of the natural light is therefore a guarantee of energy saving during the day because it reduces the need for intake of artificial light during the 70% of the duration of use of the offices for a total average from 8 to 18 hours throughout the year[133]. The same Atelier has proposed the installation of low-temperature emitters (gentle heat) to limit the thermal gradient between the head and the feet, causing discomfort, while the thermal inertia makes possible to rapidly heat the rooms and encourage the contributions of solar energy, minimizing temperature variations. Furthermore, the use of low emissivity glass with a core of argon reduces the effect of cold wall. The electricity production is entrusted to photovoltaic solar panels installed on the roof terrace or integrated into windows, dimensioned to provide the necessary amount of artificial lighting of the building, and the excess production is sold back to the French Electricity Company (EDF)[134].

The maintenance of brick linings of the existing façades has avoided the application and the manufacture of new materials, while in the addition they have opted for beams and reinforced steel frames for supporting the overlapping cells containing the protrusions of the offices. The use of solid wood for the construction of walls, intermediate floors and ceilings made possible to find the right stiffness through a limited weight than the corresponding in reinforced concrete, an inertia adapted to the comfort of the offices and a limited need for materials thanks to a level of finishing that can be left exposed. The assembly of these wooden panels has been further refined by an insulating layer made of wooden wool, 20 cm thick in the shell and 14 cm in the walls,

[133] Ibidem, p. 3.

[134] Ibidem, p. 5.

which completes the construction of the building cycle respecting the will of the use of renewable materials, little wasteful of energy to manufacture and easily recyclable, removable and reusable. The distribution and the manufacturing flexibility also allows you to predict in future a further formal, structural and functional evolution thanks to the highly innovative nature of the entire Loos - en - Gohelle site [135].

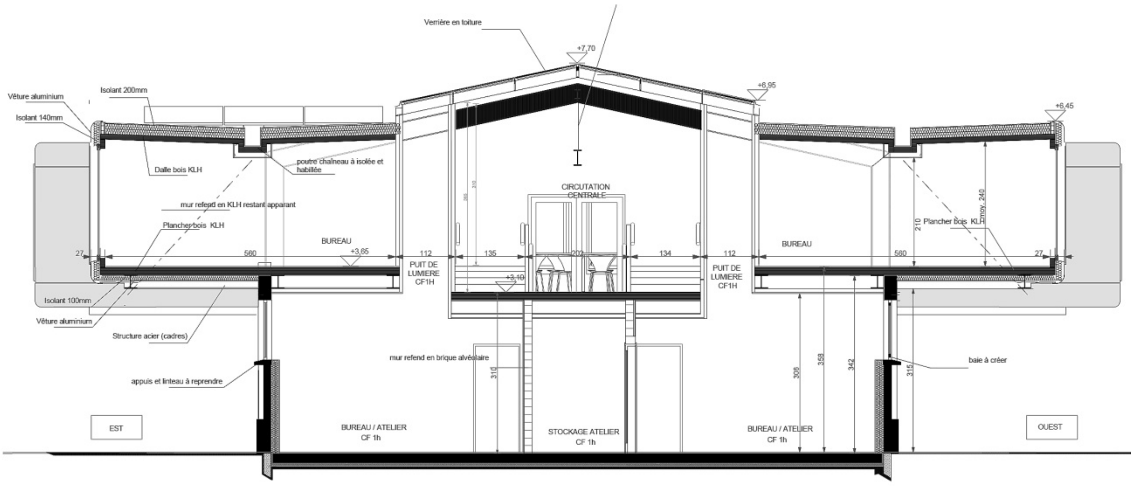


Figure 26. Section Project of newly added bodies. Source: CommunAupole Lens - Liévin

Figure 27. Front office. Source:www.agencehouyez.com

*The LumiWatt platform: research centre of renewable energy*

Since 2011 Cd2e has entered in the 11/19 Eco-pole a platform for research and development of solar energy, called LumiWatt, with 22 laboratories for testing 10 types of photovoltaic cells. The research program has therefore revealed a new and independent window on the issues of renewable energy, developed in two distinct phases to go from test phase to the implementation of the forms of green power with the introduction of wind energy.

In phase 1 of LumiWatt platform – launched in 2011 in partnership with the Cd2e, the City of Loos - en - Gohelle, the Électricité de France (EDF) and *France Développement Electronique* (FDE) to encourage the development of photovoltaic in a moderate sunlit zone – the desired objectives were initially submitting to local and regional stakeholders the photovoltaic potential

[135] Ibidem, p. 4.

as a form of alternative energy supply in those latitudes, the formation of industry employees and future beneficiaries of photovoltaic, researching and development of this technology and the dissemination of results. Photovoltaic systems are installed on 22 fixed or mobile structures of 3 kWp each to study the behaviour under different climatic and meteorological conditions in order to analyze the results, which are annually and monthly spread to the public[136].

Phase 2 began in 2015 and is based on the perspective of *parité réseau*, theory according to which the renewable sources of energy could be implemented without the need for special subsidies if their cost falls below that of the electricity on retail market, putting thus in evidence the logics of consumption promoted by Horizon 2018 protocols for residences and Horizon 2020 for professional and productive infrastructure. This initiative is obviously inserted and connected to the regional strategic frameworks of the Country, particularly in relation to climate dossier contained in the Regional Scheme of Improvement and Sustainable Development of the Territory (SRADDT)[137], whose objectives correspond to the transition from the "performance of production" to "performance of the uses" or the reinforcement of knowledge of potential actors involved in the introduction of solar photovoltaic. The actors become thus the proponents of this change of paradigm in the field of the energetic technology. The instruments used for this to happen include then the testing of future applications of the medium-term renewable energy to stimulate an economic interest in the regional actors, the storage and the presence of these forms of energy alongside traditional ones depending on the "production vs. needs" factor and the intelligent control of the distribution at the local level. At this stage it is also envisaged the "mixing" of different sustainable energy supply technologies.[138].

Figure 28. LumiWatt Solar Platform. Source: www.Cd2e.com

*The cultural offer: Culture Commune - scène nationale*

It is an inter-municipal association for the artistic and cultural development which brings together 34 municipalities of the Nord - Pas de Calais mining area in three communities of agglomeration (the Lens - Liévin, the Hénin – Carvin and Artois Comm). The main office is in the Factory Theatre run by *Culture Commune* and located in the former premises of the mining site, whose mission is the promotion and the organization of live shows and entertainment.

[136] See LumiWatt Phase 1 available in www.cd2e.com/?q=expertise/energies-renouvelables/lumiwatt-phase1

[137] See LumiWatt Phase 2 comes in www.cd2e.com/?q=expertise/energies-renouvelables/lumiwatt-phase2

[138] Ibidem.

Founded in 1990, the *Culture Commune* is the result of a concerted effort at local and regional levels that wanted an association for the adoption of the new cultural policies and initiation to new artistic projects in all possible forms for the benefit of the population and its direct participation. The settlement within the site was concerted basing on the artistic, cultural and social project of the Ecopole 11/19 of Loos - en – Gohelle, promoted in 1995 under proposal of the director Chantal Lamarre. The cultural centre is in fact located within the Hall of Hanged, the former miners' changing room, that was renamed Factory Theatre and houses: 22 people who make up the team; the artists among whom the resident groups disseminate their knowledge and sensitise young people to the artistic practice with local exhibitions; the Centre for the Contemporary Theatrical and Writing Resources (CRET) opened to everyone, which reviews many theatrical pieces, artistic and cultural magazines[139].

Over the years numerous collaborations have been undertaken with the municipalities, the communities of agglomeration, the schools, the University of Artois and cultural associations giving rise to interesting events such as the European Festival of street arts, entertainment and inaugural soirees in collaborations with the Louvre – Lens Museum etc.

The project for the construction of a second Factory Theatre was carried out on the initiative by the Lens – Liévin Community and *Culture Commune* in terms of the need for new spaces for the development of cultural functions in the site of Loos - en - Gohelle. In 2012 5 possible scenarios for the exploitation of free surfaces were proposed by the *Polyprogramme* team (consisting of *Polyprogramme*, *Kanju*, *Behi*, *SCB économie,* Atelier *Rouch*), ranging from 3500 to 4500 $m^2$: the new features included a rehearsal room, the production hall, administrative offices and premises for other members of 11/19 Base. The project proposals according to five different buildings included new buildings adjacent to existing ones, the rehabilitation of the Factory Theatre n.1 and the gradual reconversion of several part of the building standing at the base of the metallic shaft and the building below[140].

Figure 29. La Fabrique Theatrale in 2010. Source: www.euralens.org

[139] Euralens (Ed.). *Livret Euralens No. 3: Quelle dimension métropolitaine pour la 11/19 Base? Compte rendu du Cercle de qualité Euralens du 19 juin 2014*. [sd]: [sd], 2014, p. 11.
[140] Ibidem, p. 24.

## Conclusions: strategies for a further recoversion of Monteponi

*Synthesis of the actions of recovery and reuse of the European mining heritage*

At the light of the experiences of valorization and reuse of the mining heritage in Italy, France and Belgium we aim to synthesize the applied methodologies through a comparison of the various scenarios, in order to further formulate the possible strategies for the reconversion and the promotion of Monteponi's heritage.

| Years | 1970s – 1988 – 1990s – 2008 – 2010s | 1980s – 2000s – 2010s | 2000s |
|---|---|---|---|
| Actions | France | Italy | Spain |
| Preservation of historic buildings | Mining buildings, shafts, workshops | Shafts, workshops, industrial facilities | Mining buildings, shafts, workshops |
| Preservation of environmental elements | *Terrils* as landmarks, green belts | Water tanks, *decantaters*, hydraulic plant | Galleries and urban settlements, mining fences and historic routes |
| Remediation of polluted areas | Pole of competence on "contaminated sites and soils" | - | Remediation of mercury – polluted areas |
| Scientific and researching facilities | Centre of Sustainable development and Eco-pole | - | - |
| Cultural facilities | Factory Theatre, Archives, Conference Rooms | Public Library, Museums, Theatre, Archives, Dissemination Facilities, Conference Rooms | Centre of Interpretation, Museum, Mining Archives, Conference Rooms |
| Energetic enhancement | *LumiWatt* platform | Water – recycle, energetic enhancement of buildings | - |
| Economic development | Business incubators | Food exhibitions and sales, hostels and accommodations | - |
| Main strategy | Energetic – economic | Cultural and short – distance tourism | Cultural and specific tourism |
| Attractive/determining factors | Heavy energetic development/resources | Well – known touristic destination | Short distance tourism and investigation |
| Intensity | strong | medium | light |

These actions could be translated then into methodologies or strategies applicable to Monteponi case in terms of touristic development, environmental remediation and preservation of buildings, with the further implementation and installation of services and facilities on the basis of those installed and promoted in the case studies.

Synthetically we might define two hypotheses for the case study where the main aims of the interventions define the most important actions to be done for the valorization of the heritage and its environmental surroundings:

| Actions | Monteponi | |
|---|---|---|
| Preservation of historic buildings | Mining buildings, shafts, workshops | Shafts, workshops, industrial facilities |
| Preservation of environmental elements | *Scoria* and slag heaps as green belts and public areas, water tanks | Water tanks, *decantaters*, hydraulic plant |
| Remediation of polluted areas | Pole of competence on "contaminated sites and soils"<br>Remediation of polluted areas<br>Identification of strategies and actions to be set in the further years | - |
| Scientific and researching facilities | Centre of Sustainable Development and Eco-pole | - |
| Cultural offer | Museum of the Mine, Mining Archives, Conference Rooms, Dissemination activities | Guided tours, exploration of the site, Centre of Interpretation, Museum, Mining Archives, Conference Rooms |
| Energetic enhancement | Photovoltaic platform for the energetic independence | - |
| Economic development | Business incubators | Food exhibitions and sales, hostels and accommodations, transports |
| Main strategy | Energetic – economic - environmental | Cultural and short – distance tourism |
| Attractive/determining factors | Availability of huge areas, highly signifying heritage | Connection to other mining poles to create a territorial web of touristic – cultural resources |
| Intensity | strong | light |

The actual conditions of Monteponi mine may therefore suggest two different approaches for the reconversion and the restitution of the heritage to a new life: the first would be a soft concept that involves the whole mining heritage for a touristic purpose, in order to disseminate the most important values of the heritage in an educational and relaunching optic. The second option would be more intense, in the way that it would set a new functional organization for the majority of the building in order to create a web of services, which would go beyond the mere touristic fruition to foreseen the reuse of several facilities and the implantation of permanent functions.

*First strategy*

The "soft" approach would therefore see the creation of those services required for the touristic purpose, i.e. ways of access, transporting services, restoration and leisure facilities, along with the educational and cultural means to divulgate and to teach the history of the site, its evolution and the most important elements linked to the exploitation of lead and zinc. The visit would thus be the main purpose of the touristic approach and might lead to a creation of further connections with the other mining sites of the area, which are already interested by touristic programs and explorations, e.g. Flavia Port in the coast, the *Italian Centre for the Culture of Coal* in Carbonia and the inner mines such as Rosas.


Figure 30 The main entrance to Porto Flavia. Source: IGEA Spa

Figure 31 The Museum of the Coal in Carbonia. Source: Museo del Carbone.

The main objectives of this strategy would therefore be the availability of suitable paths and areas to set the route of the visit, to create a visitors' centre and to guide the exploration of the mining site, mainly dedicated to the explications of the historical traces of the compound and the exploiting works from the ancient times until the closure. The visitors could explore the site up to the peak of the hill where they may discover the panorama towards the valley and Iglesias, the ancient core of the first exploitations and the remains of the ovens and workshops for the extraction and treatment of calamines from 1870s.
The mine would therefore become one of the main points of exploration of this mining region and would feature a temporary presence of users and visitors, creating a new pole of attraction for the discovery of its heritage and of the main town: the seasonal touristic fluxes that interest this area mainly in spring-summer periods should be turned into permanent fluxes in order to create a proficient approach to the site and an economical feedback for the local communities. The territorial connections could be provided through the involvement of transport companies for the vehicular movements and through "green" paths in order to set a web of pedestrian and cycle routes and paths: these options would be sustainable thanks to the already built cycle lanes in the Municipality of Carbonia that connect the town to the land's end. A more "invasive" solution would aim the recovery of the ancient railway tracks that connected Monteponi to Vesme Port and to Iglesias Railway station, allowing thus to move visitors and personnel directly from Cagliari and from the peripheral areas of the southwest coast.

However, there would not be a further development in the fruition of the whole compound in order to investigate its environmental and architectural issues, but the teaching and the dissemination of the historical data. The already-planned use of Sella Shaft as a Museum dedicated to the mine would certainly be suitable for the completeness of the cultural and social program since it could house several of the main didactic functions and become the core of the exposition thanks to the restoration of the machineries and the rooms. Referring to the environmental components, there would not be a modification or a remediation of the problematic affecting the soil and the air, i.e. metallic pollution and possible damages due to dangerous elements in the aquifer, but it would keep as a further instance to be solved in a future remediation program. The main reference for this strategy looks to the case of Almadén and the revival of the mine thanks to the touristic approach, consisting in guided visits into the most attractive facilities, the exploration of the galleries and the transformation of the majority of the buildings into didactic points, such as the Museum of the Mercury and the Visitors Centre. The typological and constructive affinities between the Spanish and the Sardinian cases may in fact suggest similar approaches, since the recovery of both the heritages would follow the cultural and touristic addresses in order to create a web of actors and actions able to disseminate and valorise the historical, technological and landscape values.

The involvement of local actors, such as public administrations, organizations and associations, transporting and accommodations consortiums and trained personnel (e.g. guides, tour operators etc.) and the Sardinian Mining Geopark, to which compete the preservation and the valorisation of the mining heritage, would turn into a global web of actions that could improve the promotion of this site along with the other mining poles and start a new economic and social deal in this territory. Briefly we may identify these figures through the definition of skills, locations and actions as in the following scheme:

| Actions | Actors | Site / Location |
|---|---|---|
| Guided tours and training for personnel | Trained personnel: accredited guides, tour operators, local consortiums, Public Administration (Municipality, Departments for Touristic promotions), Tourists office, faculties of History, and Geology | · Monteponi<br>· Iglesias<br>· Cagliari |
| Food and beverage | Local businesses, suppliers, catering Institutes, Ho.Re.Ca. services | Compound of the Ex Calamine Washery |
| Didactic activities | · Introduction to the site<br>· Explication of the history of exploitation, mining works, evolution of techniques and technologies for the extraction of lead and zinc etc.<br>· Visit to the galleries and to the mining village | · Museum of the Mine (Sella Shaft)<br>· Visitors Centre (Bellavista Villa)<br>· Mining Archive (existent)<br>· Galleries and tunnels |
| Leisure activities | Sports: running, walking tours, cross country | · Natural paths |

| | | |
|---|---|---|
| | Relaxing and lounge areas | · Green areas<br>· Terraces and belvederes |
| Links to the other mining poles | Bus Companies, Car Rentals, Public Administrations, Railway Companies, Bicycle Rentals | · Former railway tracks and stations<br>· Green paths for sustainable connections<br>· Road infrastructures |
| Accommodations | Local Consortiums and Associations, Touristic Office, Municipalities, Hosting facilities | · Scattered Hotels, local B&Bs and Hotels<br>· Monteponi's Guest House |

*Second strategy*

The "strong" approach, on the contrary, would provide a permanent and a differentiated use of the site with the implantation of facilities that allow the stable presence of a certain number of functions and people to reanimate the exploitation and the development of this mine. The referring example is certainly the reconversion of the French mining heritage as in Lewarde, where the main axes for the new development of the site aimed to turn it into an economic pole to set up business incubators, researching activities linked to the environmental and energetic issues and leisure facilities. The main purposes of this address would be the reconversion of the whole site from both a functional and an environmental point of view according to the settlement of a pack of services and facilities that count:

A researching pole on the environmental issues that affect the site: given the high level of toxicity that affects the environment in Monteponi – as a result of centuries of exploitations of heavy metals – there is firstly an urgency for the remediation of the polluted soils and natural environments. The lack of previous actions in this direction probably determined the failure of precedent projects for the reuse of Monteponi, since it is unavoidable that the reclamation of soils is at the base of any action of development and reuse.
The pole would therefore investigate on: air, water and soil pollution, metal pollution, reclamation of slabs and protection of the ecosystems that are present in the whole area. The study of the geological, hydrogeological and floristic components and the morphology of the site would therefore improve the knowledge of the problematic affecting Monteponi and at the same time offer an innovative field for the development of researching programs to valorise the

natural and territorial potentials. The implantation of decontaminating factors such as phyto-resources, plants and vegetation would also create a fertile soil for the reclamation of this area, reducing the amounts of dangerous agents and dusts, which still today represent serious risks for people's health. This strategy would involve therefore different actors, starting from the University, the Region, the CESA (Center of Excellence for the Environmental Reclamation) up to the local administrations and the figures charged of the architectural reconversion of the site in order to set the scientific pole in the most appropriate locations and to provide the best fitted measures for the reclamation and the reuse of the soils.

Training and educational facilities for skilled personnel: there would be an interactive approach between different actors in order to train and educate the future personnel who will work in the remediating campaigns, involving local and institutional actors such as investors, associations and scientific tutors to start a permanent program for the improvement and the dissemination of the knowledge in the fields of reclamation and environmental pollution.

Annual or periodical conferences on the topics of remediation and reuse of the mining heritage and/or polluted areas: the creation of a periodical scientific program to disseminate and divulgate the results of the investigations and the researches on the reclamation of lands and heritage in critical areas would be a proficient approach to interact with international actors and to develop a confrontation with the national and foreign realities, such as the same French - Belgian experiences, the German strategies developed in the Ruhr area and the Spanish valorising and promoting activities related to the mining heritage (e.g. the Almadén territory affected by a centuries-long pollution from the exploitation of quicksilver). The conferences would also offer proposals for the management of these territories that could be brought forward at different levels of participation, from the communities to the institutional and academic characters: the multiple involvement would in fact create an expanded knowledge about the potentials of the territory, with projects and initiatives that could end into global strategies for the reconversion and a variegated fruition of the site. The Sardinian Mining Geopark would therefore be one of the most important agents for the development of these strategies, since it could interact with a worldwide web of institutions and agencies involved in the enhancement programs at an international scale. The State and the Sardinian Region could also be promoters and sponsors of the disseminative approach and possible stakeholders in the scientific activities promoted by the Conferences, leading initiatives similar to the *Mission Bassin Minier* in order to create an institutional and political chain of actors and promoters.

The "scoria" as identifying landmarks: the huge amount of mining slag heaps and scoria that characterize Monteponi thanks to its extension and red colour are perceivable as secular witnesses of the mining activities as a result of the exploitations. Their role in the environmental and morphological asset of this site is however dual: on one side they represent a serious and alarming thread for people's health and for the ecosystems since they contain high rates of heavy metals; on the other the wastes represent an important landmark of the presence of a millenarian "industrial" settlement. The preservation of this artificial monument should therefore

follow two main addresses, on behalf of the approach already applied in the Nord-Pas-de-Calais mining basin: the reconversion of the heaps as habitat for natural species and the reclamation from polluting agents, in order to reduce the health risks and to offer a new potential ecosystem for the growth of vegetation, which could become a sort of a green belt delimiting the site. This specific issue could be approached by the scientific and technical teams involved in the reconversion of Monteponi in order to formulate suitable proposals for the remediation and the improvement of the environmental conditions.
In this direction it could be interesting looking at the project of landscape restoration of the D'en Joan Valley in El Garraf (Barcelona) by the firm Battle and Roig (2002): the conversion of landfills into a new landscape was based on the topography and the use of vegetation and the rationalization of the geomorphology through the creation of terraces and slopes. The project consisted in the transformation of the landfills into a site of extraction of biogas connected by pipelines to a plant for the production of electrical energy, creating thus an ascending web of paths that recall the traditional features of the Italian hill gardens, usually arranged in terraces: the area became therefore a public space and at the same time an energetic supplier, in the manner of a Metropolitan park thanks to its extension and the proximity to the urban centre. The hydraulic support for this project was achieved thanks to drainage systems placed in the terraces, accordingly thus to the morphology and the natural sloping of the site, to convey rainwater into water tanks to create a permanent reserve at the border of the site; the whole plant is powered by the energy produced by the biogas plant. The choice of tree species opted for indigenous and resistant species, needing little amount of water and suited for the environment.

Figure 32. Battle and Roig's project of restoration for the D'en Joan Valley. Source: www.batlleiroig.com

The consequent application of these strategies to the scoria would turn them into "green slag" with the creation of paths and terraces looking to the landscape and the installation of pipelines and drainage to support the vegetal strata. The paths could therefore become both sporting-leisure recourse and an integrative system to rationalize the scoria, without deleting the dimensional and the evocative appeal. The link between the upper part and the lower level (Scalo) would be rebuilt through the former inclined ramp, which would become a sort of a pedestrian stronghold, recalling the colours and the heaps of the scoria thanks to appropriate materials and colours, running from the house of the crane to the end of the former rail tracks: the ramp would be emphasized through a linear fence formed by blocks of purified mud, keeping the original colour and pattern of the slag in order to recall the former heaps. The Railway station could then be recovered to house the new transport services in order to improve the web of green solutions for the visitors reaching the other mining poles of the area.

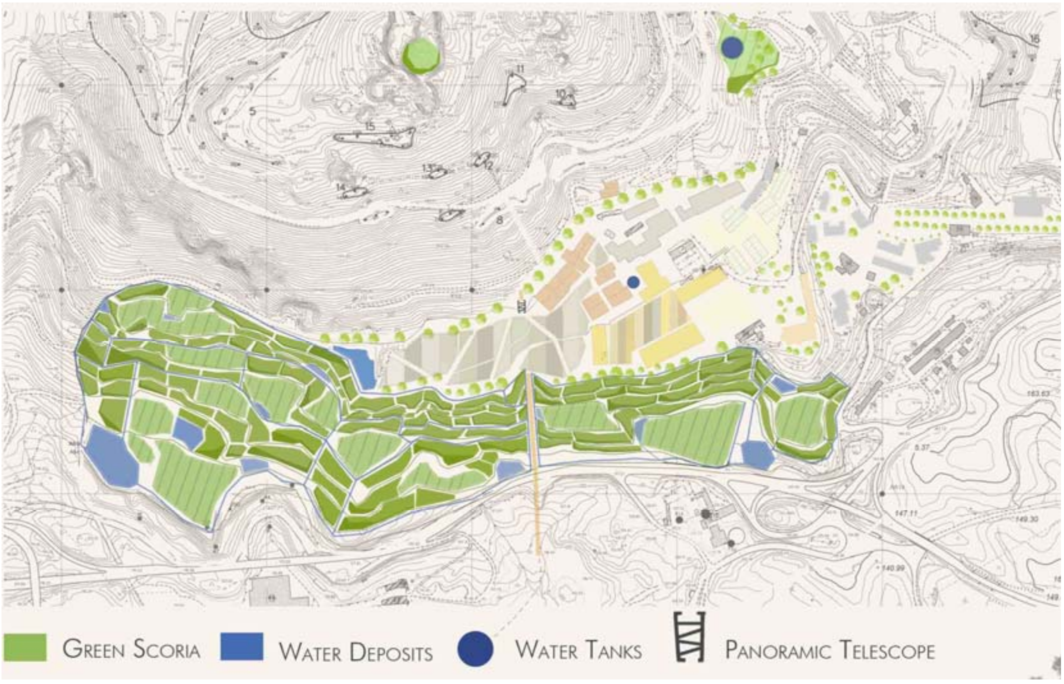


Figure 33 Reconversion of polluted areas and water tanks with new trails and the telescope.

Restoration and reuse of buildings: the requalification of several among the most important buildings of this heritage would start from the safeguard of the "emerging" buildings that feature the most peculiar critical and formal characteristics already explored in the previous chapters of this thesis, which express the linguistic completeness and the technological evolution of the 19$^{th}$ century mining architecture. The most suitable buildings would be those belonging to Pellegrini's and Ferraris' directorates since they feature the most emblematic elements showing the evolution of the linguistic and constructive approaches between 1870s and 1890s: the former Calamine Washery, the Bellavista Villa, the Delaunay Hospital and the ancient Directorate.
The settlement of cultural activities, e.g. the Museum, in Sella Shaft would then run along with the installation of administrative offices, workshops and assembly halls in those buildings that are suitable for the new functions without the risk of losing the original architectural characters. The proposal would see:

Bellavista Villa for the administrative sector thanks to the already settled inner disposition;

Sella Shaft would keep its supposed function as a future Museum of the Mining History;

the **Mining Archive** would possibly be reopened to the public in order to house visitors and researches, to valorise the huge amount of documents and materials related to the mining activities and to the history of Monteponi mine, to host social and cultural activities such as meetings, studies and dissemination the scientific and economic results.

The compound of the **Calamine Washery** would be intended for the scientific and researching functions: the research on the reclamation of polluted soils and environment, air and underwater contamination, phyto-resources and monitoring of the environmental quality. The restoration works would however keep the main structural elements in order to preserve the formal composition of the 1890s, avoiding reformulating or modifying the spatial and the constructive articulation of the buildings. The final result would be an Ecopole where the researching activities could pace with the discovery of the whole site in a sustainable and advancing way thanks to the application of resources that leave the architectural heritage unmodified and to the development of strategies for the reclamation of the site.

The **Delaunay Hospital** would house the auxiliary services for the personnel, such as the guest house and the refectory through the reconstruction of the vertical elements, i.e. the stairs, and the collapsed slabs and roofs. The new functions could be settled in the three levels of the main building and in the rooms of the rear volume.

The **House of the Crane** would be converted into a covered viewpoint, a telescope forming an axe connecting the start of the new path on the inclined ramp and the level of the former Delaunay Hospital"; floors would feature a terraced display in order to achieve spaces for the rest, the contemplation and the transit. This strategy would preserve the external structure and add new slabs and ramps to create an ascending movement toward the upper level of the hill or a descending direction towards the heaps. The area between the House of the Crane and the "green" scoria would be terraced and adapted as a public platform connecting both to start of the terraced routes and to the pool that conclude the promenade towards the west side of the platform.

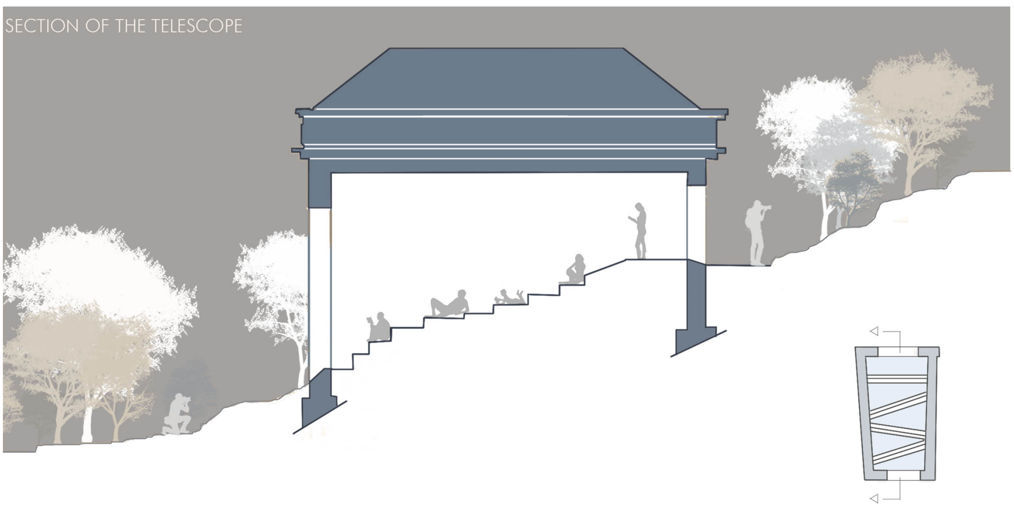


Figure 34 The conversion of the Crane Room into a telescope and a reading hall.

The **"permeable" square**, completely crossable, would create a visual and a physical connection among the buildings and the "green" scoria, emphasizing both the new natural vocation of the slag and the dominance of the mine in the landscape;

The existing **water tanks**, placed in the area of the former electrolysis compound and in the duct of the exhausted fumes, would be kept in function as water collectors and preserved as memorials of the industrial activity, enhancing their constructive and formal peculiarities, such as the concrete structure for the former and the stone masonry for the latter. The references of this reuse could be addressed to the restoring project of Ravi Marchi, in Gavorrano where, thanks to the intervention by the Camassi firm, the tanks and the decantation basins have been restored and refilled with water to remark their original role and to provide a source of water for the hydraulic system of the new site. The tanks in Monteponi would thus be a sort of new *Dorr* involved in the hydraulic balance as collectors of rainwater and also a memorabilia of the old basins.

The **energetic and environmental sustainability** would be provided thanks to two strategies: the first is the realization of a photovoltaic platform in order to supply energy for most of the buildings. This platform would be placed as coverage of the remains in the foundry of lead, which today consist of the metallic skeletons of the ovens and the workshops, allowing a further installation of facilities and services when needed. This approach would involve local and regional stakeholders, in order to supply the photovoltaic energy to the new buildings and sell the exceeding amount, and employees and technicians to investigate the behaviours under different climatic and environmental conditions. The second strategy promotes the integration of the managements of water, waste and energy basing on the same Program of High Environmental Quality in order to rationalize the resources, to use only materials from certified origins and recyclable products, to collect and reuse rainwater and purified sewage to feed both buildings and gardens, to create buildings with a low environmental impact and to promote initiatives for the divulgation and dissemination of the results of the researches on sustainable energies.

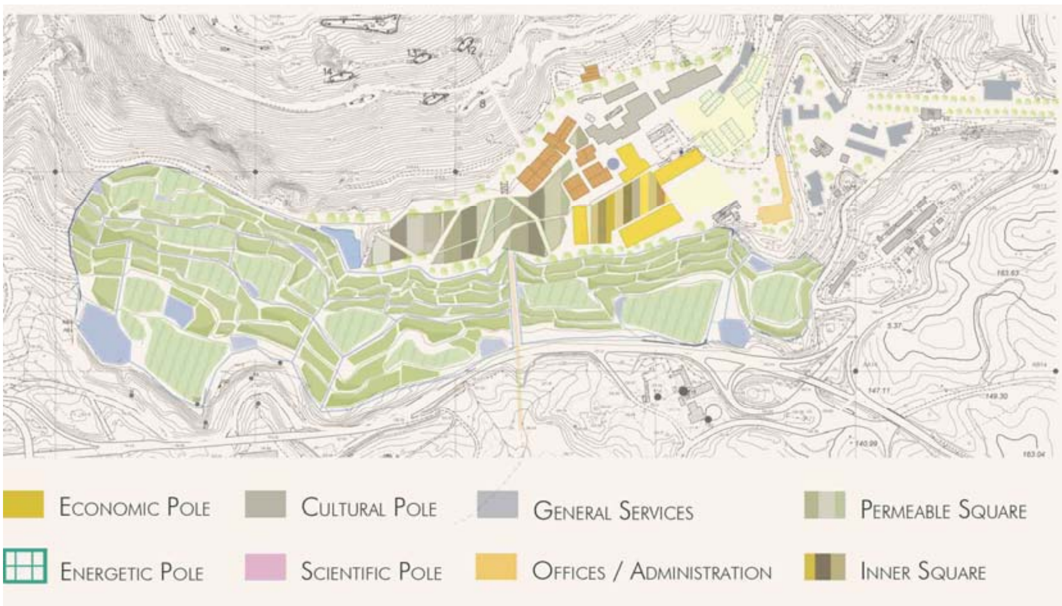


Figure 35 The poles to be settled in the existent buildings and the new business incubators.

The **economic restart** aims to create new facilities to house productive/commercial services such as business incubators, meeting rooms, offices and workshops dedicated both to consolidated and emerging realities that are interested in setting their activities in a recovered scenario. The new studios would house therefore offices, meeting rooms and business and social services under an optic of environmental sustainability, through energetically self-sufficient plants, sustainable materials such as wood, heat exchangers, natural light and climatic regulation in summer/winter conditions. The installation of photovoltaic cells would provide a correct energetic behaviour according to the targets of Horizon 2018/2020 for the *parité réseau*. The suitable location for the settlement of these new activities could be the area today occupied by the remains of the electrolysis cells, which are mostly collapsed or about to: the intervention aims to remove the ruins of the electrolysis cells since we think that due to the levels of damage and compromise of the concrete structure, it would be extremely expensive to set a program of restoration, which could however lead to the loss of the original physiognomies and features. The former building would then be replaced by new buildings that would feature two floors with different dimensions and sliding walls allowing to group multiple rooms and studios according to the tenants' necessities. The business compound would be connected through an inner square opened towards the "green" scoria, putting in communication the economic pole with the natural environment and the existing buildings. The constructive choices for these new buildings aim to use natural or low – impacting materials such as steel frames, timber slabs and earthen fillings and plasters, which are suitable both for the energetic behaviours and for a chromatic evocation of the former slag.

The main front of the electrolysis compound would be preserved since it features the most significant characteristics of the 1920s architecture in Monteponi – i.e. the coexistence of masonry and concrete frames, the decorative motifs, the presence of Eclectic formalisms, the evocative language expressing a "reconciliation" between the modern building approach and the 19th century architecture – and could be further converted into a new facilities or be kept as a memorandum of the last period of Monteponi's mining epopee.

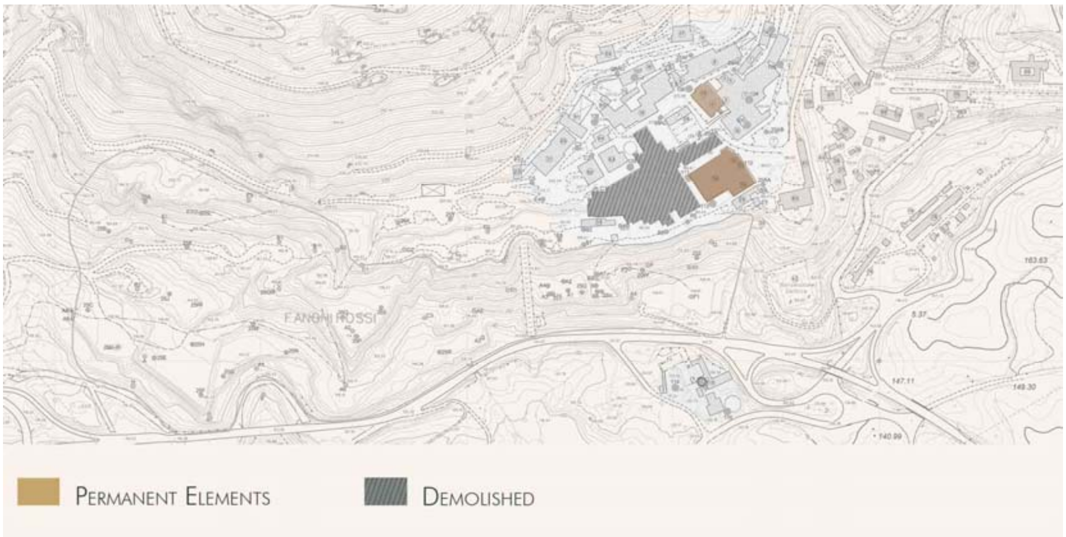


Figure 36 The demolished parts of the Electrolysis plant and the preserved elements.

In terms of available surfaces, we might suppose the following destinations:

| | |
|---|---|
| Economic Pole | ~ 7000 m2 |
| Green Areas | ~ 90000 m2 |
| Cultural Pole | > 4600 m2 |
| Water Tanks/Deposits | ~ 3900 m3 |
| General Services | 3500 m2 |
| Panoramic Telescope | 120 m2 |
| Permeable Square | > 10000 m2 |
| Energetic Pole | > 3500 m2 |
| Scientific Pole | > 4000 m2 |
| Offices/Administration | 1200 m2 |

# GENERAL CONCLUSIONS

## General Conclusions

In the first part of this dissertation we defined the main objectives and methodologies that would have been followed and pursued in the development of the research. The conclusions aim to explain if the starting hypothesis, the methodology and the results of the investigation have been validated and accomplished.

Briefly resuming, the thesis based its formulation on several considerations:

- although Monteponi has been acknowledged – by UNESCO too – as an important example of the mining epopee that interested the European industry between the 1800s and the 1920s thanks to the maturation of the architectural, technical and economical features, it is still far to be properly investigated and discovered from the points of view related to the constructive evolution of its heritage, the definition of the paradigms at the base of its nucleation and development, the linguistic formulas that characterize the buildings of the most important period from 1860s to 1900s.

- The *Construction History* and the role of this site in the scenario of the Neoclassic and Eclectic declinations, which are peculiar of the industrial architecture of the 19th century, have not been explored, impeding therefore to identify the affinities and the divergences between the case study and the referring examples.

- The worrying status of Monteponi's heritage has gone forward and seems unstoppable without an adequate recovery program that goes beyond the episodic initiatives that until nowadays have proved to be insufficient and referred only to single elements or single issues;

- There is a need for a general layout to propose solutions directed to the safeguard of the main peculiarities of the whole heritage, its linguistic and constructive features and to the settlement of new functions and uses to develop a suitable program of renovation.

The starting hypothesis focused on:

- the possibility to create a deeper knowledge of the Construction History of this compound in order to prove if this could be considered as an excellent incubator of the fundamental features of the European architectural epopee of the 19th century;

- the existence of formal and technical connections that put the case study in touch with the other examples of mining heritage of the 19th century – which, we remind, represents the period of the deepest innovation and dissemination of the constructive culture thanks to the introduction of new techniques, principles and materials – through the research on the Construction History of the European cases;

- the case study to be worthy thanks to the consistency and the relevance of its heritage to undergo processes and researches to elaborate proposals, methodologies and approaches for the recovery.

The objectives consequently focused on the research of the Construction History of the case study in order to:

- define the formal and constructive elements that concur to make Monteponi an excellent workshop of industrial heritage, although not yet explored;

- set a confrontation between Monteponi and the other examples of mining heritage to confirm the international context in which the case might be inserted and to search the analogies and the differences in formal and building terms with analogue facilities from the French and Spanish contexts;

- study a symbolic building within the mining palimpsest to define the most relevant aspects under the architectural, constructive and linguistic profiles, which could be assumed as emblematic of the 19th century industrial architecture;

- define the emerging elements of the architectural palimpsest, keeping in foreground the architectural and material components that must not be lost in the process of recovery;

- formulate proposals for the sustainable and rational recovery and the reuse of this site going along with the initiatives already settled in the European contexts, where the sites have been converted into touristic/didactic/cultural facilities and/or scientific/technological/economic centres under the optic of the environmental and architectural safeguard.

The methodology of the investigation proposed the typical path of the Construction History investigation, basing itself on the archival and bibliographic resources in order to build the most possible complete background to identify the evolution of the mining buildings, the materials, the formulation of the projects by the designers, the modifications that involved one or more compounds, the static and the formal features. For the researches on Monteponi's compounds we refer mainly to the Municipal Archive of Iglesias (ASCI) and to the Archive of the Mining District that provide the documents referring to the individual buildings and to the whole site, consisting of graphics, projects, photographs, cartographies and maps, while the urban and the territorial relations were analyzed through the documents provided by the digital cadastre. Unfortunately an important part of the existent documents related to Monteponi was not available due to the closure of the Mining Archive of Monteponi, which was closed in 2014 and is still inaccessible to the public.
For the mining site of Almadén most of the documents related to the shafts of the 1870s – 1900s period was supplied by the Mining Archive, which provided the projects of the two most important facilities.

The bibliographical study started with the definition of the field of research, i.e. the industrial heritage and the Construction History from an academic and cultural point of view, in order to elaborate the state of the art and to collect the theoretical and methodological fundaments to support this dissertation. The research on both the Construction History of the case study and the European examples led to the exploration of the evolution of the building culture and the industrial architecture of the 19th century, how it spread in the most evolved Countries and how it was stylistically, technically and formally influenced by the local declinations and by the dissemination of architectural and engineering treaties, handbooks and scientific publications along the whole century.  Thus the scenario of the cultural and scientific innovations and features of the 19th century industrial architecture allowed to trace the linguistic and technological physiognomies of the mining facilities that could be compared to the case study and of the most relevant buildings from the Sardinian context. However, since Monteponi has not been deeply investigated by the disposable literature from the constructive and formal point of view but mainly for its historical and industrial development, the setting up of the knowledge of the constructive and architectural evolution had to be built through the archival sources, the Company's records, documents and catalogues: these were finally arranged in tables, drawings and schemes showing the processes that involved the mine from the ancient period to the 1920s. These materials represent the tools for the identification of several characters of the case study: we have in fact the analysis of the building evolution, of the territorial connections, of the constructive details and the catalogue of the most important buildings from the 1860s to 1928.

Validation of the hypothesis

At the light of the followed methodology we may state that the hypothesis have been confirmed since we highlighted the relevance of Monteponi's architectural palimpsest: this in fact consists of a great variety of buildings and facilities expressing the formal and constructive characteristics of the 19th century Eclectic architecture inserted in an industrial panorama.
The connections with the other mining centres, derived from the analysis of the constructive culture and of the single European cases, depicted a common background of knowledge and experiences in the definition of the constructive and linguistic features: we may trace in fact the same behaviour in terms of decorative and structural configurations, similar approaches in the use of the materials, influences and technologies.
The worth of Monteponi to be considered as a great example of mining heritage at an international level – thanks to the characterization of its architecture – proved that this compound of industrial heritage must not be lost due to the damages and the decadence of materials and structure; moreover, the affinities and the linguistic analogies between Monteponi and the European cases strengthen the importance of its reuse and valorisation in order to disseminate and promote the historical and cultural values retraced in this dissertation.

Validation of the methodology

The methodology based on the archival investigation allowed to identify the most important elements of the Construction History of the case study and of the European examples, since we traced the evolution of the architectural palimpsests, the historical background that led to the various configurations and the most valuable static and formal features of those industrial

realities. The European cases have proved to be useful for the definition of the approaches in the development of mining heritage in different contexts and provided a sufficient amount of information regarding the constructive technologies, the use of materials, the linguistic evolution of the facilities and the attention paid to the building techniques. The archival research on Monteponi provided an indispensable apparatus of drawings, schemes, data and notions that allowed to depict the historical and cultural field for the identification of the most important features of Monteponi's buildings, such as the evolution of the architectural characteristics, the predominance of Eclectic formalisms in the period between 1860s and 1880s, the further relevance of the technical aspects in the projects of the facilities. Still through the archival research we had identified both the territorial connections and the evolution of the sites thanks to the analysis of cartographies and maps, and the key – data of the costs and the materials involved in the construction of Monteponi's buildings, which have been inserted in the drawings of the details and in the characterization of the facilities.
The direct survey allowed to appreciate at a deep level the characteristics and the features of an emblematic building, the Sella Shaft, and to set a confrontation with the other mining poles that are part of this dissertation, in order to analyze the linguistic and the formal processes of their development.
The methodology of the archive investigation also promoted the creation of the synthetic apparatus that recollects the information about the historical development, the architectural palimpsest and the structural expedients that progressively emerged through the documents.
The bibliographical research provided the necessary elements to trace the historical background of the development of the case study, mainly thanks to the publications by Luciano Ottelli[1] and by Quintino Sella[2], while a general bibliography referring to the history of mining in Sardinia is at the base of the introductive dissertation of Monteponi.
A great bibliographical role was played by the collection of books and handbooks to identify the main features of the cultural divulgation of techniques, knowledge, practice and theories that form the scientific base for the development of the linguistic and technical expedients that we have found in the case studies (therefore both the Sardinian and the European ones).
Finally, the methodology of investigation provided the information to investigate the international cases from an architectural and historical point of view, allowing to identify the emerging elements of their heritage and the processes of reuse and valorisation that suggest the hypothesis and strategies for the preservation and recovery of Monteponi.

### Achieved results

At the light of all these considerations, we may state that the investigation of Monteponi under the profile of the Construction History has defined the formal and the constructive elements that make Monteponi an emblematic incubator of the industrial heritage of the 19th century: we have in fact identified the formal and structural peculiarities along with the historical evolution of the site and highlighted the main elements of the architectural scenario. The results are therefore the

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[1] Ottelli, L. *Monteponi. (Iglesias – Sardegna) Storia di eventi e di uomini di una grande miniera*. Sassari: Carlo Delfino Ed., 2010.

[2] Manconi, F. *Quintino Sella. Sulle condizioni dell'Industria mineraria in Sardegna*. Nuoro: Ilisso, 1999

identification of the historical and technological role of this compound in the Sardinian mining epopee in the 19th and in the early 20th centuries, deepening the architectural and constructive expressions of its infrastructures through archival sources, documents and historical data that have turned essential for the methodology of the Construction History research.
The confrontation with the European examples of mining heritage – mainly referred to the French/Belgian contexts – has put in evidence the analogies and the affinities in the stylistic and technological fields that suggest the relevant role of this mine in the International panorama and the points of contact in the definition of the formal and technical elements of these heritages.
The study of a symbolic building of the Sardinian heritage defined the architectural, constructive and linguistic features that are emblematic of the industrial architecture of that period and analogue of those traced in the European examples: the Eclectic and Neoclassic languages are therefore expressed at various levels as emerged through the confrontation with the most important mining buildings chosen for the comparison, validating the belonging of Monteponi to a wider and international background.
The analysis of three case studies that on one side provided the background of the investigation of the processes and the objects of the Industrial Archaeology and on the other represent a link for the topics of reuse and valorisation of the industrial heritage.
The definition of the guidelines of reuse and rehabilitation of the case study of Monteponi took references from the experiences of valorisation and recovery in the European cases, keeping in first place the preservation of the most relevant components of the mining architecture and proposing different hypothesis for the cultural and social reuse of the site. The strategies are focused on the conservation and on new uses of the buildings with the purpose to create paths of cultural divulgation, touristic services and reclamation of the environment without affecting the original physiognomies, but with a critical sense about those "emergencies" that, at the light of the aims of sustainability and feasibility of the recovery plans, could be replaced by new and more efficient facilities.
The innovation of this investigation lies therefore in the research on Monteponi in an yet unexplored direction thanks to the integration of two addresses: the methodologies of the Construction History – i.e. the exploration of the constructive, technical and material elements of the heritage up to a detailed scale – and the proposal of strategies for the valorisation of the mining heritage following the European models.

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Bibliographical Report

The research on the case study of this Thesis, the mine of Monteponi, was based on the recent publications, the available archival sources and the numerous publications dated back to the $19^{th}$ and the $20^{th}$ centuries, which offer an exhaustive background of the conditions that led to the development of the mine and to the technological and constructive expedients of the time.

*Bibliographical sources*

The knowledge of the main focus of the thesis could be, reasonably, considered as completed thanks to the availability of the main resources related to the state of the art. The history of mining vicissitudes of Monteponi was investigated mainly through the reading of the publication *Monteponi (Iglesias - Sardegna). Storie di eventi e di uomini di una grande miniera* by Luciano Ottelli, which gives a logic and continuous dissertation about the building and economic strata of the mine, particularly referring to its most important period and to its key elements, although it does not focus on the details of the architectural and technological solutions. These aspects, both building and technical, are mainly explained in the *Catalogue of Resources-the compound of Mining Archaeology of Monteponi*, by Salvatorico Serra, Alfredo Ingegno and Lorenzo Ottelli, which contains inventory files and a catalogue of the whole building heritage and depicts both a useful description from the historical, material and constructive point of view and the actual conditions of the buildings.

More bibliographical sources refer to the publications by Tatiana Kirova, Francesco Manconi and Franco Manis, which will be better explained in the attached bibliography. Moreover, the books dating back to 1860s and 1870s by Alberto Ferrero della Marmora, Quintino Sella, Carlo Corbetta, Leon Gouin, Louis De Launay etc. were essential to complete the general background of the historical and architectural development of Sardinian mines. These publications in fact represent a valuable resource to define the main characters of the $19^{th}$ century industrial era, with a particular accent about the technical and productive standards of the Monteponi mine from its founding to its highest development.

Technical magazines such as *Les Annales des Mines*, *The Mining Department Magazine* and *The Agriculture Magazine-Relations on the mining service*, *The Italian Mine*, the industrial statistics edited by the Minister of Agriculture, Industry and Trades in 1880s and the technical reports written by the experts who worked for the Monteponi Company – *in primis* the publication in honour of the centenary of the Monteponi Company and the scientific essays by Erminio Ferraris – are essential to complete the process of investigation on the evolution of the mine and on the *modus operandi* of its managers in the main phases of its history.

The Construction History of the Monteponi mine was explored through two main typologies of publications: the first contains all the essays and the texts relating to its buildings, to the state of the art and technical-scientific texts. The second one is based on the publications explaining the present conditions of this site, the causes for its progressive dismantle and abandon and the degradation that affects the buildings and the industrial plants. In this typology we find the last publications about the recovering experiences of other mining and industrial sites that offer a comparison with the Monteponi case in a frame of reference, in order to elaborate proposals of environmental and landscaping recover, or to study the restoring operations and the results promoted by the Sardinian Mining Geopark, which since 1998 is involved with the socio-cultural, touristic and functional reuse of the dismissed industrial compounds in Sardinia.

The analysis of the constructive solutions – both in their academic and scientific canons, than in their local expressions – and the architectural culture of the Nineteenth century in relation to the Monteponi case was based on the historical handbooks and the treaties of architecture and construction in order to study the main elements of the practice of building, on the technical magazines published in the 19th century and on the contemporary publications about the evolution of the technology of building in Italy and the diffusion of scientific topics in the Academies of Engineering and Architecture. Particularly the Atlas containing graphic drawings and illustrations of constructive details, building variations, applied technologies and typologies and practical data of the employed materials have been useful to this research since they provided important information to trace the cultural background of the Italian Construction History and the technical knowledge in the Nineteenth century.

In synthesis through this phase of investigation we find the main characters of the building practice to which Monteponi refers thanks to its managers' educational background and technical knowledge, nonetheless the analogies between the constructive experiences and the technical culture during the 19th century and, finally, the main characters who led the mine to its highest development, in particular the manager Adolfo Pellegrini and the designer Franz Stiglizt. It is clear, in fact, the strong connection – which is often a real identity – between the European architecture of the second half of the century and the formal expressions and the languages typical of the Eclectic era in the highest expressions of industrial buildings. It is not by chance, for instance, that few years after the publication of the *Polonceau* trusses by its designer, we find the same constructive solution in one of the main building of the mine, i.e. the Sella Shaft.

### *Archival Sources*

Inside the bibliographical references and funds, the historical archives are a fundamental source of drawings, documents, photos and technical data: through the analysis of the obtained materials it was possible to create the analysis tables on the buildings, the constructive details, the abacus of the building strata both in a historical and a technical point of view. Referring to Monteponi we find two kinds of sources: the Municipal Historical Archive of Iglesias (further indicated as ASCI); the Historical Mining Archive of the IGEA Society; the Archive of the Mining District of Sardinia (further indicated as ADM). The documents released by the creators (Mining Companies, Public Offices, mails and correspondence etc.) referring to mining activities are collected in homogeneous series in the different archives.

Generally we find[1]:

General Administration: constitutive acts or corporate management acts, assembly reports, protocol records, mailing, instance of licence and concessions and their renovation, buying-selling records, rent of lands and buildings, disputes, various agreements and contracts, dispatches and rules.

Financial administration and payrolls: licensing fees, inventories of goods and buildings, employees payroll, master-books, journal-books, invoices records, invoices, bank operations, fund raisings and bank accountability, budgeting and cash flow projections.

Employees enrolment and management: contracts, wages, records, payrolls, daily records, statistics, records of employed children and women, accidents, reports to / from the syndicates, orders of service, transfers of employees and workers, photos and audiovisuals testifying the working conditions in the mine.

Productions: working programs, mining sections and plans, mineral cultivations, underground works, statistics of productivity, technical reports and relations, photographs and audiovisuals testifying the life curse of the minerals from the extraction to the finishing.

Researching and projects: researching programs and surveys, technical studies and essays, scientific publications, articles on mining magazines, drawings, chemical analysis, diagrams, models, projects for new plants, buildings, machineries and apparels, environmental recovery plans, geological charts, topographic surveys, thematic atlas, photos testifying the inspections and the surveys on the fields.

Social aids and works: documentation attesting the social initiatives promoted by the mining companies such as housings, refectories, hospitals, kindergartens, social cooperatives, after work recreational spaces, sporting facilities, playgrounds, gifts, summer colonies for workers' children, loans and monetary aids for the families of dead workers, photographs and audiovisuals testifying social and familiar day life of the working class.

## The Historical Municipal Archive of Iglesias

The Historical Archive of Iglesias collects a huge amount of documents and funds, suitable for the reconstruction of the historical data, of the political, the economical and the social events occurred in the town of Iglesias and in the Monteponi mine during about eight hundred years (from the 13th

[1] Vedi:
Concas, F., Ortu, C. L'archivio minerario di concentrazione della Sardegna. In ANAI – Associazione Nazionale Archivistica Italiana (eds.) 2010. *Archivi*, anno V, vol. 2. Padova: C.L.E.U.P., pp. 5 – 35.

century during the Pisan dominion through the Catalan – Aragon, Spanish and Savoy conquests to the nowadays). Besides the *Breve* of *Villa di Chiesa* (*Breve Villae Ecclesiae*) – a Pisan document dated 1327 and adopted by the Aragons, which contains important information about the exploitation of the local deposits of lead and galena in Monteponi, there are funds from the Monteponi and the Montevecchio mining companies (further named MP-MV) that offer important technical and historical elements coming from their former seats in Milan. These funds in fact allow to trace the vicissitudes of mining exploitation in Southwest Sardinia from 1850 to 1993 and contain the documents produced by these two Companies, both when they were separated and later joined into new enterprises (such as *Monteponi Spa* from 1850 to 1961, the *Montevecchio Italian Company of Lead and Zinc* from 1940 to 1961 and the *Monteponi-Montevecchio Spa* from 1961 to 1978 and so on).

In particular, there are funds from the following Mining Companies finally merged into the Monteponi-Montevecchio Company:

*The Monteponi Company*

*The Italian Company of Lead*

*The Italian Company of Zinc*

*The Italian Company of Lead and Zinc*

*The Anonymous Mines of Montevecchio*

*The Montevecchio Anonymous Mining Company*

*The Montevecchio Italian Company of Lead and Zinc*

*The Monteponi-Montevecchio Company*

The MP-MV fund comprehends the following series of documents:

General Administration: contains all the administrative documents and the payrolls. The index of the titles, completed in 1994, refers directly to the Offices that created the documents.

Personnel: contains the documents referring to the social interests of the Monteponi-Montevecchio S.p.A. such as enrolment, accidents, insurances, wages, sanitarily topics, syndicates, strikes, orders of service, mailings, mutual assistance, working contracts, evaluation notes, Social Cooperative documents, training courses and transfers of personnel and so on.

Photographs and Technical data: contains circa eight hundreds of drawings of plants and infrastructures dating back to the first half of the Nineteenth century, in the *Monteponi* and in the *Montevecchio* mines. This series is really interesting thanks to the presence of old photos and maps referring to the ancient buildings of the Monteponi mine, including those that do not exist anymore.

Moreover, in the funds of the Monteponi-Montevecchio S.p.A., there are the following series:

Licenses and mining concessions

Sardinian Agricultural Enterprises: containing documents about the agricultural investments inside the mining concessions.

Social Activities: about the Social Cooperatives and the hospital in Monteponi, Montevecchio and San Gavino Monreale mines.

Bibliographical: contains mainly magazines of geology, mining, metallurgy and mechanic, bought throughout the years by the Companies. From the MP-MV fund, for the purpose of this research, have been taken the collections from the Cartography and Drawings Series.

Historical Mining Archive of IGEA S.p.A.

This archive was closed permanently in 2015, due to the lack of trained personnel to check the documents, therefore we can only note its constitutional data thanks to the *Declaration of Noticeable Historical Interest* reported by the Archivist Superintendence of Sardinia on 23rd September 1994[2]:

*"it is formed by archivist, iconographical and auxiliary sources of great importance for the social and industrial history of Sardinia and of other Italian regions (such as Friuli Venezia Giulia, Lombardia, Trentino Alto Adige ), partly acquired from the former Companies which the Monteponi-Montevecchio Company had stepped in (Egam and Eni). These funds testify the vicissitudes of one of the most important mining activity in Europe from the second half of the Nineteenth century to the critical phase"* in 1980s, which led to the closure of the mines.

This fund is stored in the former General Stores in Monteponi, but it was not possible neither to consult the documents nor to reproduce them. Inside the Archive there are the following series:

Mining plans: contains technical reports, plans and sections of the galleries, shafts and buildings testifying the evolution of the mining yards.

Technical cartography: contains records of machineries, plants, industrial and civil buildings, geological and deposits researches and detailed reports.

Administrative documentation: employed personnel, buying and selling, budgets, productions, mails and syndicate reports.

Photos

Bibliographical sources: scientific publications, magazines of mining and metallurgy, journals, technical essays and graduation thesis.

[2] Vedi Concas, F., Ortu, C. 2010.

Collection of wooden moulds: the wooden moulds, carved in the carpentry in Monteponi and employed to make sparing parts for the machineries by melting of cast iron and lead, are stored in a deposit.

Collection of minerals and technical tools.

## Archive of the Mining District of Sardinia

The District was transferred from Cagliari to Iglesias in 1872 and it was the peripheral seat of the Mining Corp, with licence to release exploiting concessions, to elaborate statistics of productivity, personnel, accidents and explosives.

The research in this Archive led to numerous cartographies and maps, useful to understand the territorial development of Monteponi mine, to evaluate its connections by rail and roads and to identify this mining system as a web of various mining centres.

Moreover, in its funds are stored the Relations on the Mining Services edited by the Ministry of Agriculture, Industry and Trades from 1875 to 1885: these publications contain updated data on the state of the works in all of the Italian mining districts and therefore they focus on the implementation of Monteponi's facilities, on new exploitations and edifications, on new plants and foundries. It is important to note that just in 1881 and 1882 there are news about the dewatering gallery, entitled to King Umberto I, with a balance of costs and the advancing of the excavations in the auxiliary pits Baccarini and Cattaneo.

In the Archive of the District there are also the cartographies of the Monteponi mine in 1868 and in 1914 and the declaration of discovery with the relative licence to exploit the mine in 1850.

The Archive contains the following series:

Cartography (1850-2003): maps, plans, sections, prospects, geological programs and surveys and the papers of the Geological and Topographic Charts of Italy edited by the Geographical Military Institute (IGM).

Administrative files (1848-1998):

Mining licenses and concessions (1872-1990s): administrative files, mailing, reports about the productivity standards and technical records.

Caves: it is geographically ordered and contains documents about the licensed mines and the exploitations.

Mining statistics: annual statistics on licenses and permissions, productivity (exported minerals and stones) and social contexts (manpower and accidents).

Accidents (1879-1983): reports on accidents, vigilance and security on working places and the referring legal standards.

Administration: contains documents related to the personnel, the wages, missions, daily presence and protocol records, which constitute the so called “tissue records”.

Recent Documents: projects of environmental reconversion in abandoned mines and proposals of reuse of mining buildings as a touristic resource, basing on the Laws 221/1990 and 204/1993.

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VITTORIO EMANUELE PIT – years 1867 – 1925

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WHITE ZINC – years 1875 – 1957

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WASHERIES – years 1885 – 1940

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RAILWAYS – years 1870 - 1937

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INCLINED PLANE – years 1875 – 1940

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BUILDINGS – years 1895 – 1953

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BUILDINGS AND FACILITIES

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# TERRITORIAL OVERVIEW

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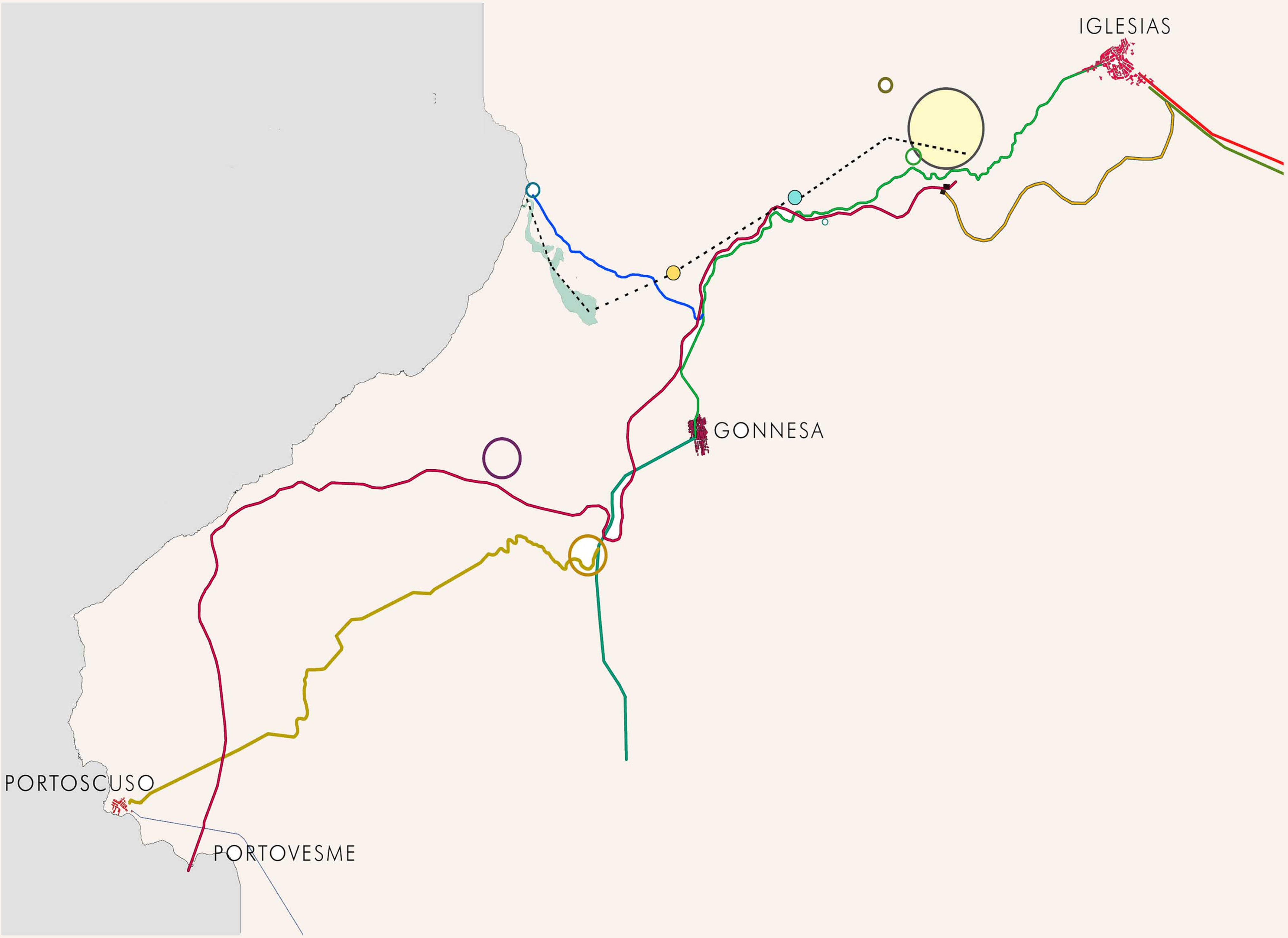
## CADASTRAL SURVEY




ROADS

- IGLESIAS - CAGLIARI
- IGLESIAS - GONNESA
- GONNESA - FONTANAMARE
- GONNESA - TERRAS COLLU
- TERRAS COLLU - PORTOVESME
- PORTOSCUSO - PORTOVESME

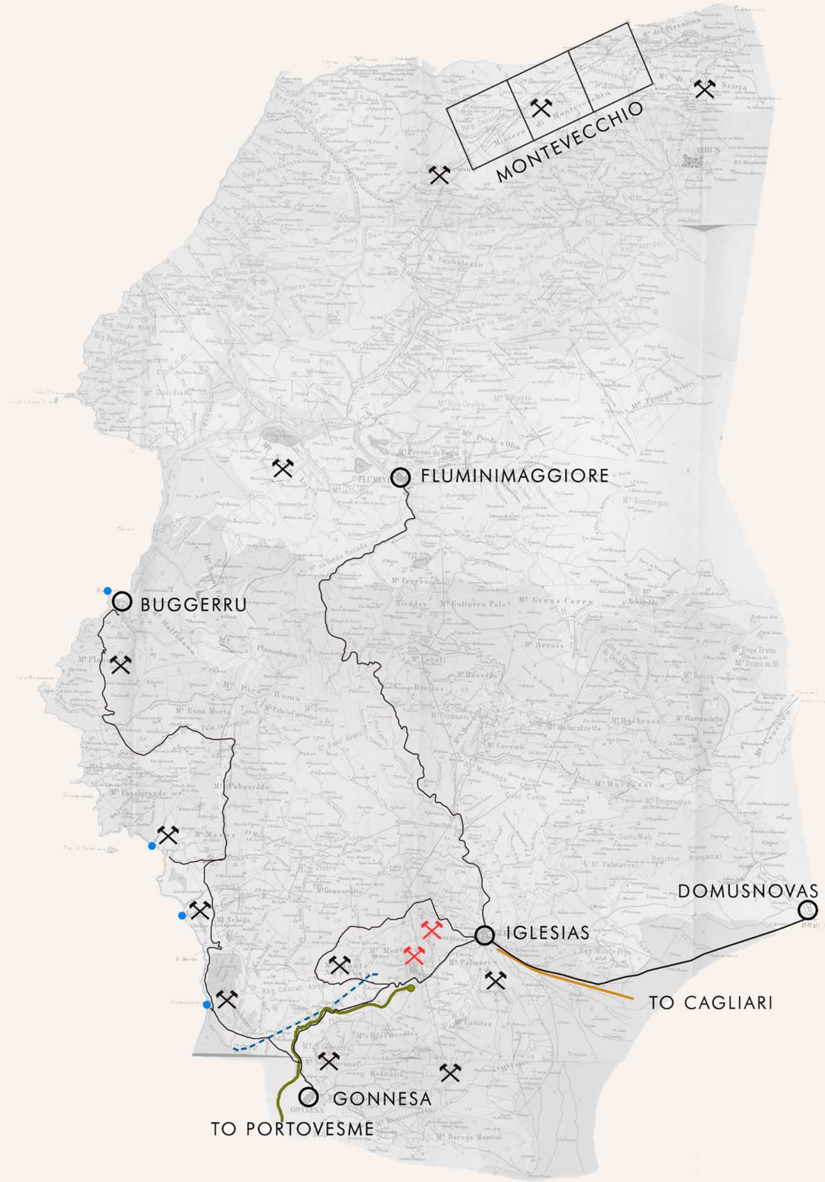
RAILWAYS

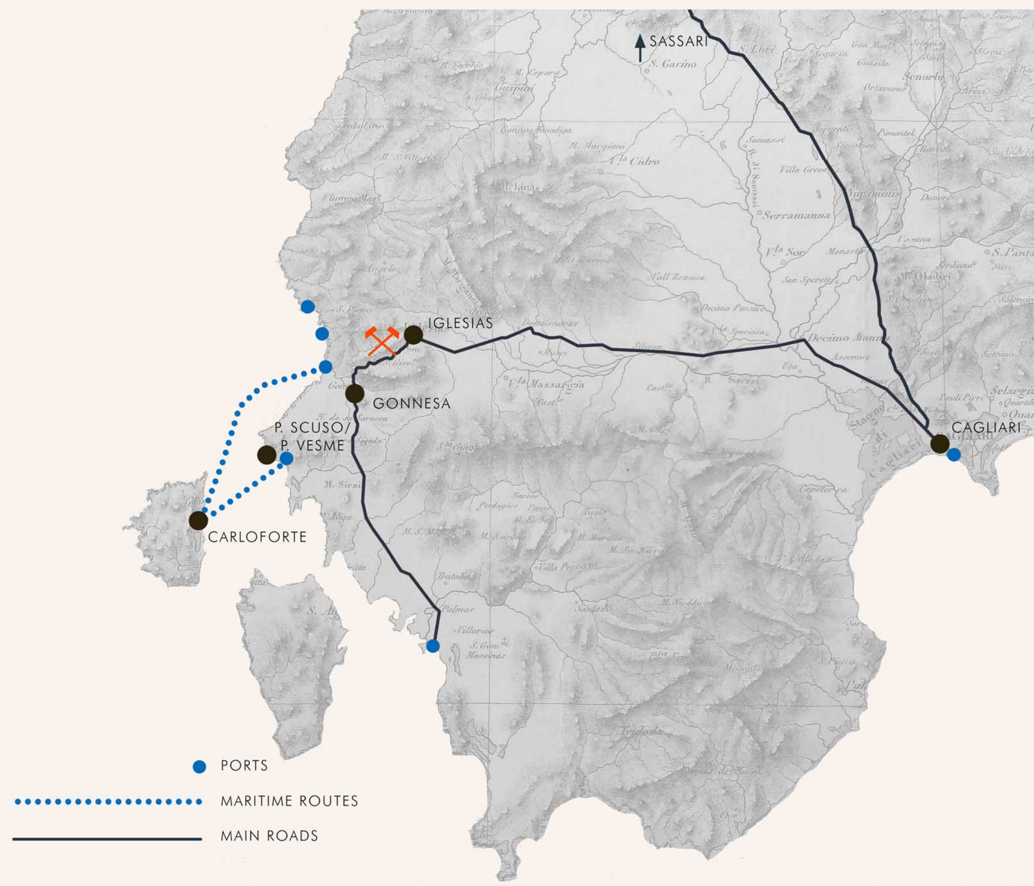
- IGLESIAS - CAGLIARI
- IGLESIAS - MONTEPONI
- MONTEPONI - PORTOVESME

MINES

- MONTEPONI
- CULMINE
- TERRAS COLLU
- CATTANEO SHAFT
- BACCARINI SHAFT
- S. MARCO YARD
- S. SEVERINO YARD
- FONTANAMARE WASHERY
- FUNTANA COPERTA WASHERY

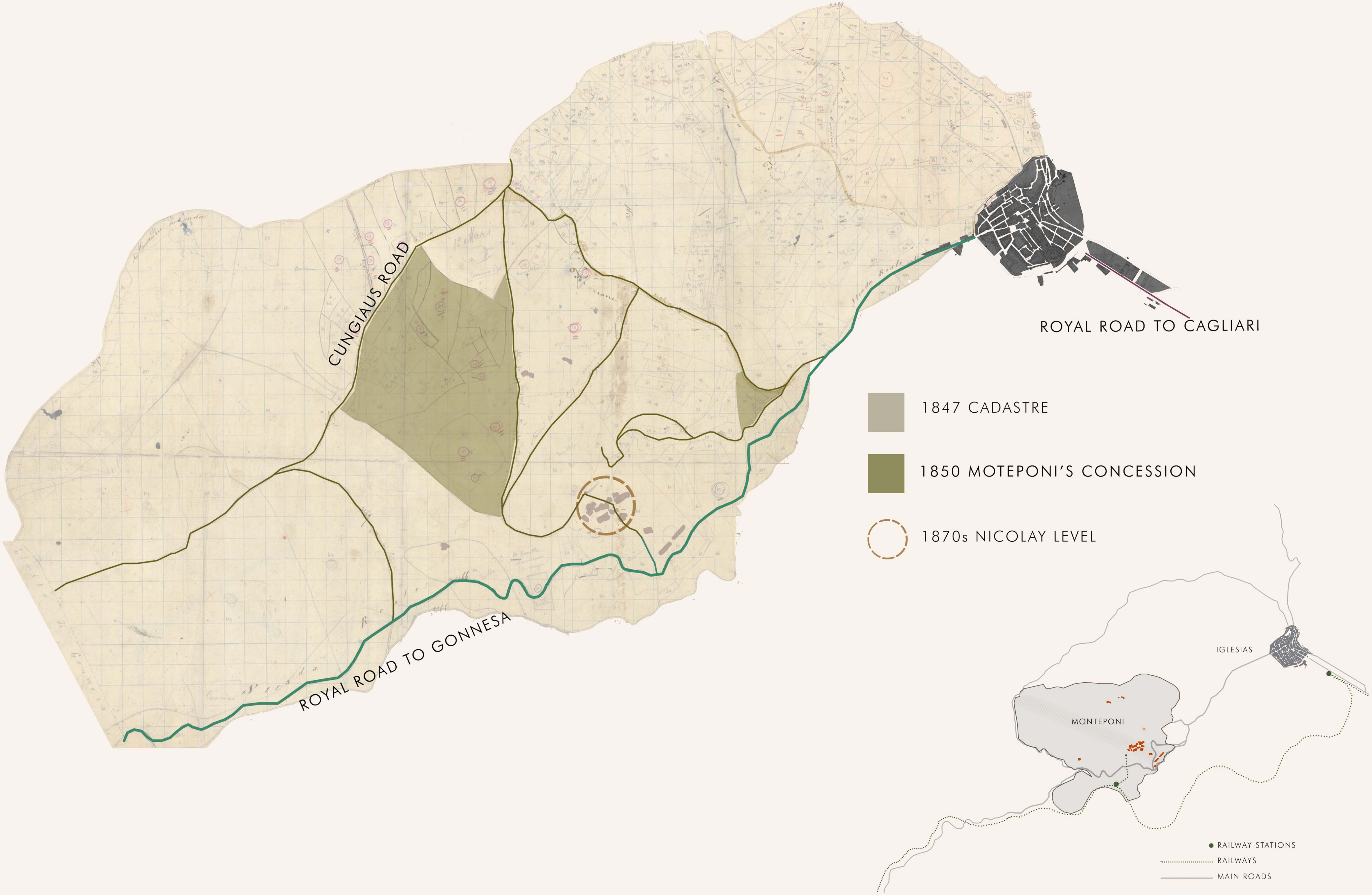
- DEWATERING GALLERY UMBERTO I
- SA MASA MARSH



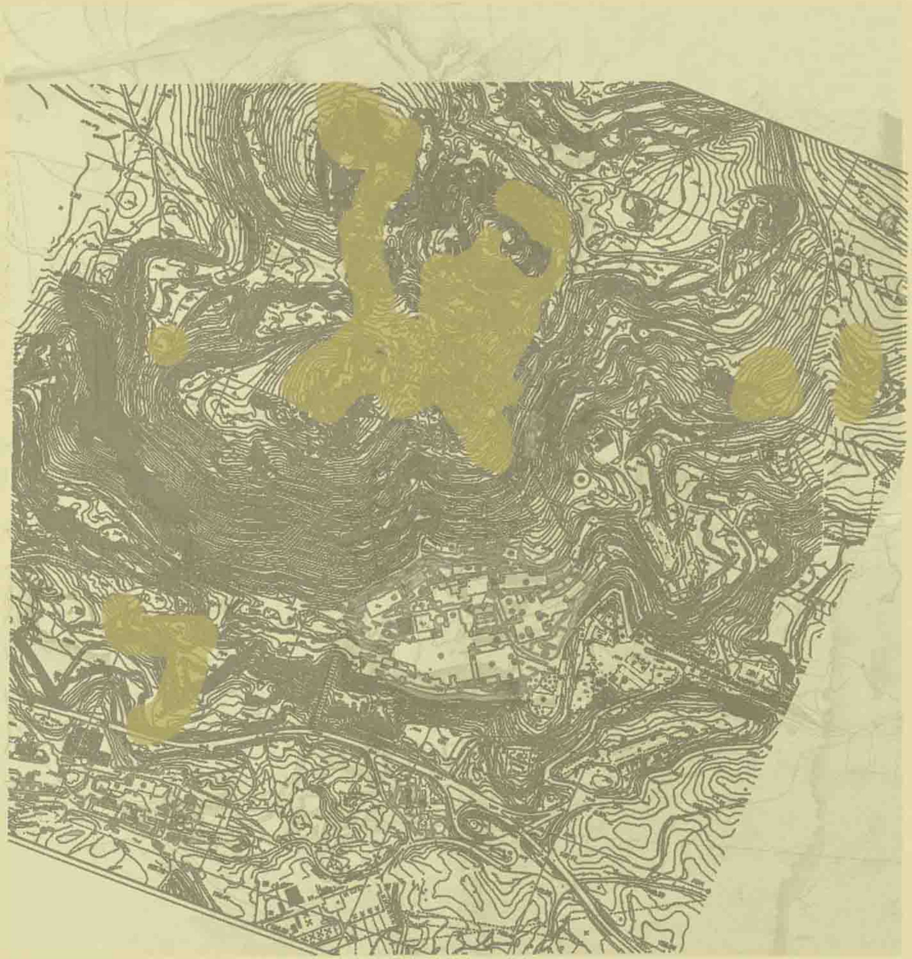

MONTEPONI MINE

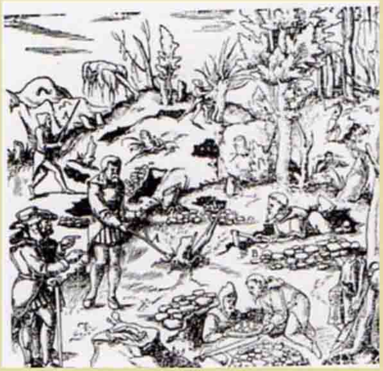
TERRITORIAL CONNECTIONS

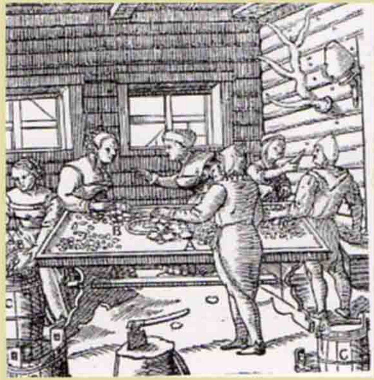

CUNGIAUS ROAD
ROYAL ROAD TO CAGLIARI
ROYAL ROAD TO GONNESA
1847 CADASTRE
1850 MOTEPONI'S CONCESSION
1870s NICOLAY LEVEL
IGLESIAS
MONTEPONI
RAILWAY STATIONS
RAILWAYS
MAIN ROADS

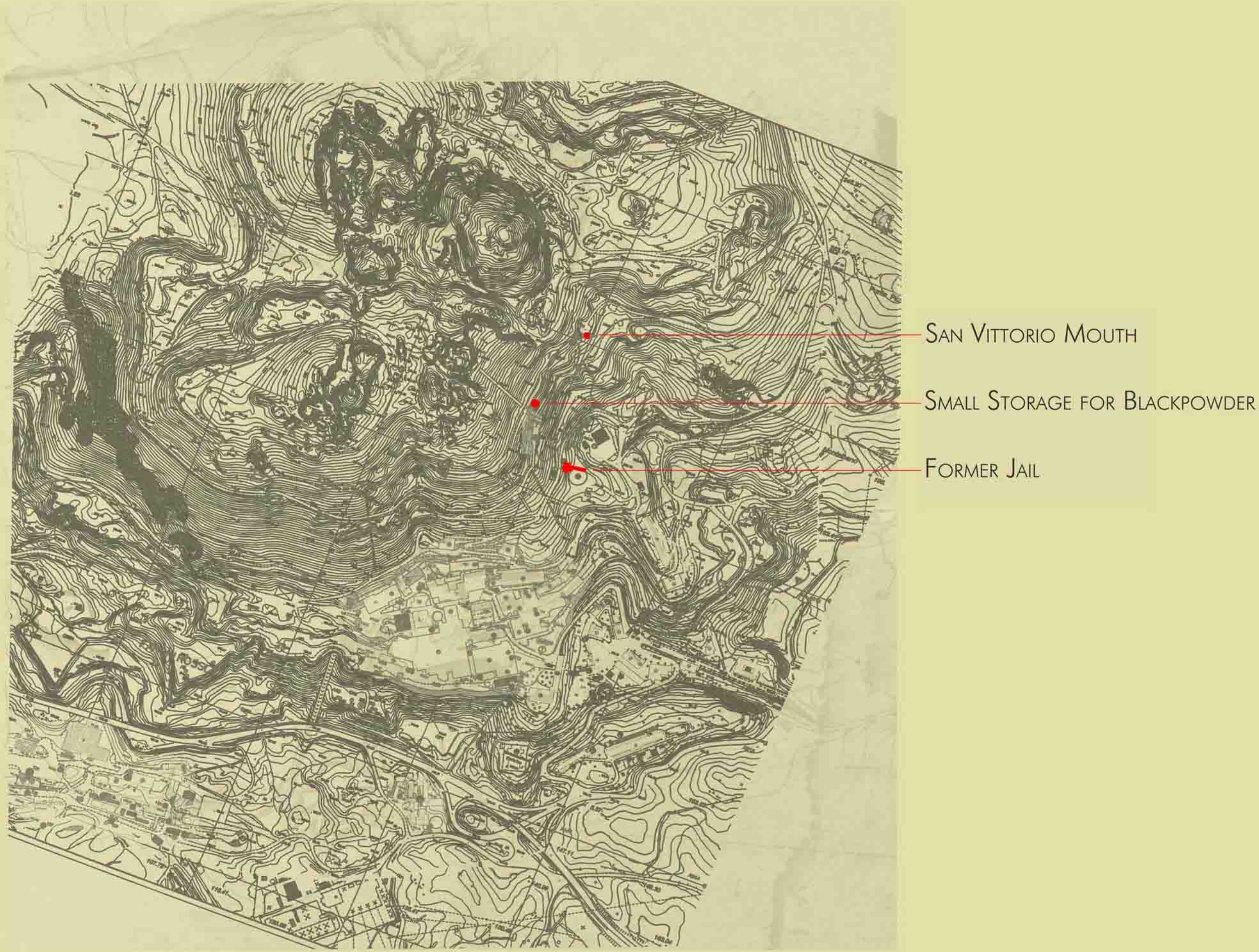
# HISTORIC OVERVIEW

## FROM 1720 TO 1928

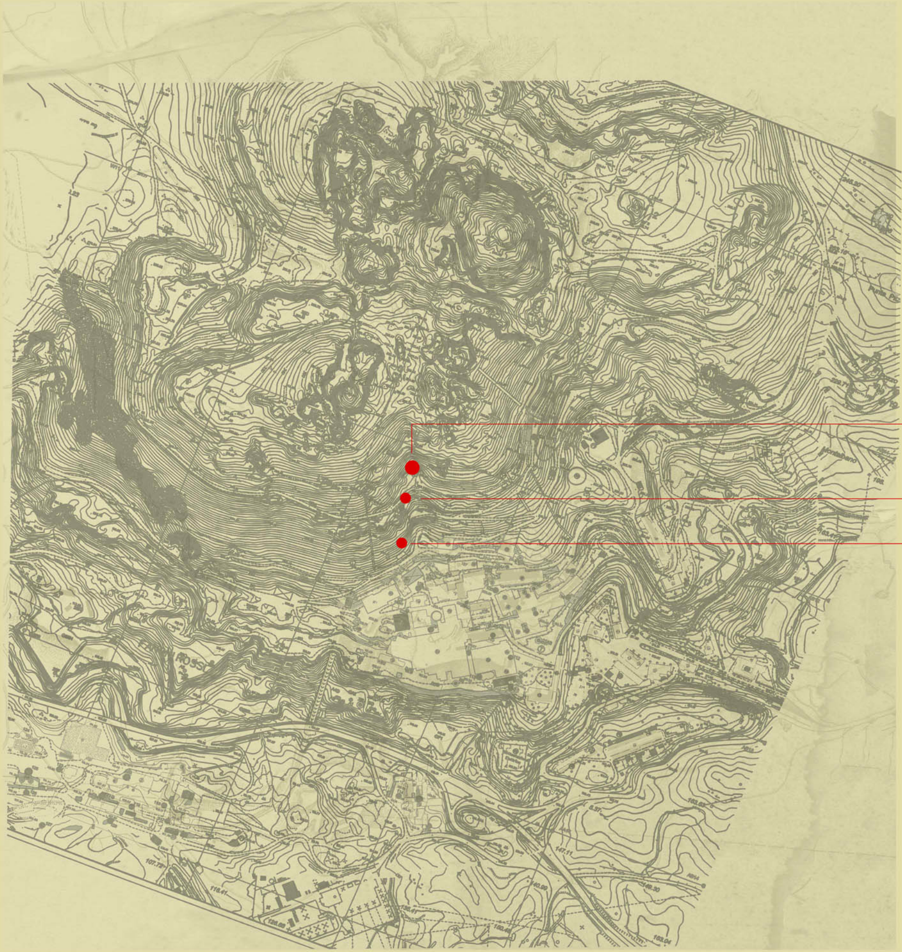







San Vittorio Mouth
Small Storage for Blackpowder
Former Jail

Saint Real Gallery

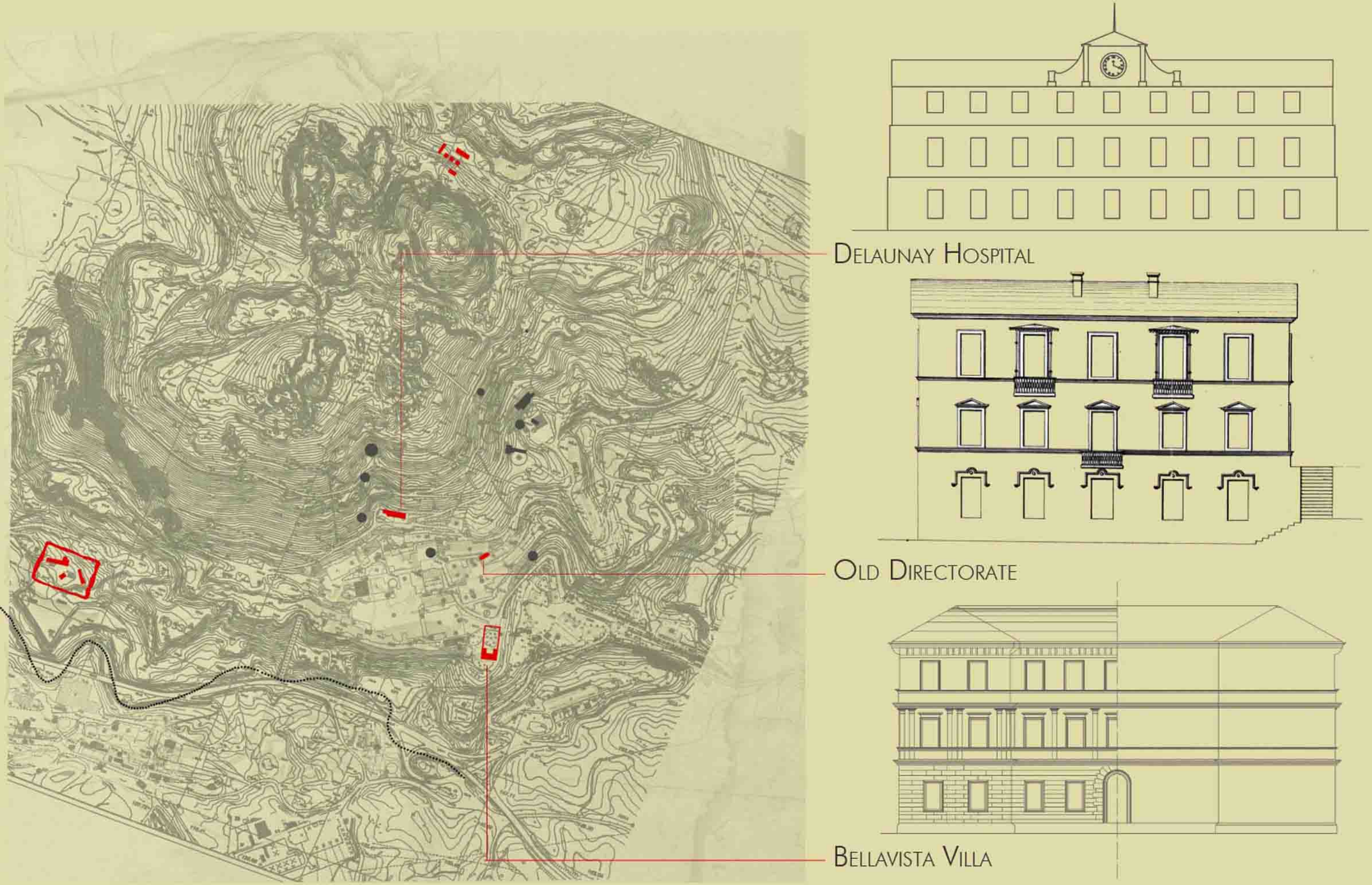

GASTALDI
DESPINE
DELAUNAY

Road to Fontanamare

# MONTEPONI MINE - Historical Development

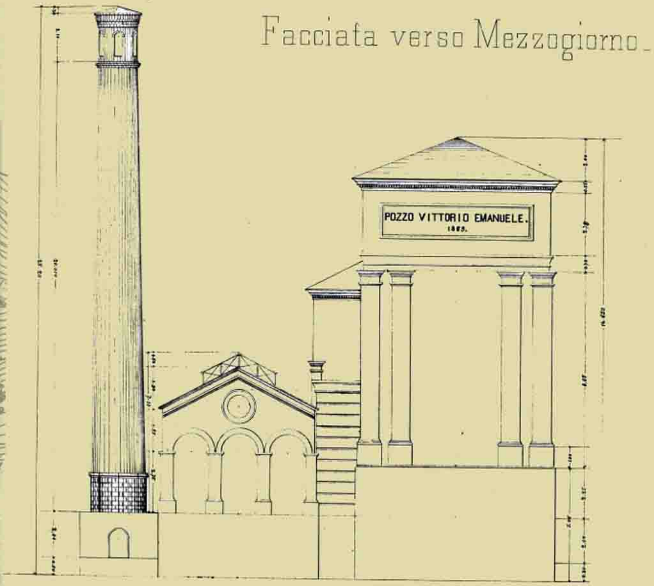
1850 Nicolay


Saint Real Washery
Nicolay Mouth
Villammarina Mouth

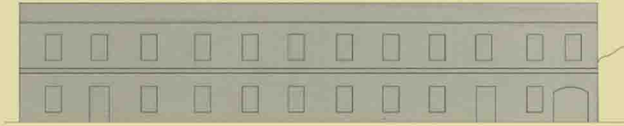



# MONTEPONI MINE - Historical Development

1861 Pellegrini

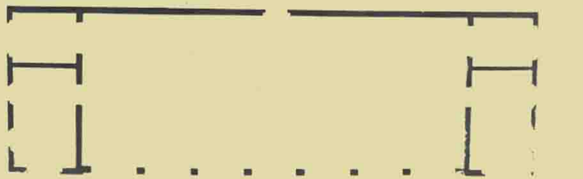



VITTORIO EMANUELE SHAFT

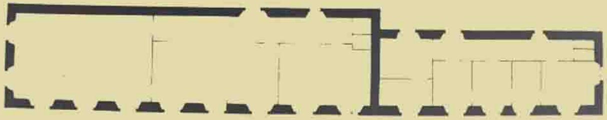



General Warehouse

Vittorio Emanuele Workshop



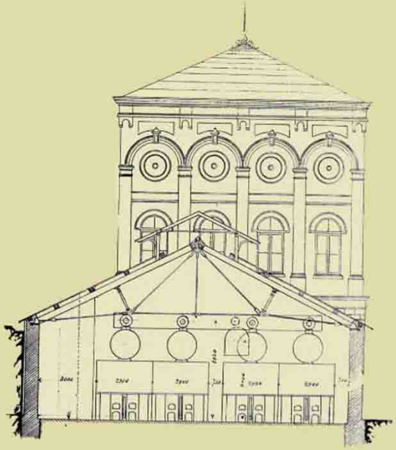
Villamarina Washery

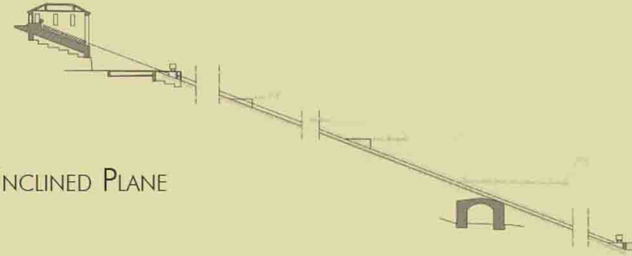


Villamarina Dwellings

# MONTEPONI MINE - Historical Development

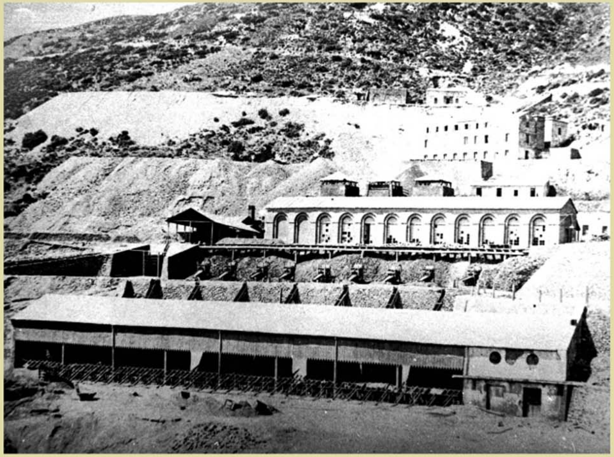
1870 Pellegrini



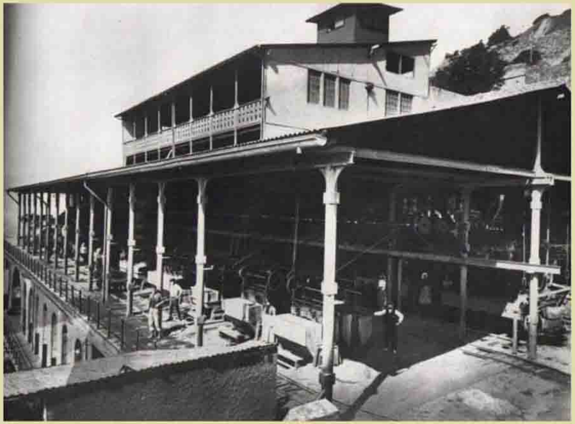
# MONTEPONI MINE - Historical Development

## 1871 - 1875 Pellegrini



Manual and then Mechanic V. E. Washery

Pilla & Sacchi Washery

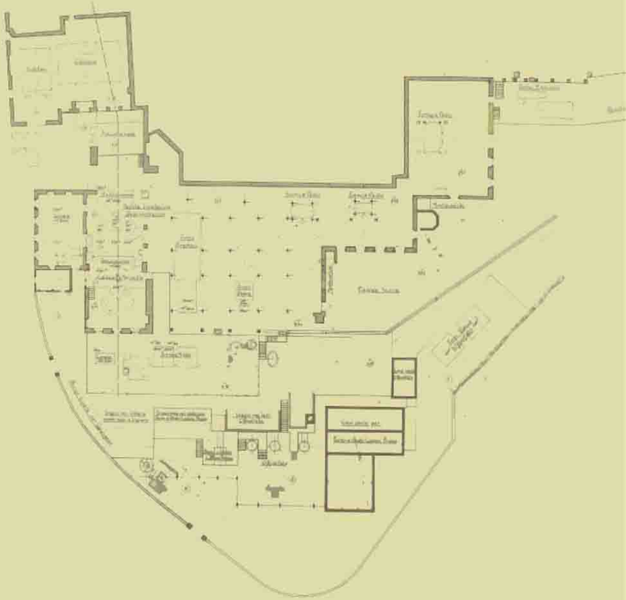


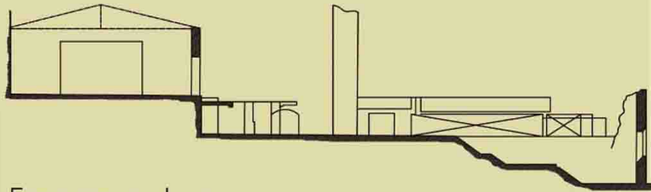
Calamine Washery

MONTEPONI MINE - Historical Development

1887 Ferraris

Foundry of Cast Iron
Mameli Washery - Charging Plant

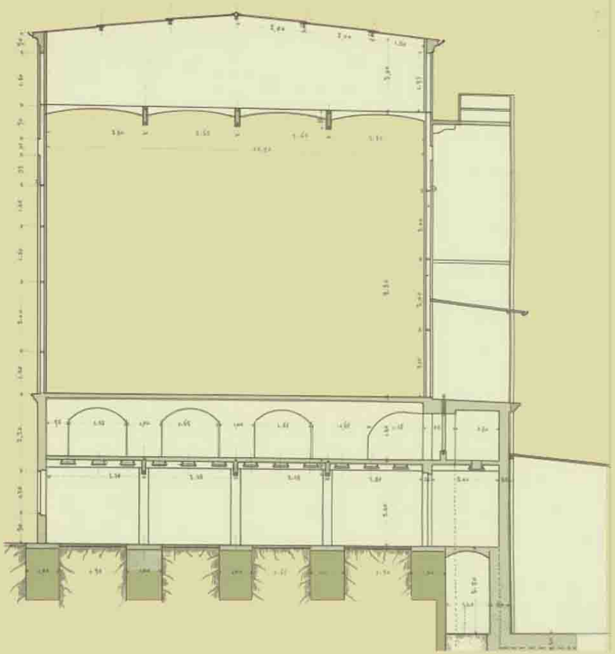





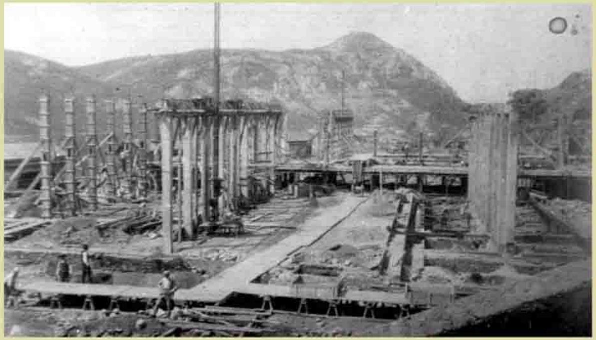
# MONTEPONI MINE - HISTORICAL DEVELOPMENT

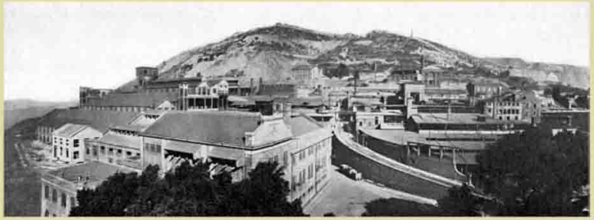
1894 - 1898 FERRARIS

Compressors Room - Vittorio Emanuele Shaft



White Zinc Factory





PLANT ELECTROLYSIS OF ZINC

# MONTEPONI MINE - HISTORICAL DEVELOPMENT

1926 BINETTI

FACTORY OF SULPHURIC ACID

## BUILDINGS AND FACILITIES

DELAUNAY HOSPITAL

ANCIENT DIRECTORATE

MANAGER’S HOUSE “BELLAVISTA”

VITTORIO EMANUELE AND SELLA SHAFTS

GENERAL STORE - WORKSHOP

INCLINED PLANE

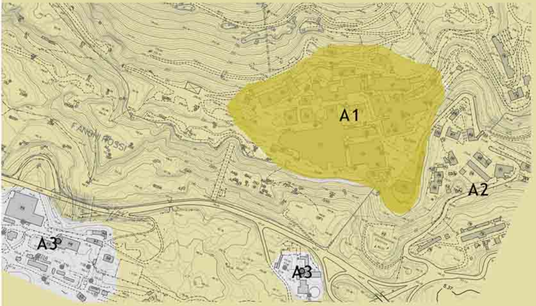
CALAMINE WASHERY

CHEMICAL LABORATORY

CAST IRON AND LEAD FOUNDRIES

WHITE ZINC FACTORY

ELECTROLYSIS PLANT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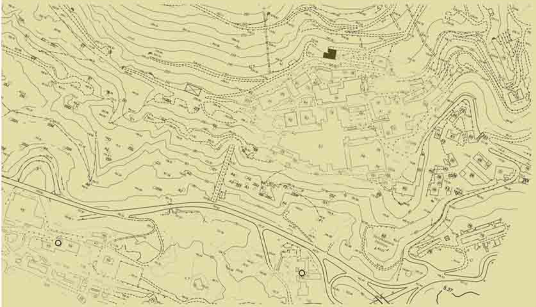
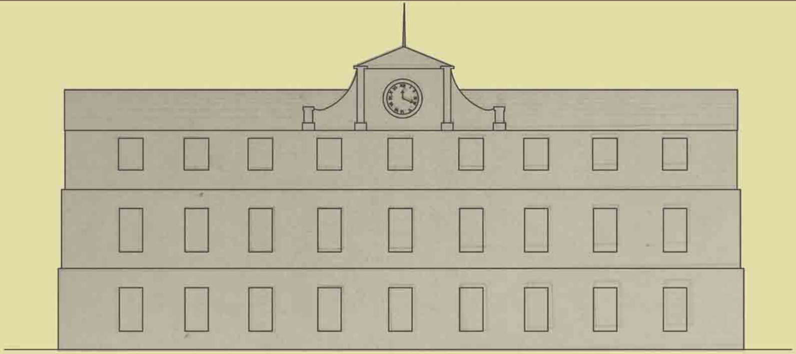
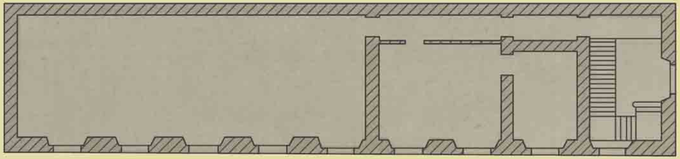
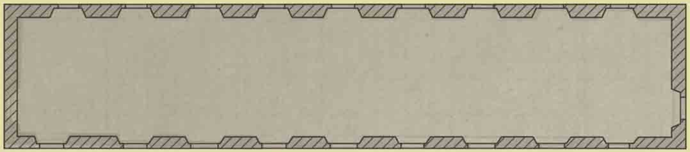
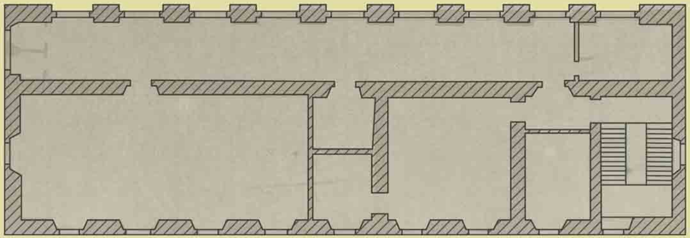
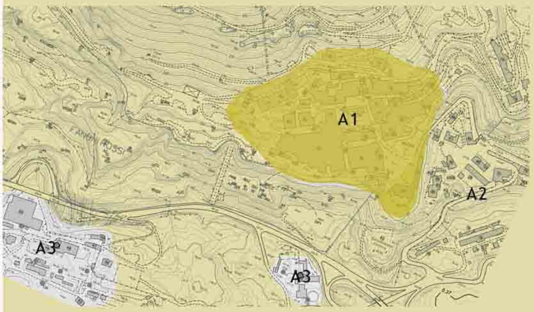


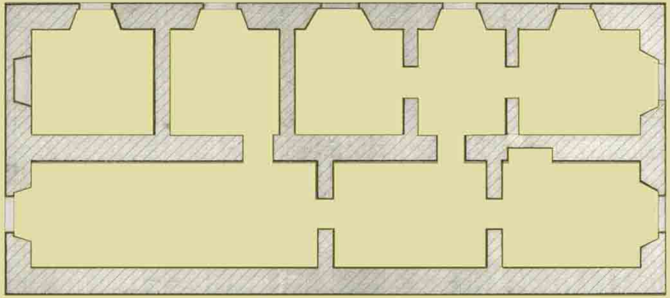




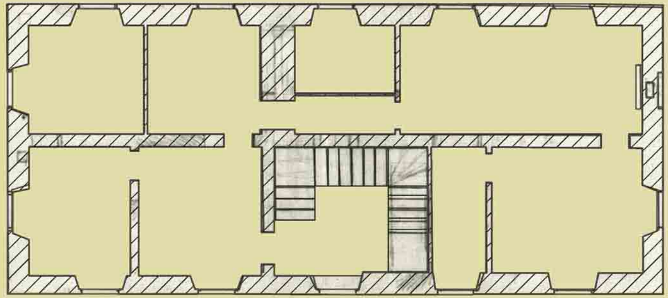






Livello 0



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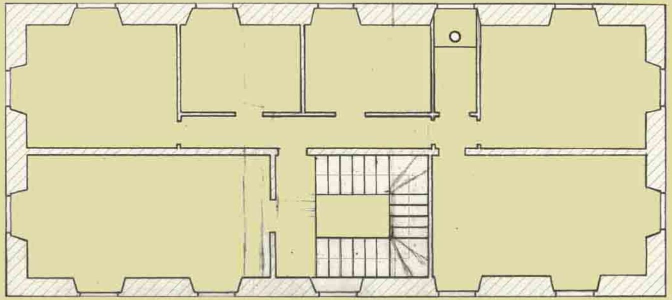

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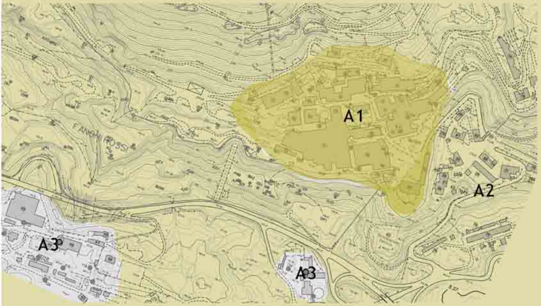
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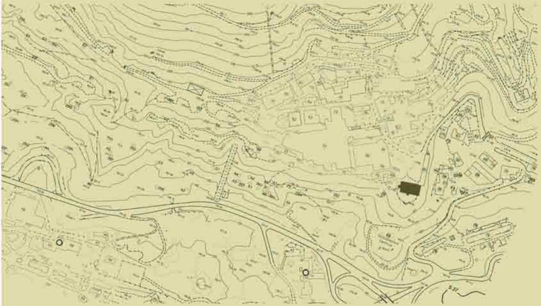

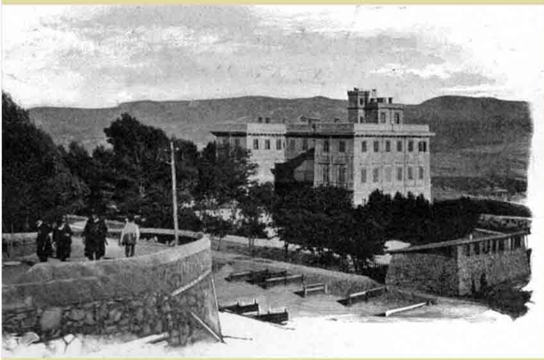

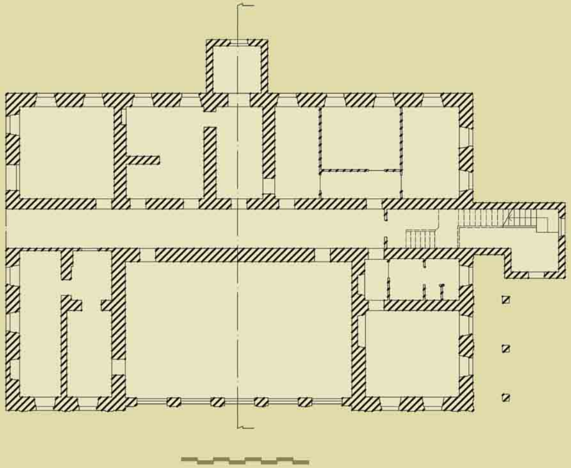

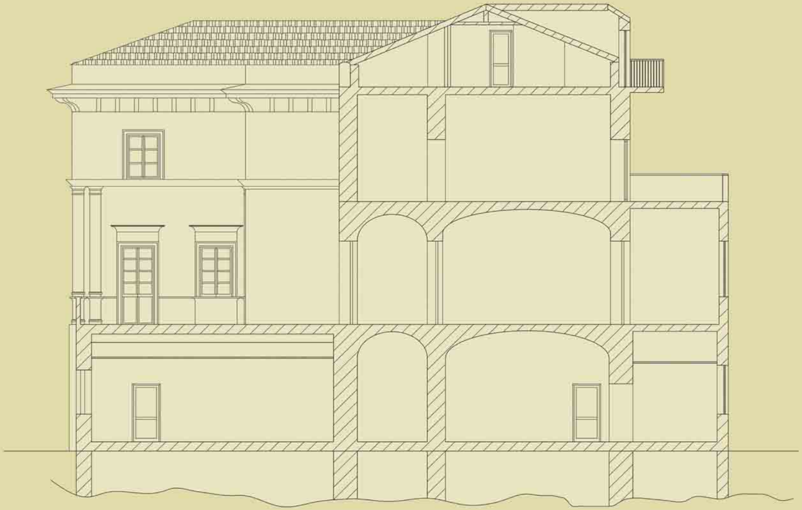

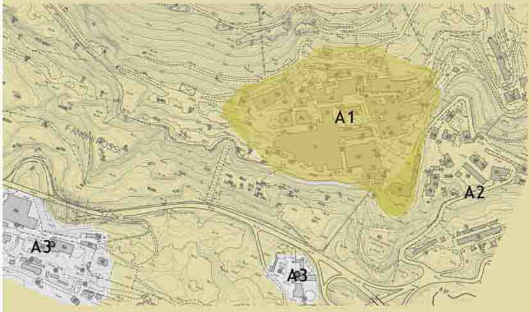
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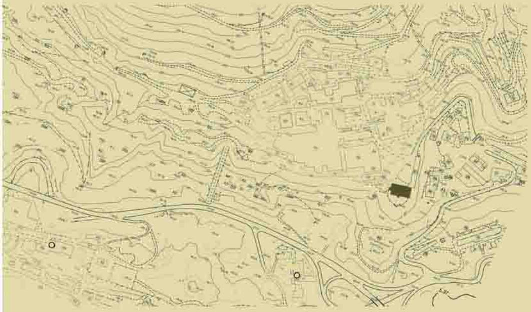
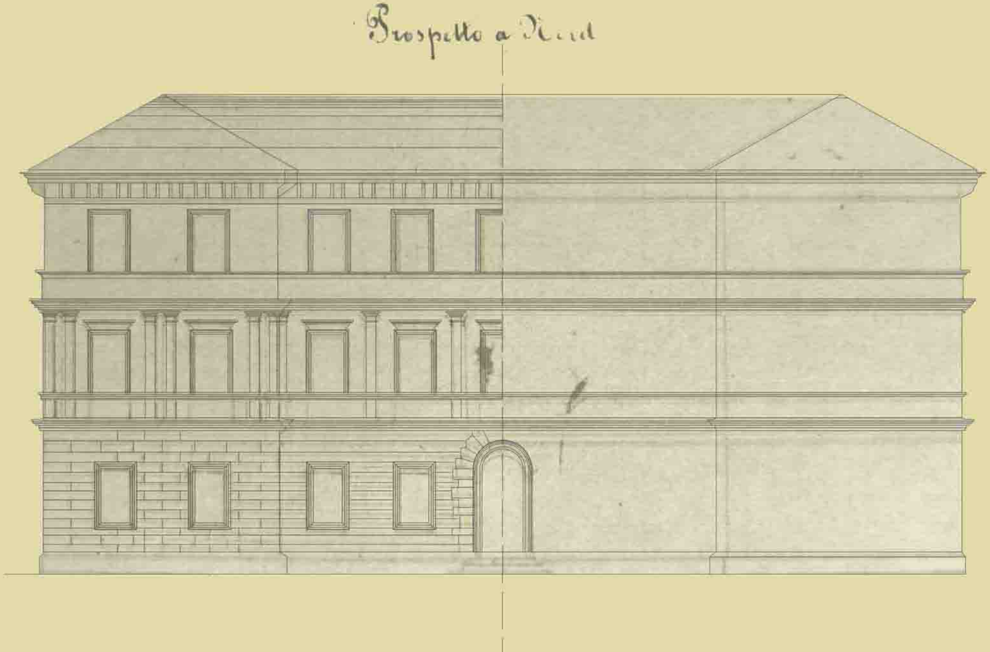
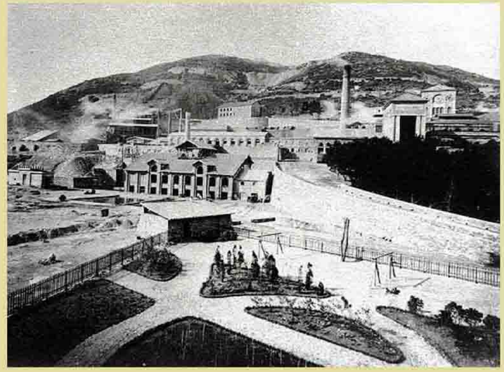
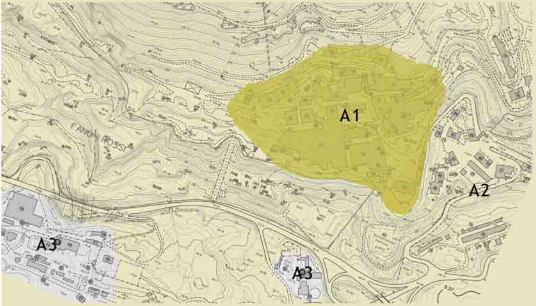



Prospetto a Nord

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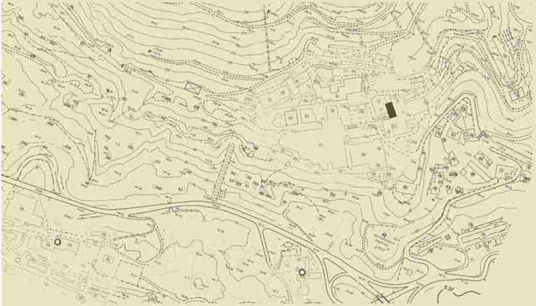

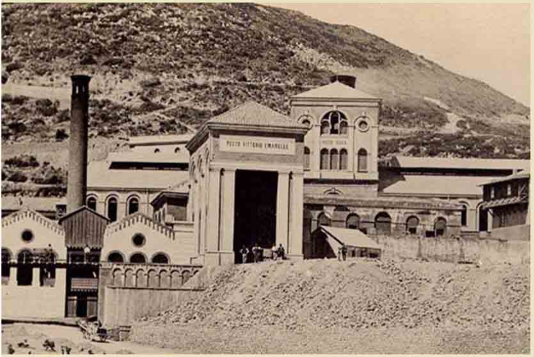

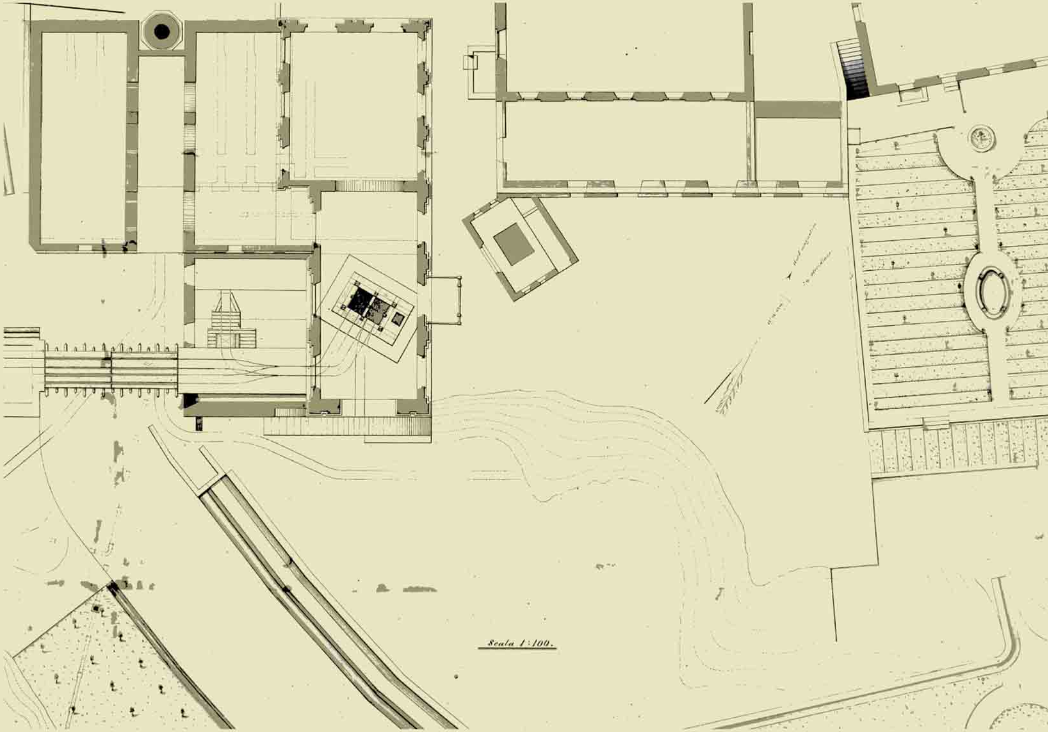
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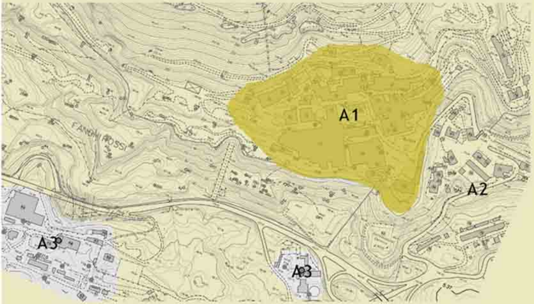
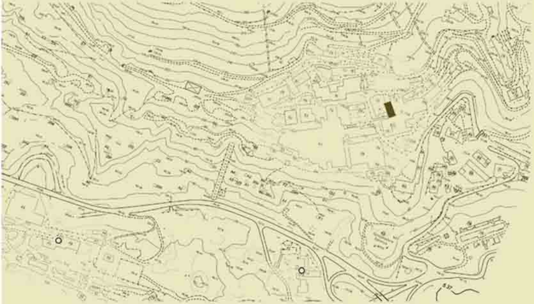
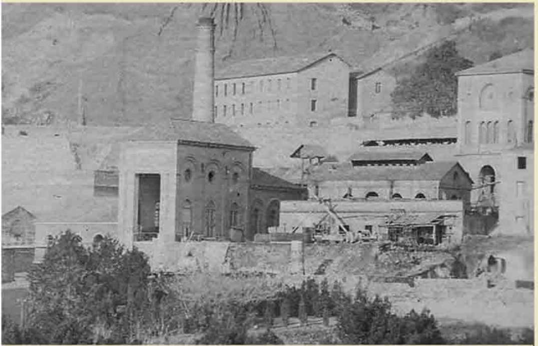
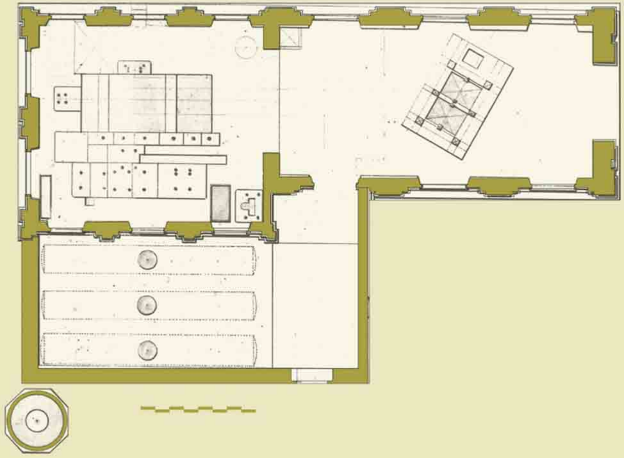
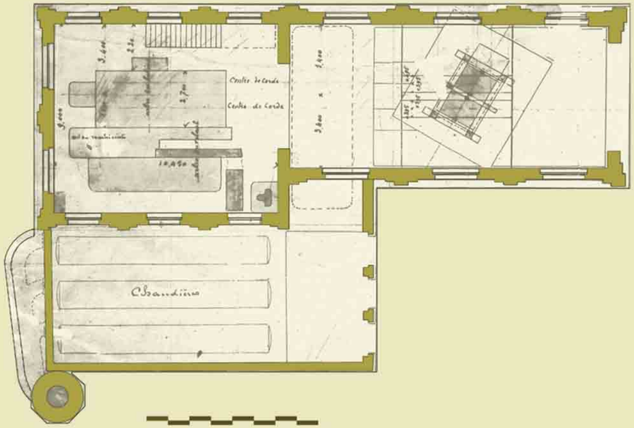


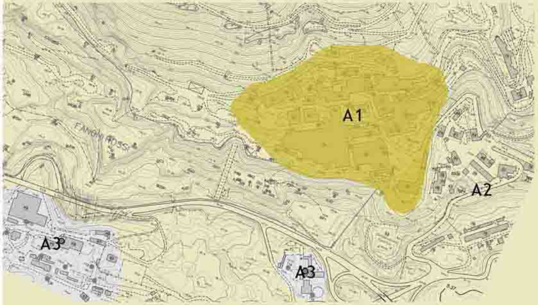


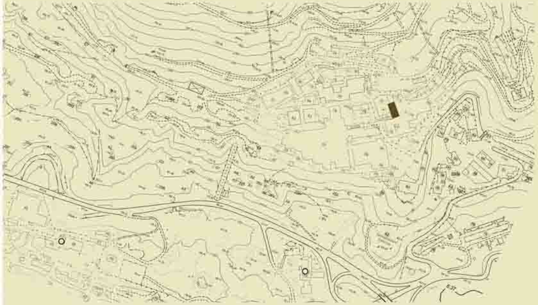


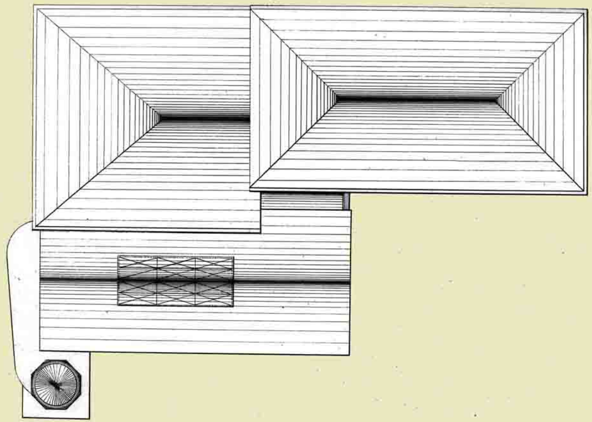


Monteponi Mine _ Building Overview

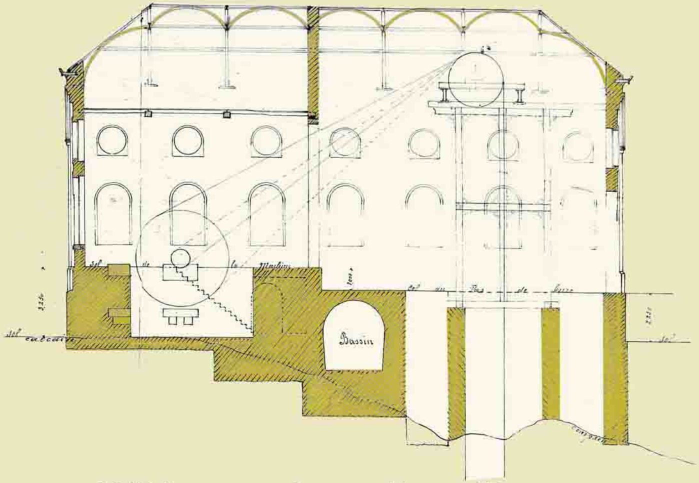
Vittorio Emanuele Shaft - Plans



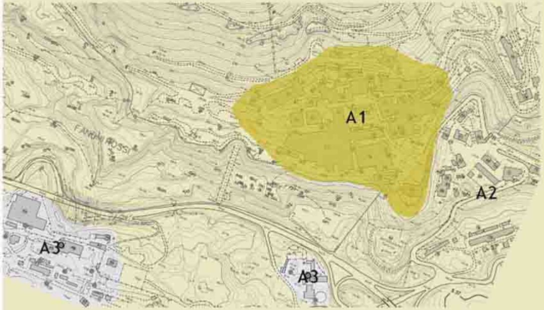





1868 (?) : Plan of Covering - Franz Stiglitz




1867: Longitudinal Section - Marcellis' Firm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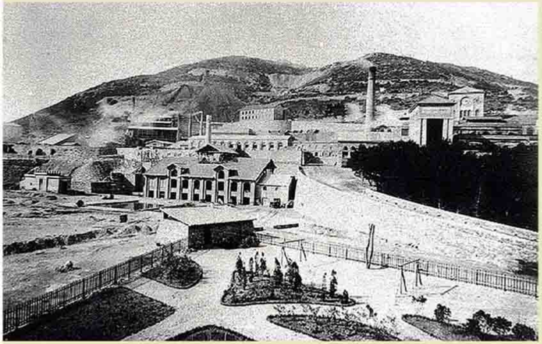

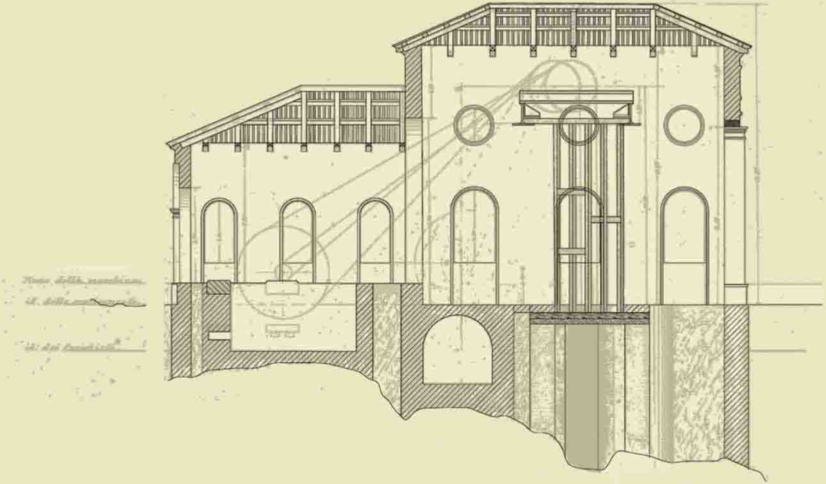

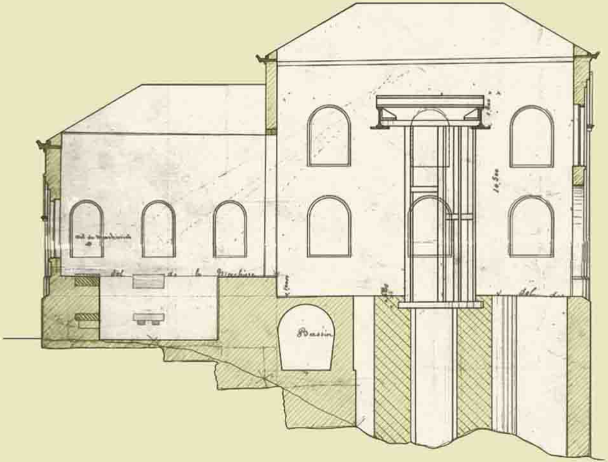

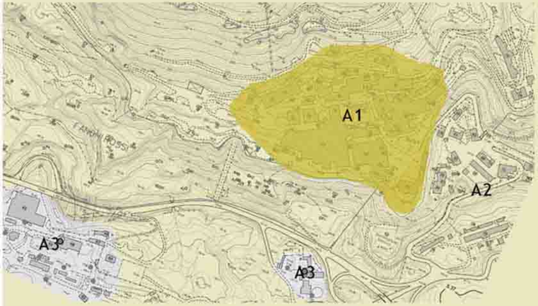
A1
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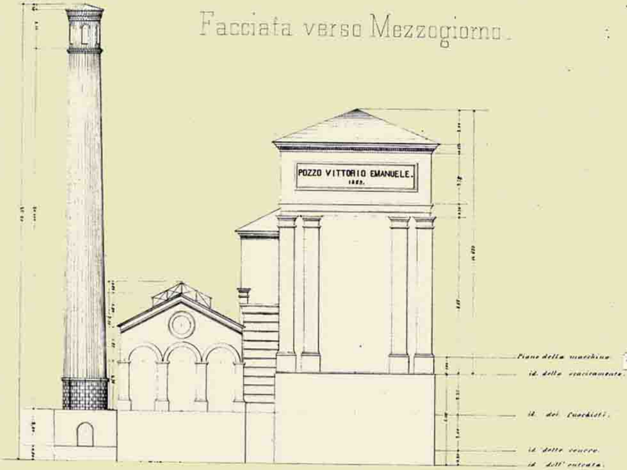
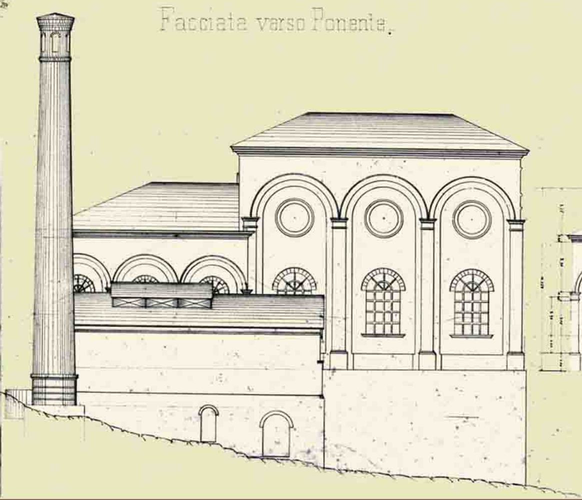
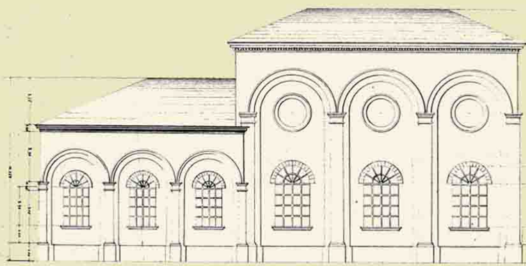
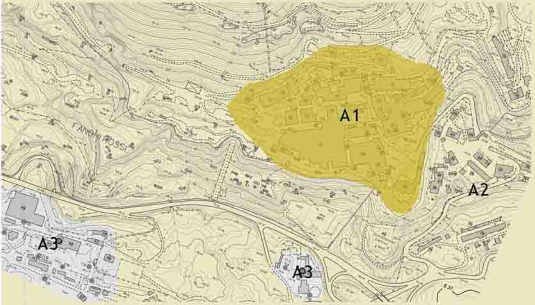

Facciata verso Mezzogiorno.
POZZO VITTORIO EMANUELE.
Piano della macchina


Facciata verso Mezzanotte.
Scala 1:100.

Scala 1:100.


Facciata verso Ponente.


Facciata verso Ponente.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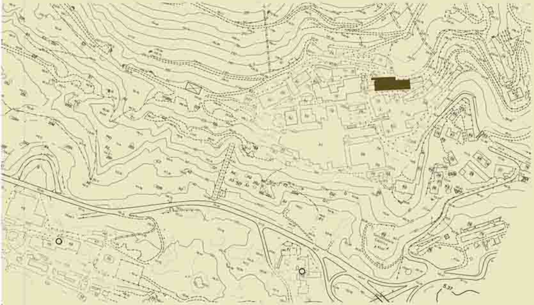
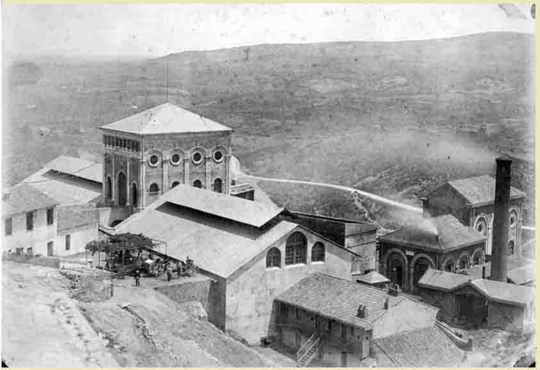
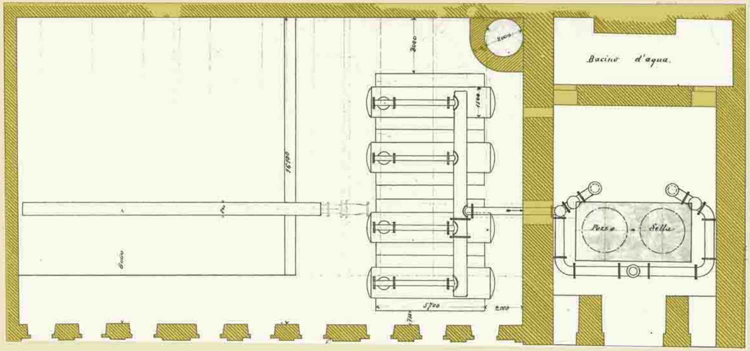
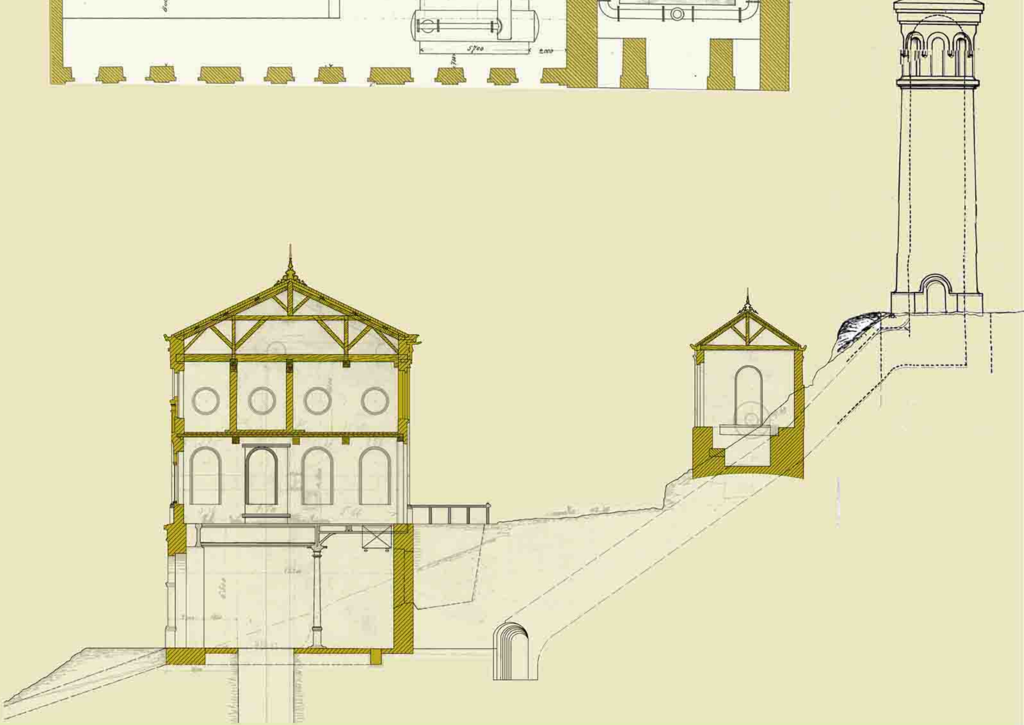
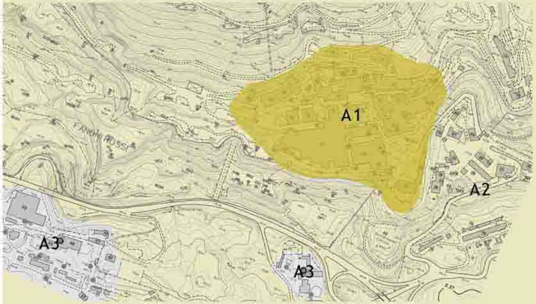
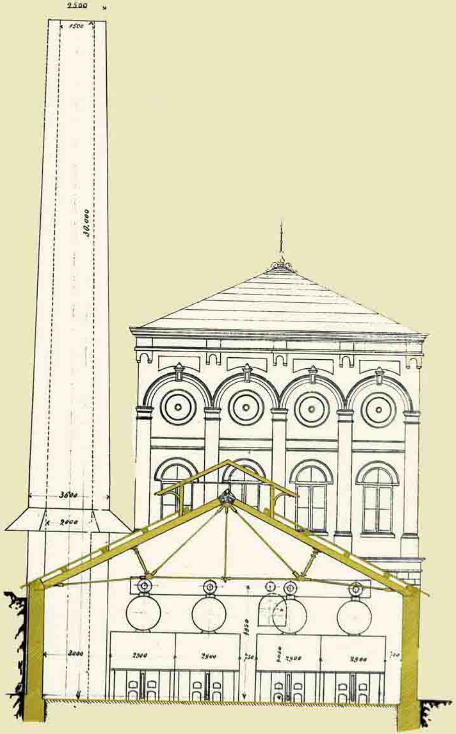





Bacino d'aqua
Pozzo Sella

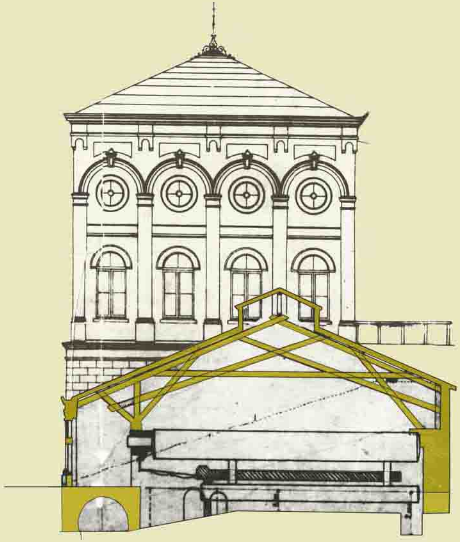




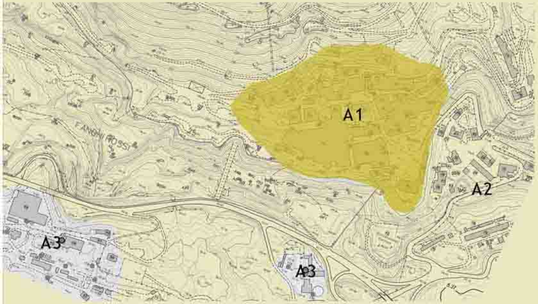



1889

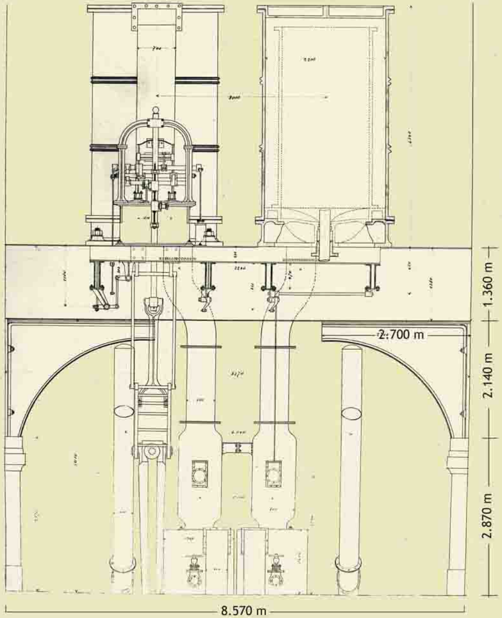
Project for the Transformation of the Boilers



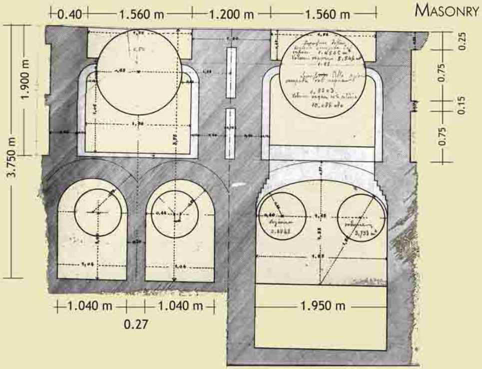
n.d. General Asset for the Machines and the Steam Boilers

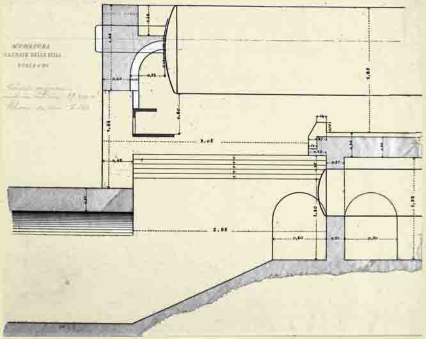


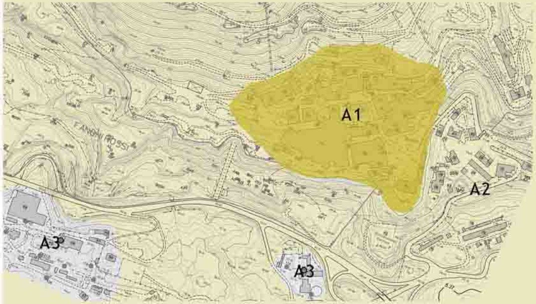

## 1889 Bearing System of the Boilers



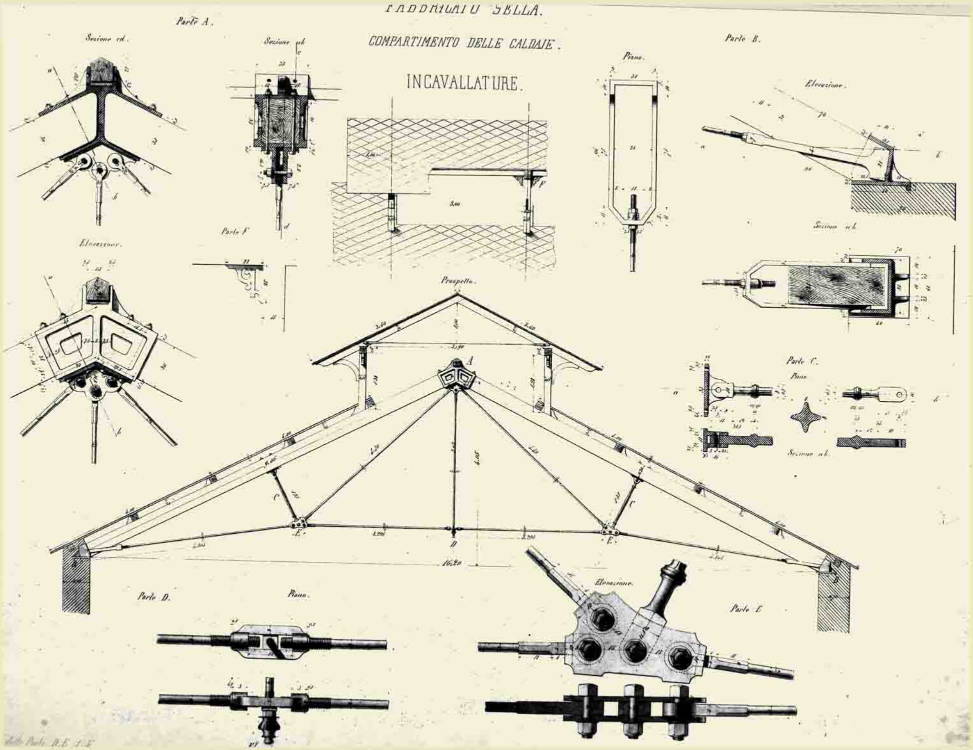

## Masonry of the Boilers Room

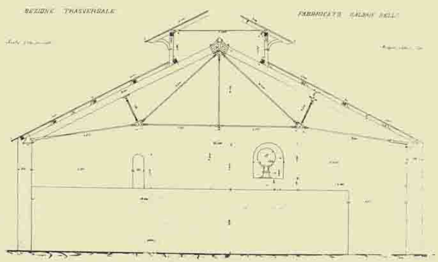


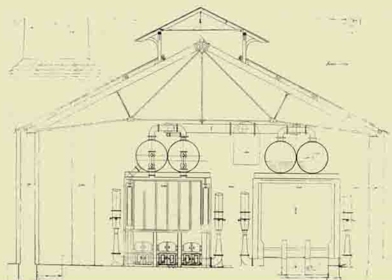







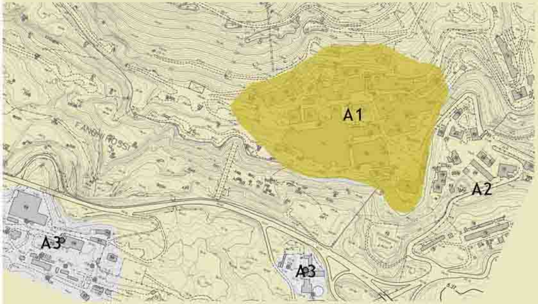


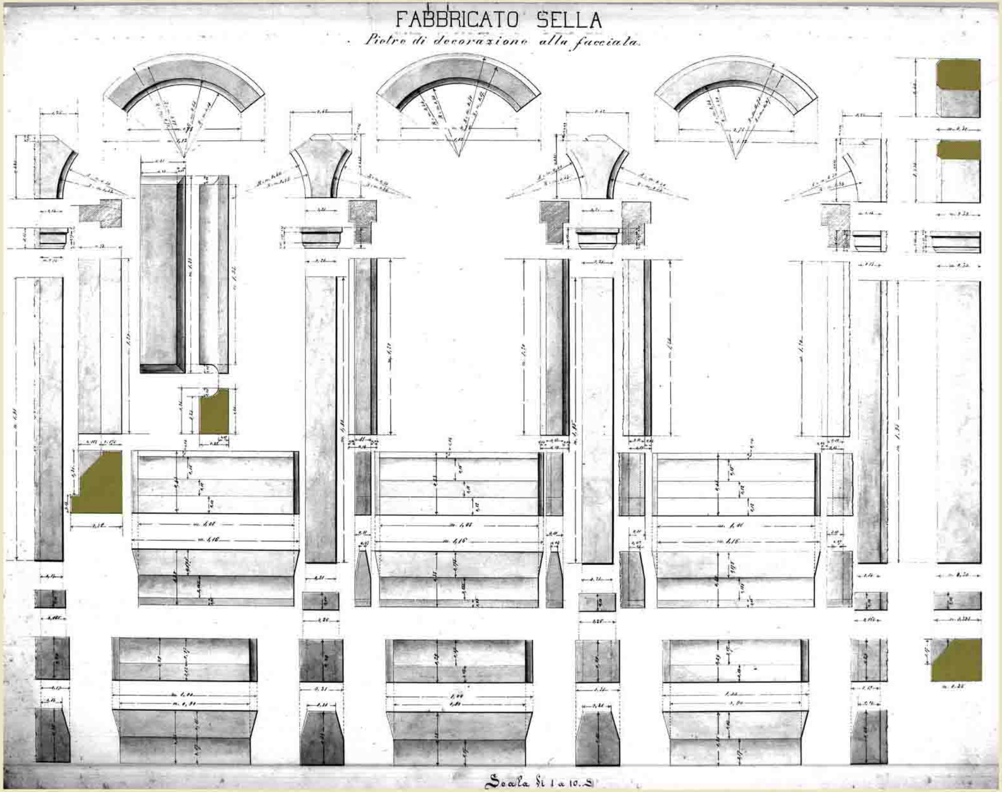



## Monteponi Mine _ Building Overview

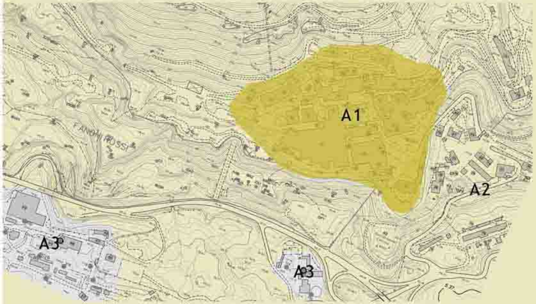
## Sella Shaft Metallic Trusses



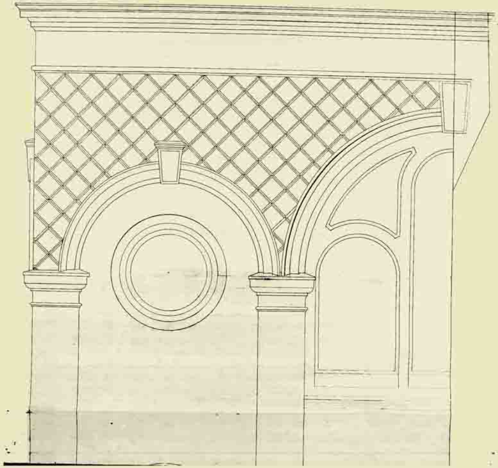


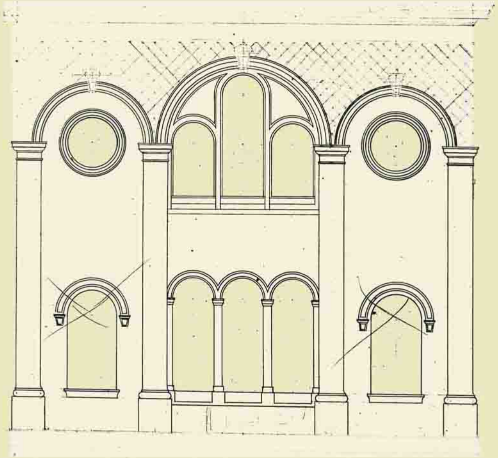


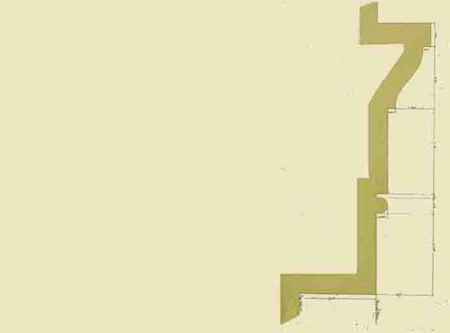

DETAILS OF THE STONED DECORATION OF THE MAIN FAÇADE.



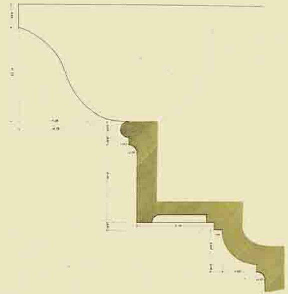




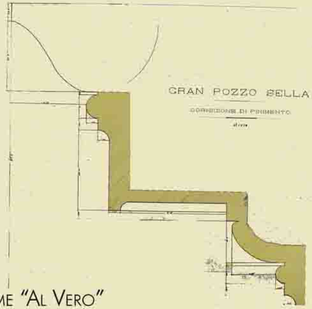




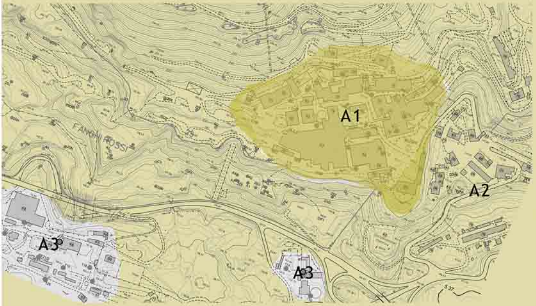
FRAME ABOVE THE ARCHES

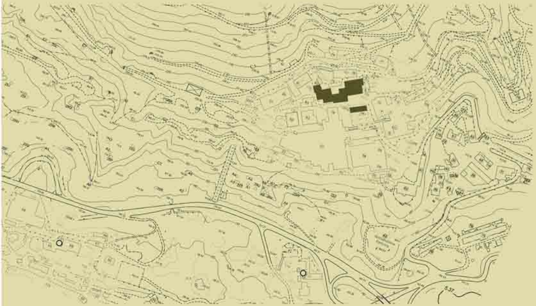


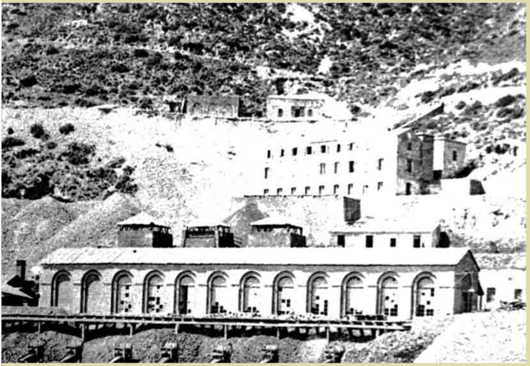
ARCHED FRAME IN BOILERS ROOM

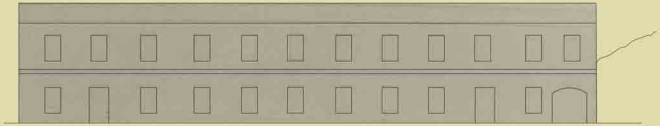


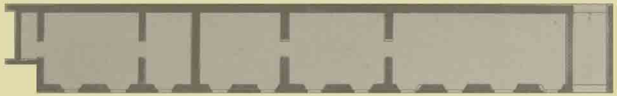

FINISHING FRAME "AL VERO"

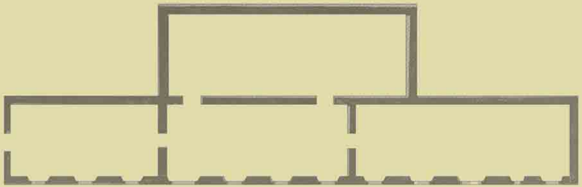


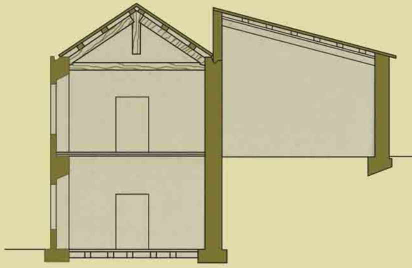



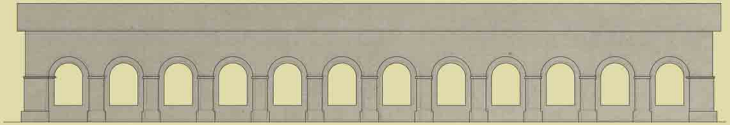


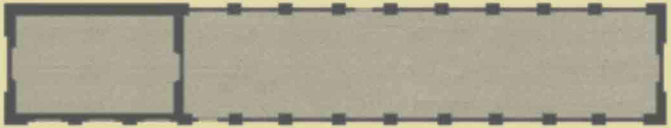






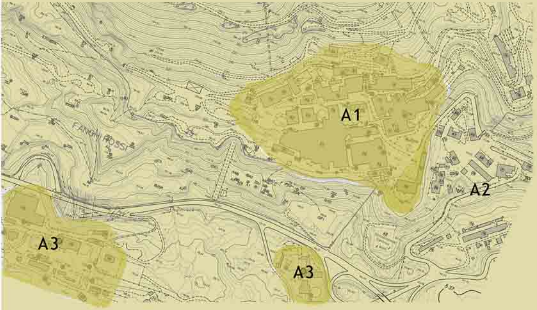








## General Store - Workshop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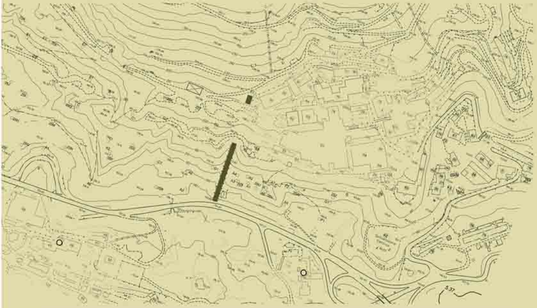
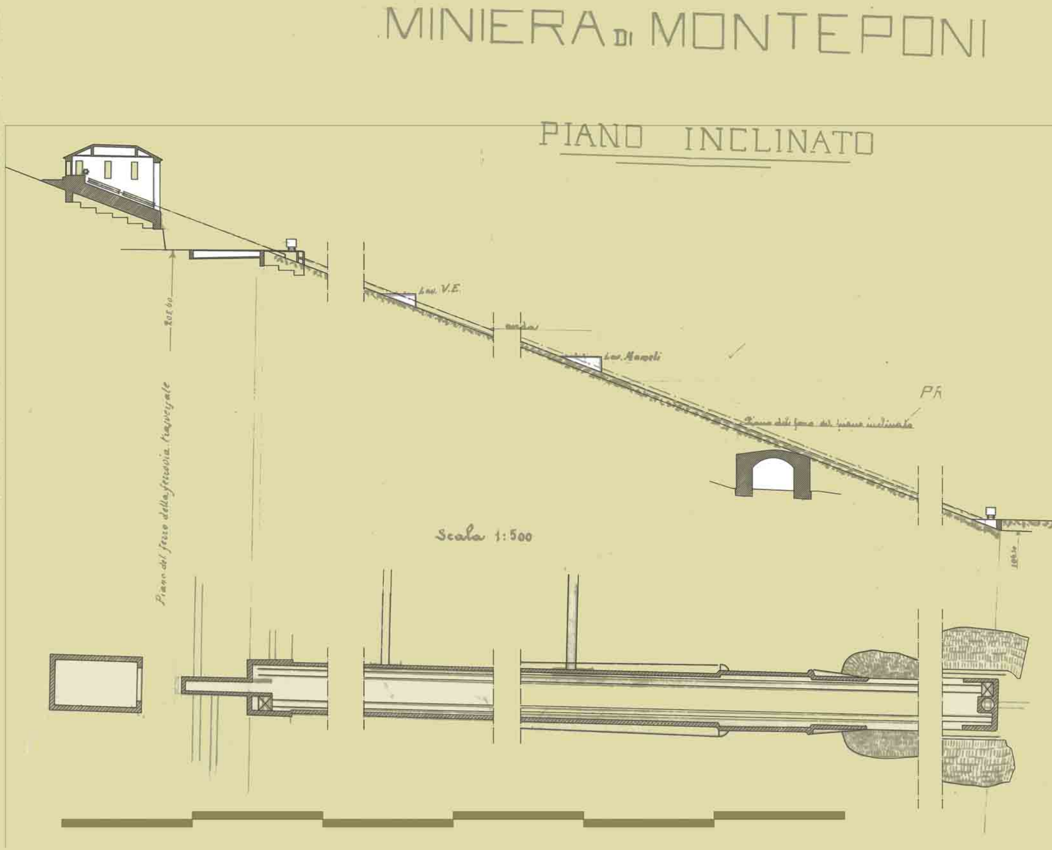
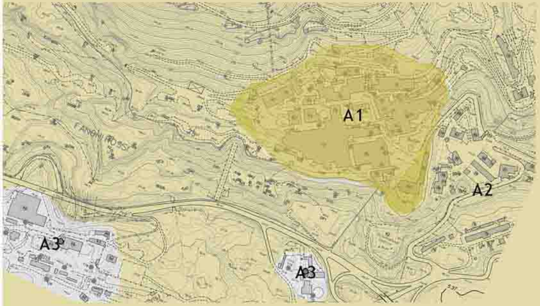



MINIERA DI MONTEPONI
PIANO INCLINATO
Lav. V.E.
Lav. Mameli
Scala 1:500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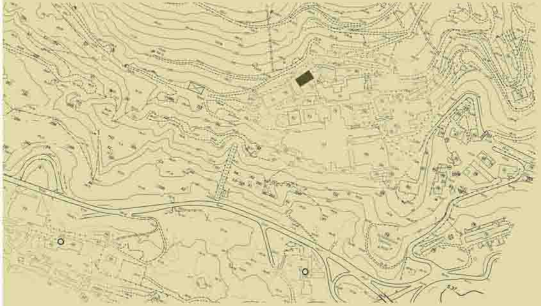

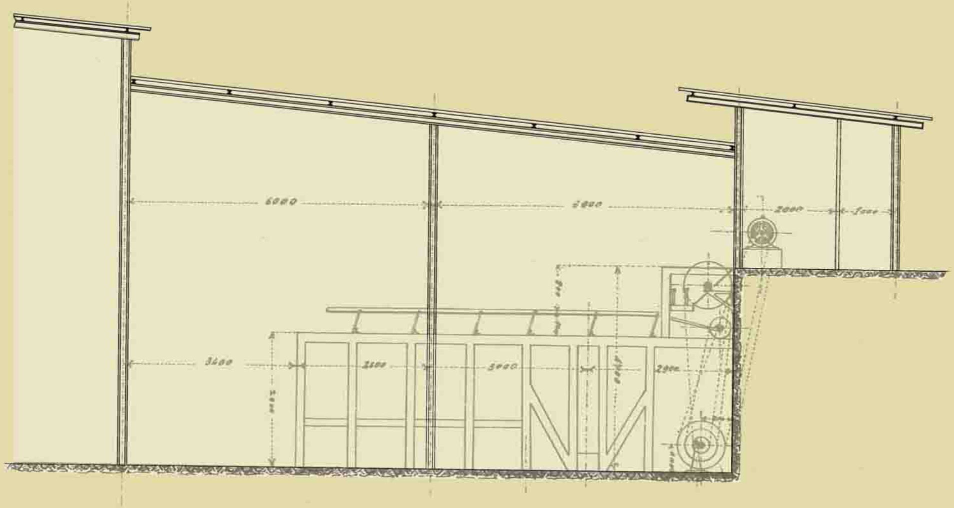

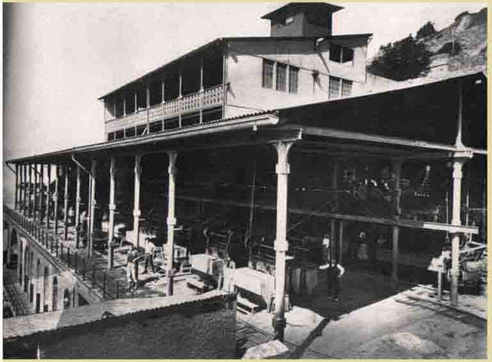

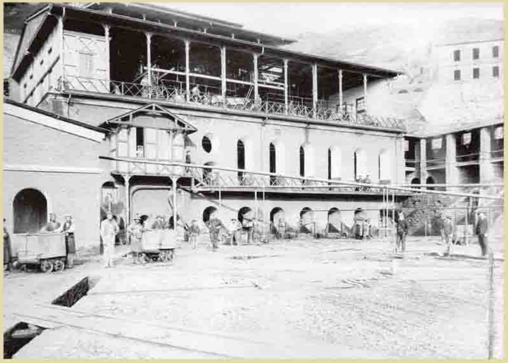

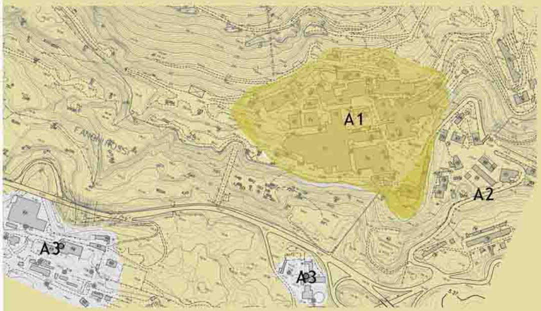
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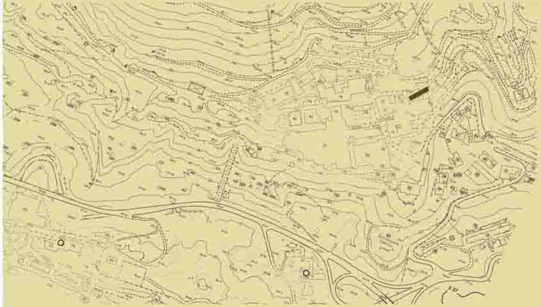

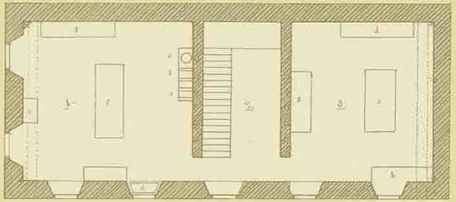

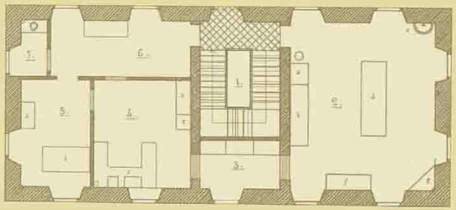

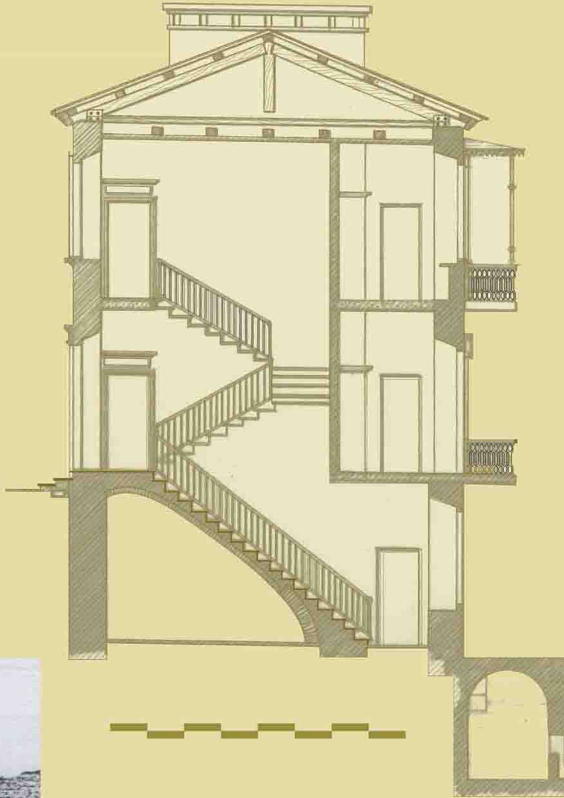

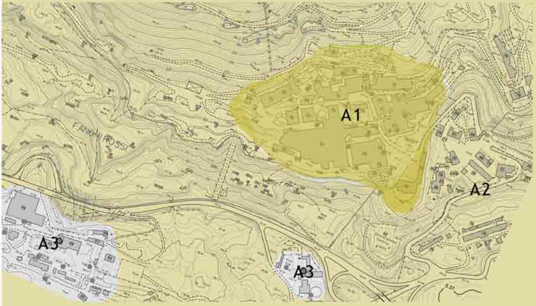
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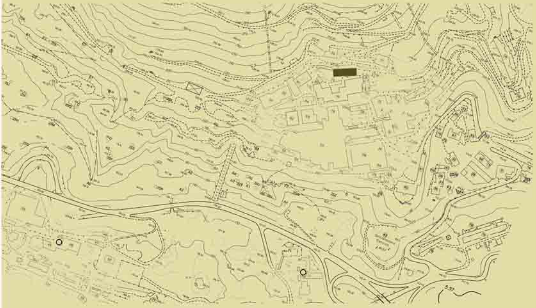
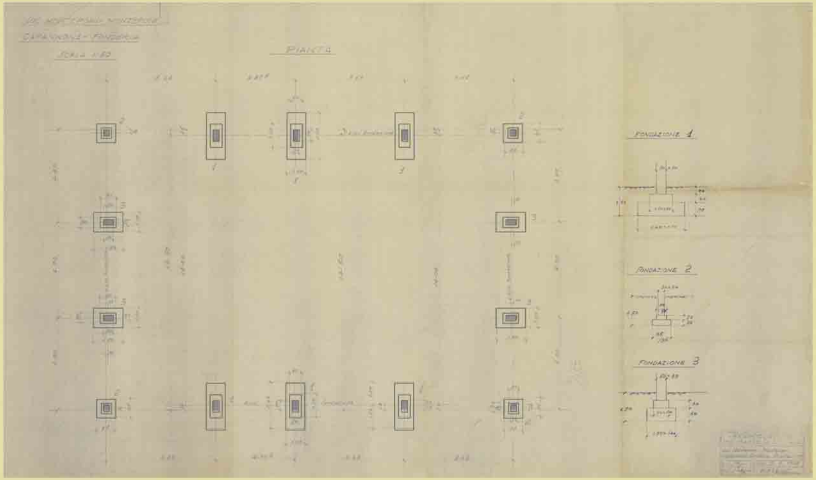
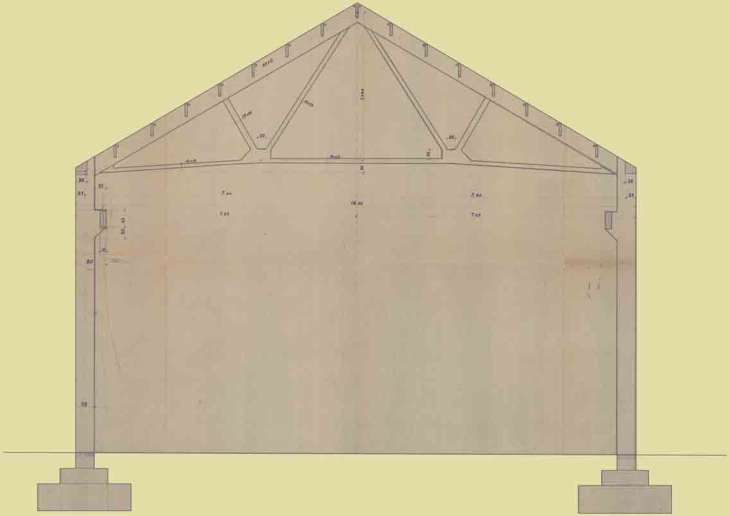
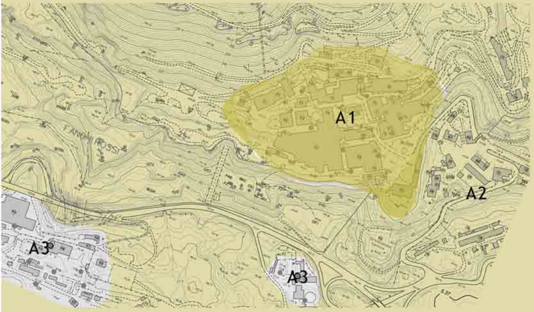
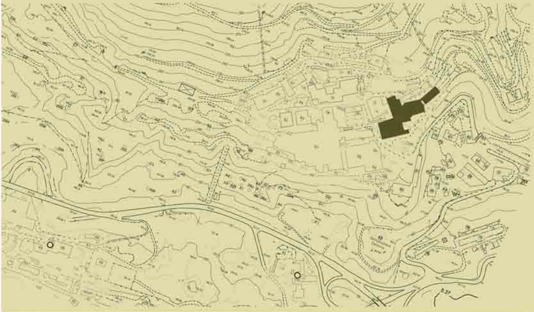
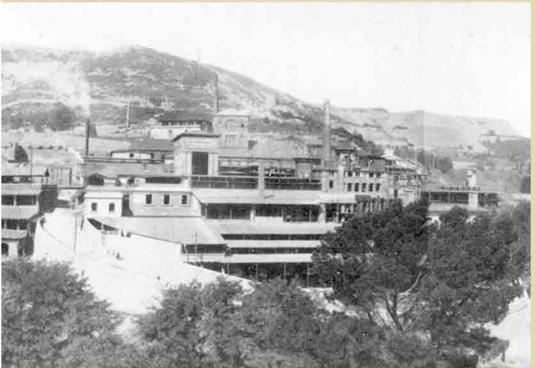


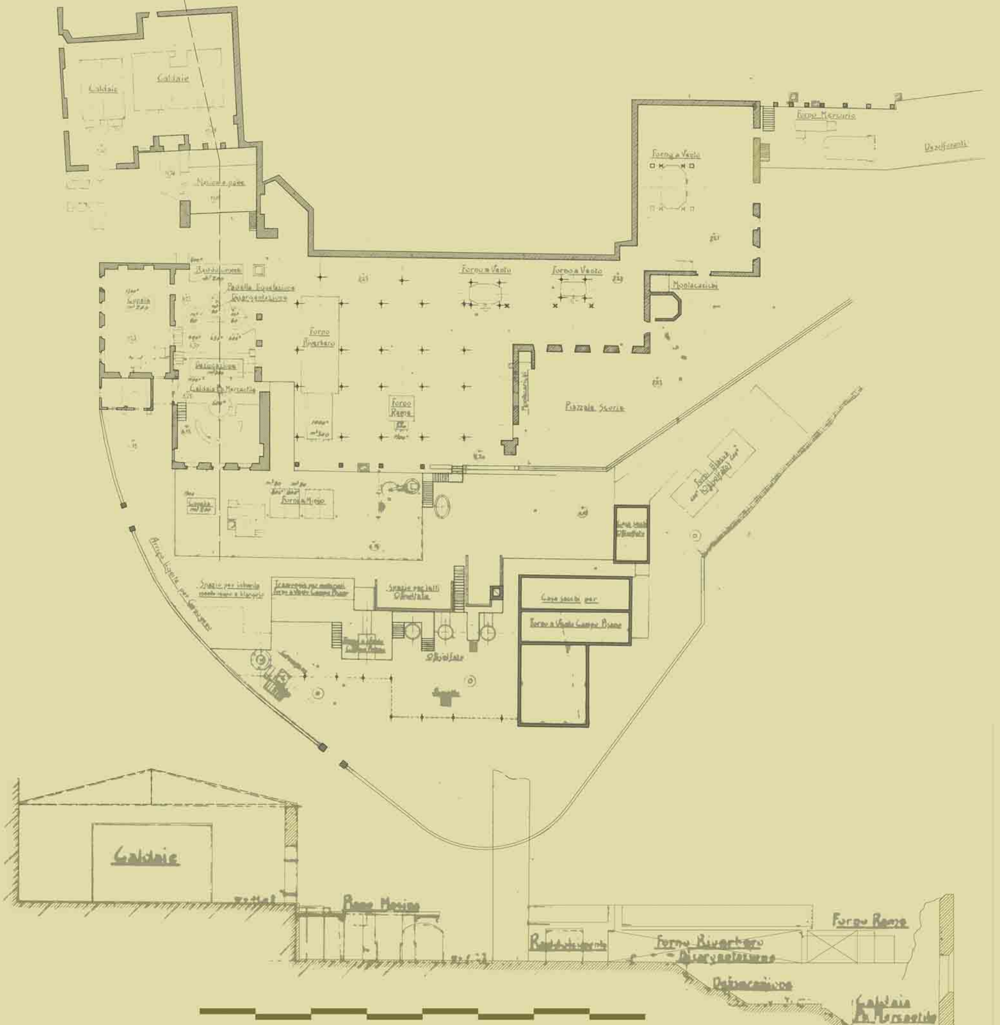

PIANTA
FONDAZIONE 1
FONDAZIONE 2
FONDAZIONE 3





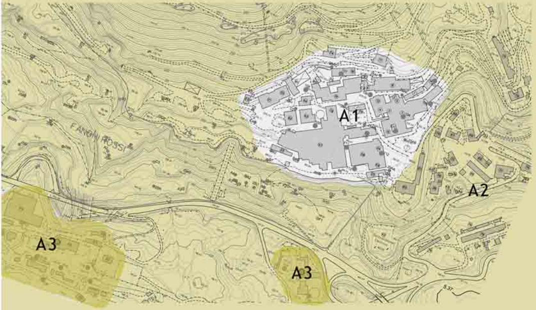



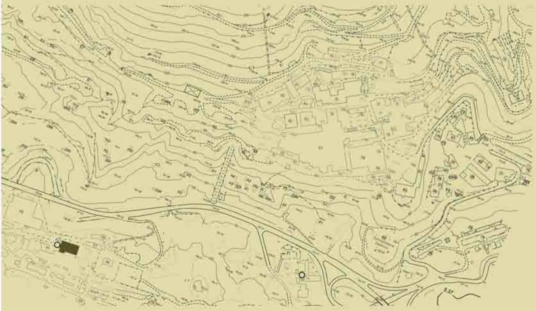


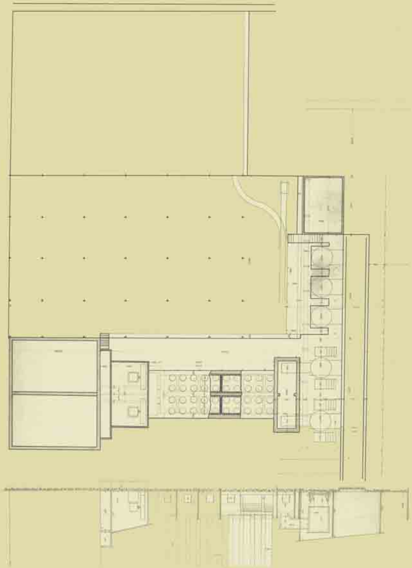


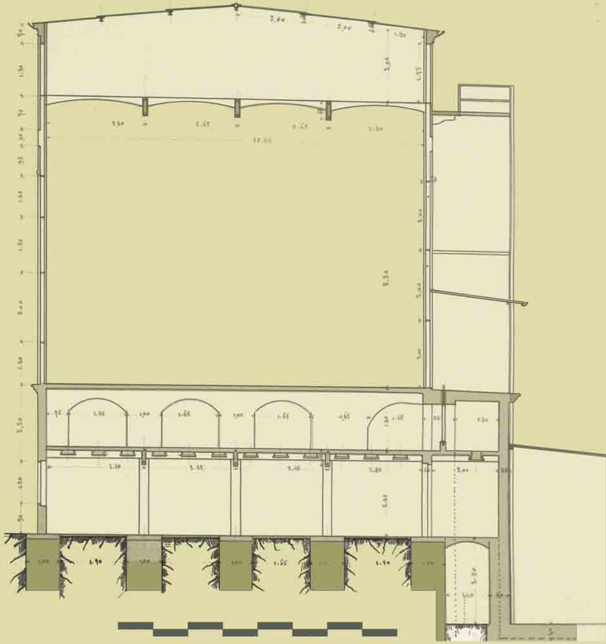

Monteponi Mine _ Building Overview

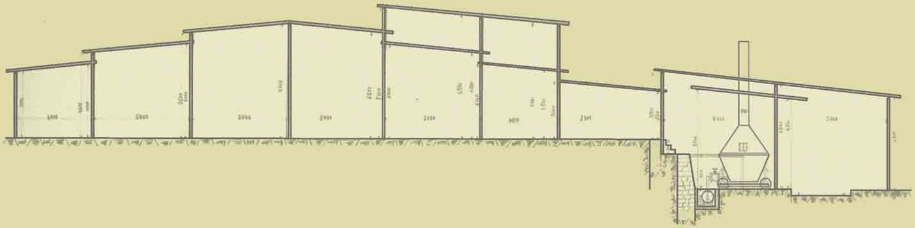
Lead Foundry



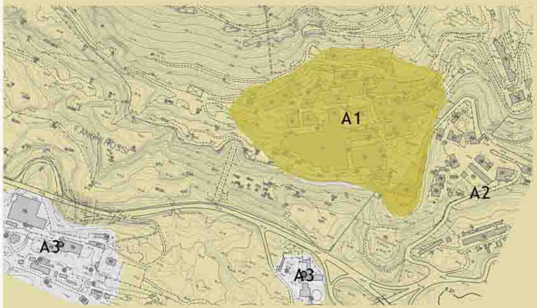


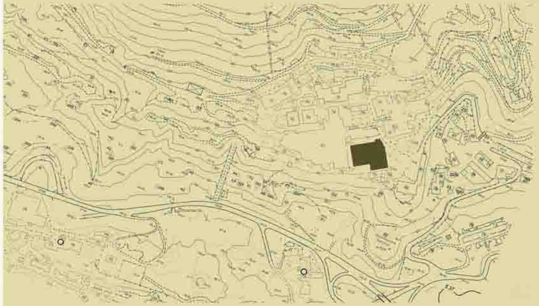


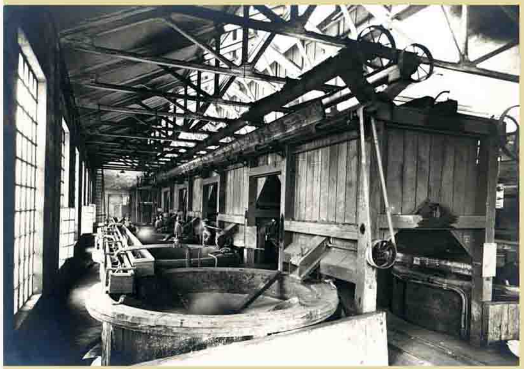


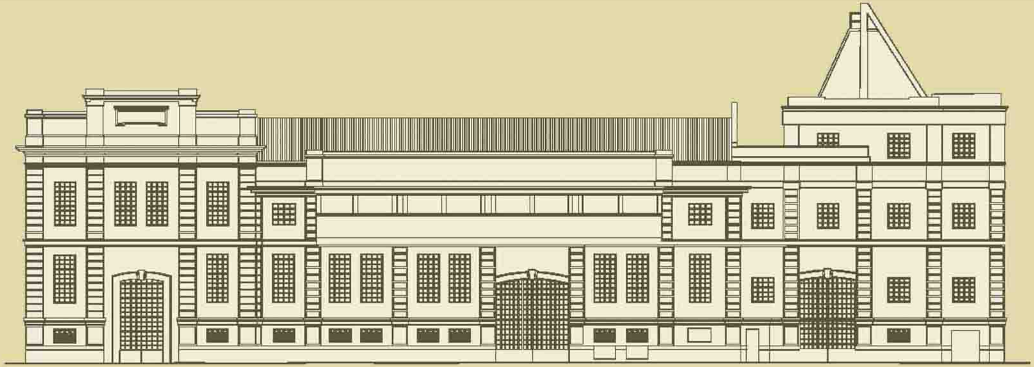
Monteponi Mine _ Building Overview

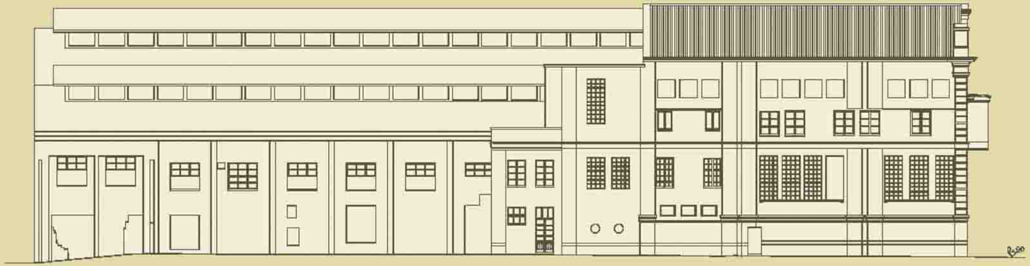
White Zinc Factory

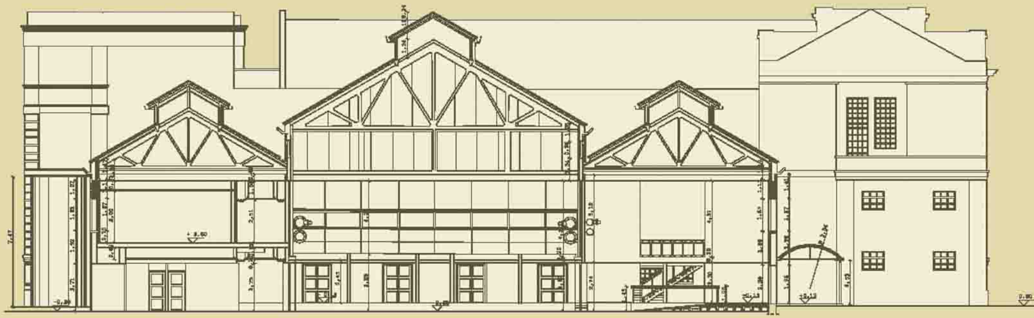










MONTEPONI MINE _ BUILDING OVERVIEW

ELECTROLYSIS PLANT

## BUILDING ELEMENTS

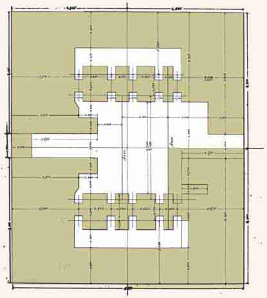
### FOUNDATIONS

### SLABS

### WOODEN ROOFS

### METALLIC ROOFS

## Capstan Building - Sella Shaft



Reinforcing Bars φ 60 mm

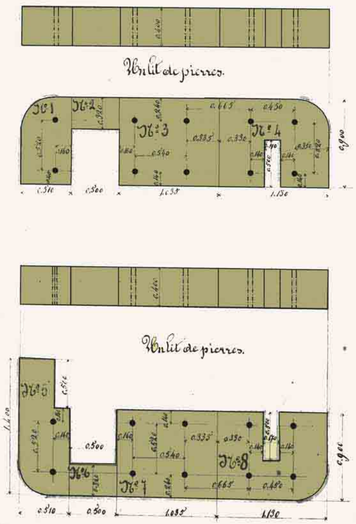
Ashlar Height 17: 20 mm

Height Layer A: 40 mm

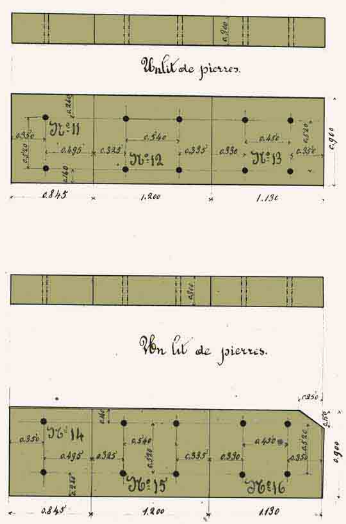
Height Layer B: 30 mm

## Details of the Stones of the Foundations

### Layer A: Ashlars 1 - 9



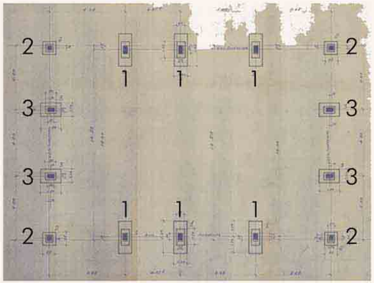

### Layer B: Ashlars 10 - 16



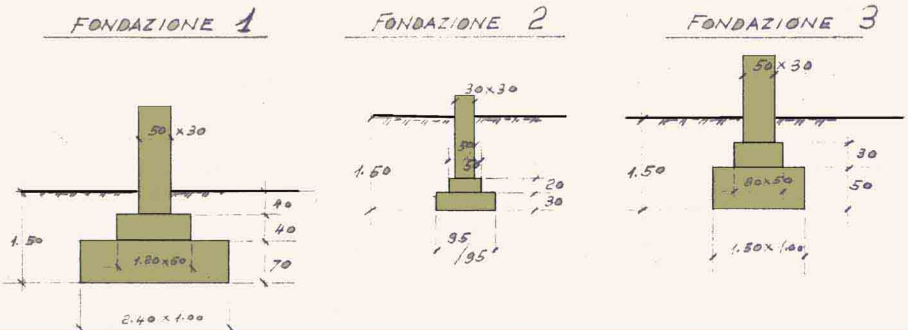


### Ashlar 17


## Cast - Iron Foundry




## Foundations of the Hut of the Foundry

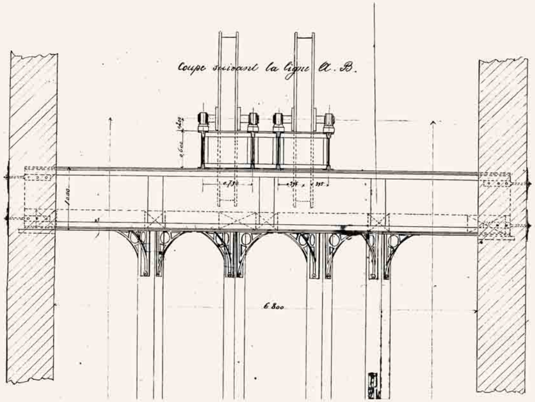


## Sella Shaft

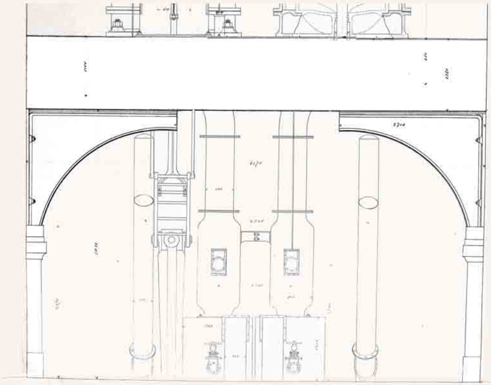
A.
Main Beam H: 1.000 m Spam: 6.80 m
Secondary IPE Beam H: 0.60 m
Span among IPEs 0.79 m

B.
Beam H: 1.360 m Span: 8.57 m
Girder H: 2.14 m
Springer Level: 2.87 m

### A. Disposition "Belle Fleur" of the Carpentry

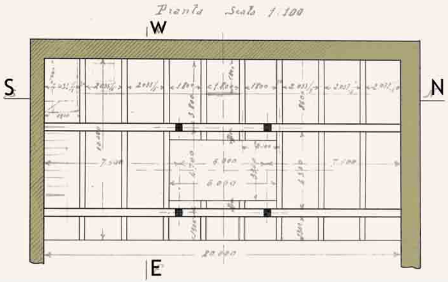



### B. Girders and Beam in the Boilers Room

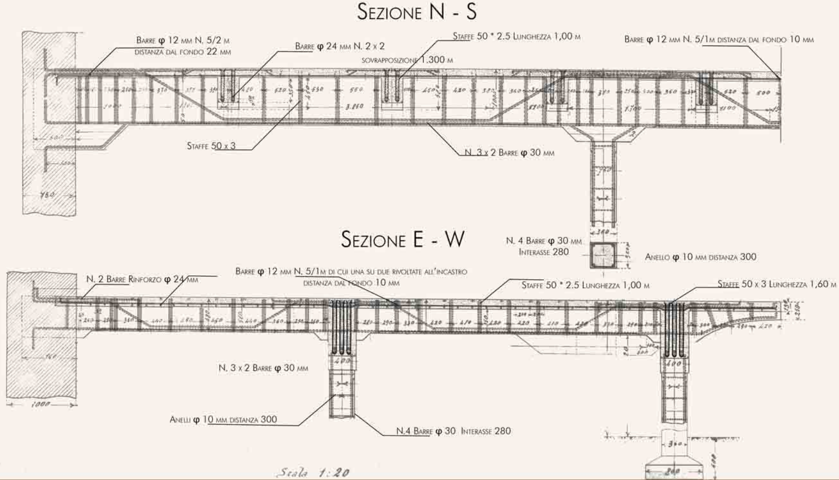


## Lead Foundry

Ribbed Slab sp. 130 mm
Height of the Slab at the Pillar 800 mm
Beams 400 x 800 x 20000 mm
Ribs 300 x 580 mm
Pillars 360 x 360 mm
Plinth Wideness 800 mm Depth - 0.60 m




### Reinforced Concrete Slab for an Overcharge of 1000 Kg / mq



## Vittorio Emanuele Shaft

Plank a: 60 mm

Ridge b: 200 mm L: 7.80 m

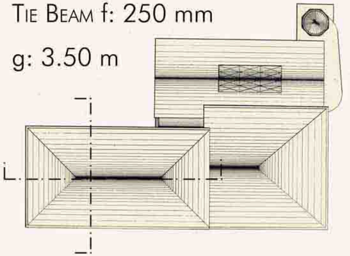
Rafters c: 260 mm x 3500 mm

Purlins d: 200 mm

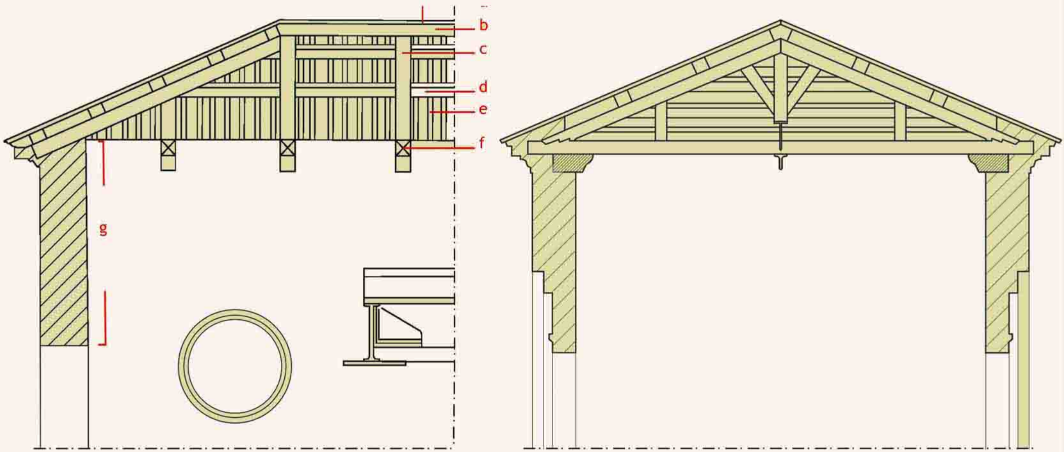
Battens e: 90 mm

Tie Beam f: 250 mm

g: 3.50 m



## Longitudinal and Transversal Section of the Timber Roof in the Machine Room




## Chemical Laboratory - Former Directorate

Ridge a: 50 mm

Plank b: 200 mm

Purlins c: 180 x 250 mm

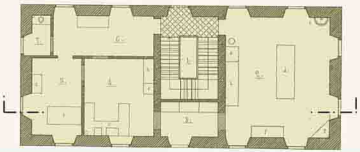
Rafters d: 300 mm

King Post e: 300 mm

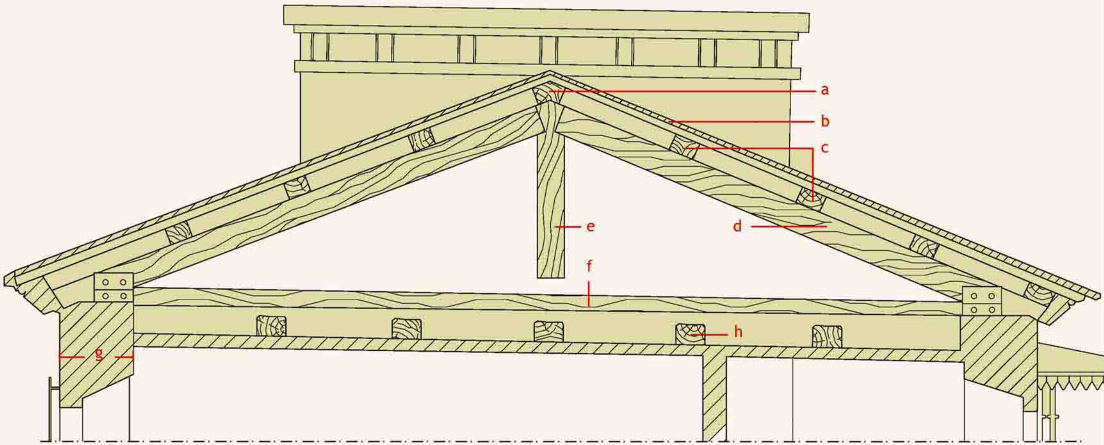
Tie Beam f: 180 mm L: 9.00 m

Masonry g: 80 mm

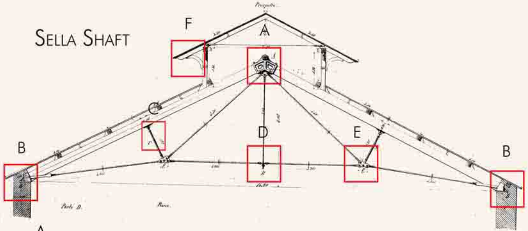
Counterceiling Beams h: 200 x 300 mm



## Transversal Section of the Timber Roof



## Sella Shaft




A.

Right Rafter 300 mm

Left Rafter 350 mm

Top Connector sp. 25 mm

a: 450 mm b: 300 mm c: 275 mm

B.

Connector a: 185 mm b: 210mm c: 400 mm

Bracket d: 40 mm

C.

Counterfixed a: 350 mm b: 100 mm c: 80 mm d: 150 mm

D.

Tensor a: 50 mm b: 100 mm

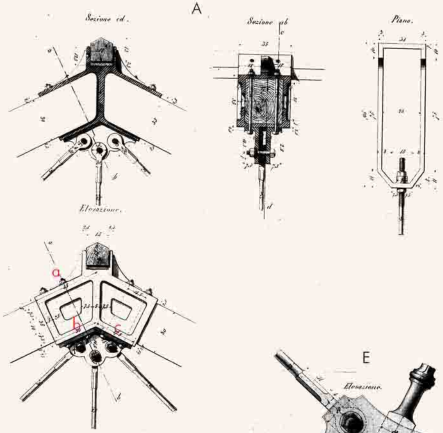
Tie Rod 30 mm

E.

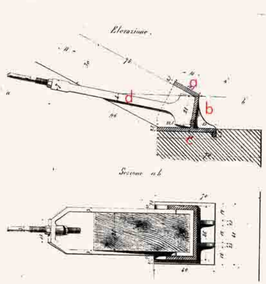
Plate a: 150 mm b: 100 mm c: 110 mm

## Mixed Covering with Polonceau Truss and Timber Rafters. Details

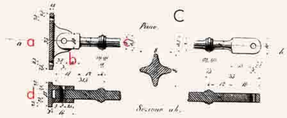
A



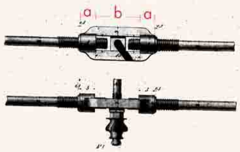
B



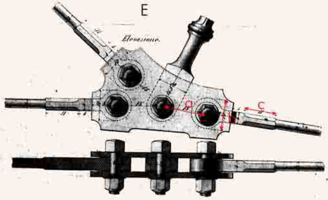
C



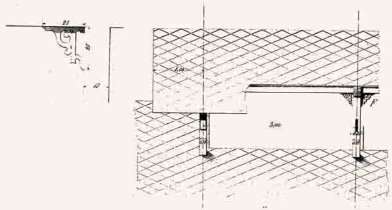
D



E



F



## Vittorio Emanuele Shaft

Span: 15.030 m Springers Level: 5.200 m

Rafters: 300 mm

a: 3.700 m

b: 8.390 m

c: 40 mm - 9400 Kg

d: 30 mm - 5460 Kg

e: 26 mm - 4200 Kg

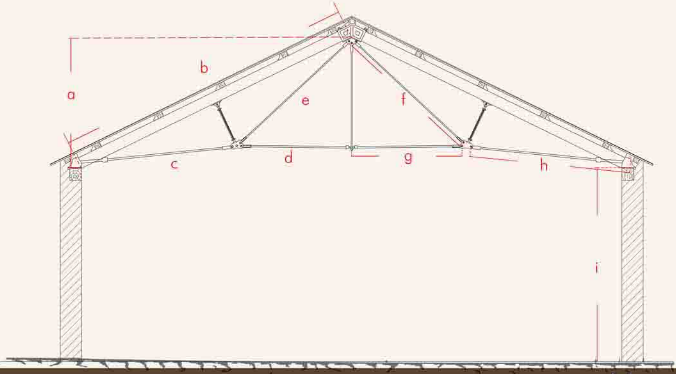
f: 4.10 m

g: 2.965 m

h: 4.460 m

i: 5.900 m

## Polonceau Truss and Timber Rafters - Boilers Room

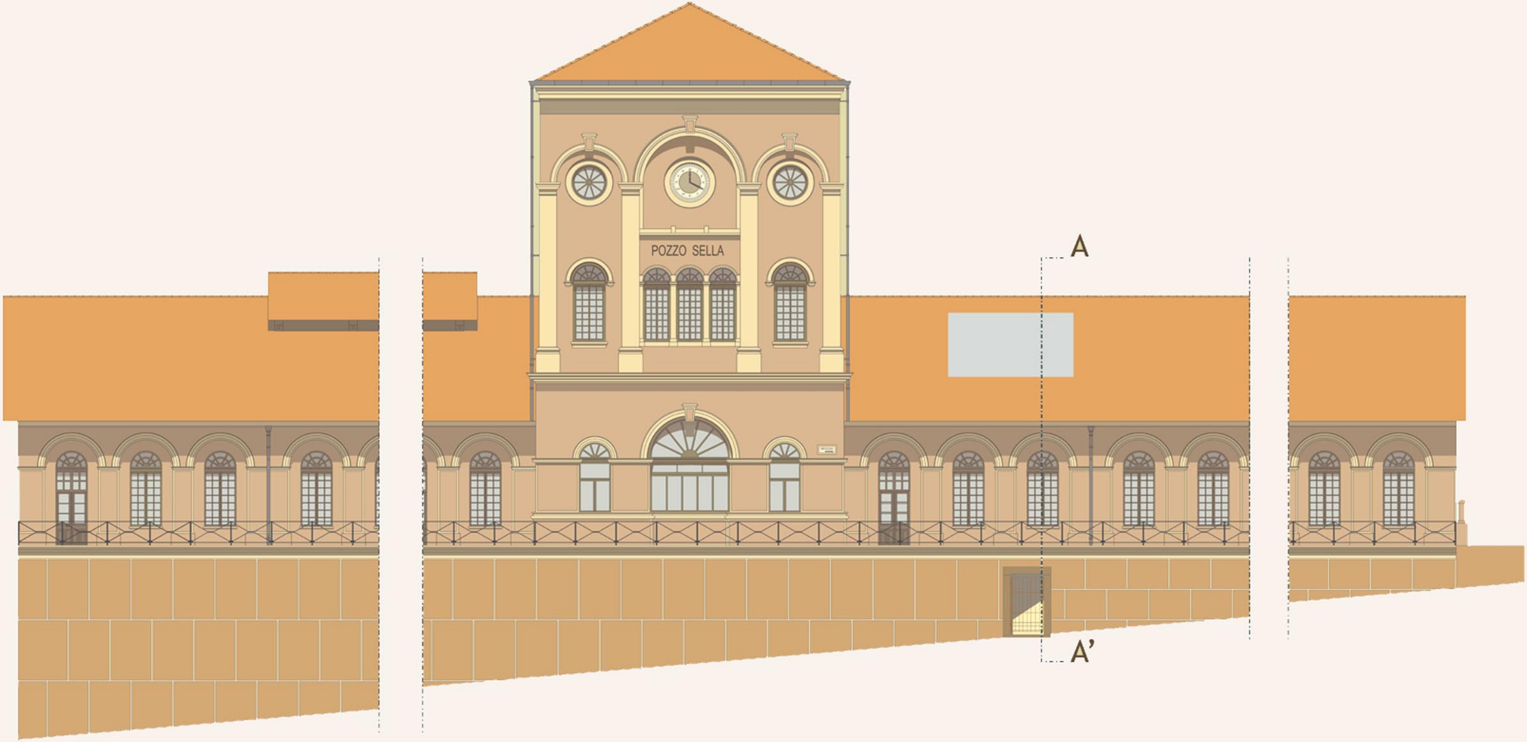


# SELLA SHAFT

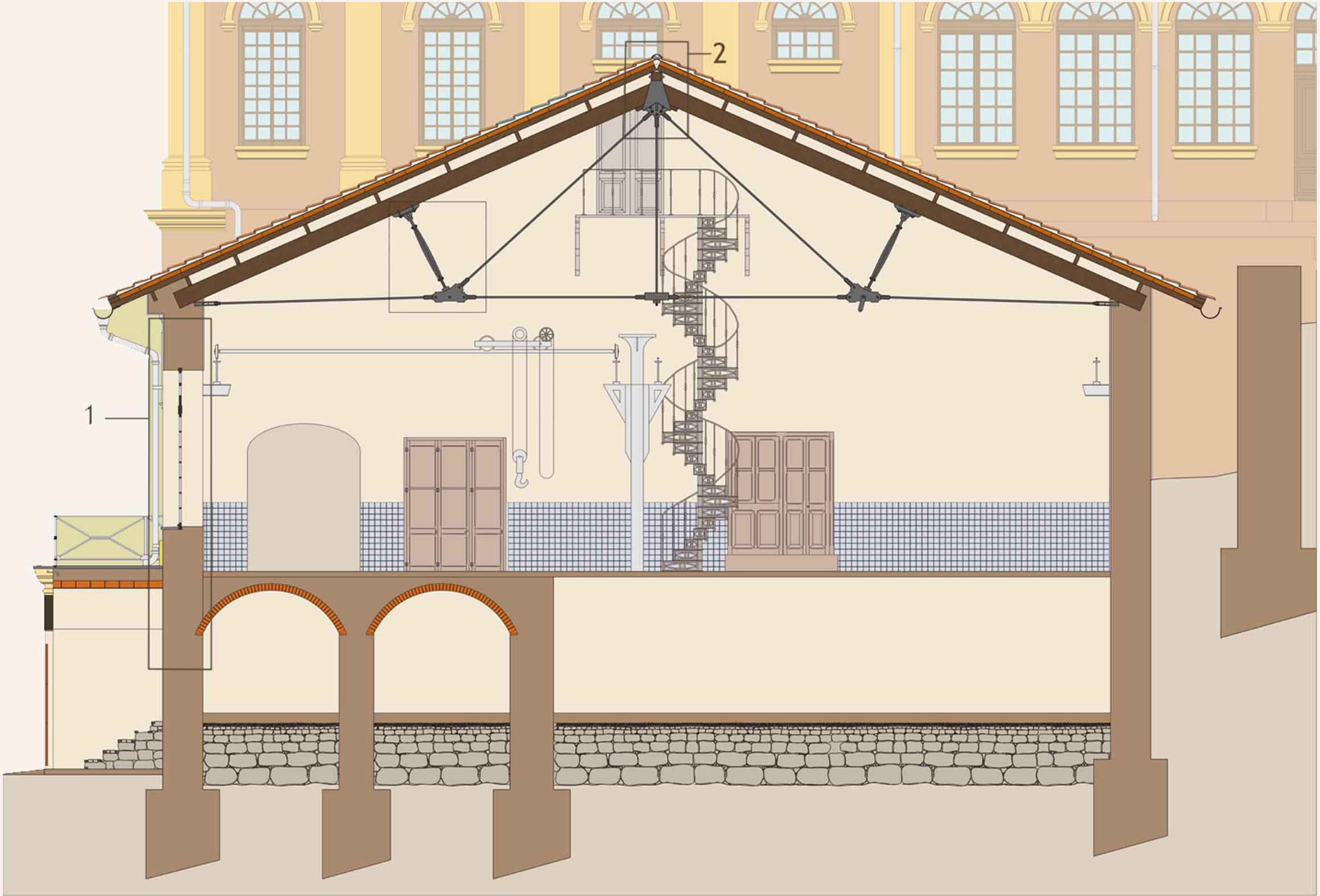
SECTION 1:50

SECTION 1:20

DETAILS 1:10

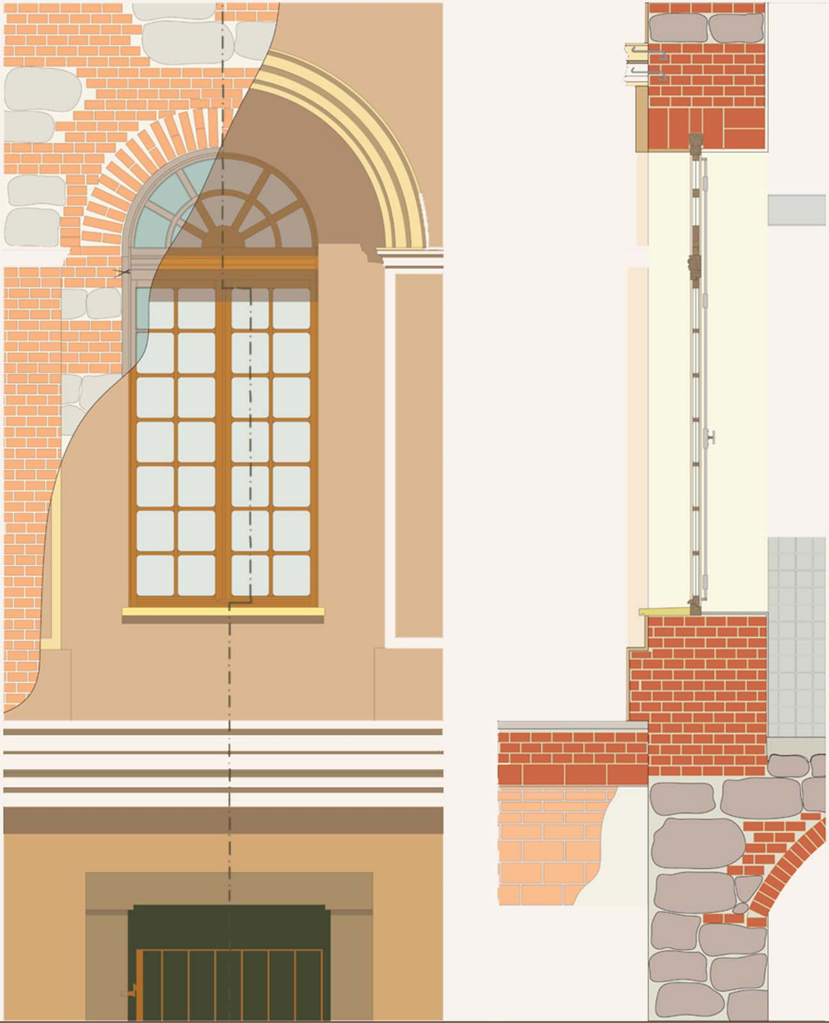



Monteponi Mine _ Sella Shaft _ South Façade 1:50




Monteponi Mine _ Sella Shaft _ Section A - A'

1:20



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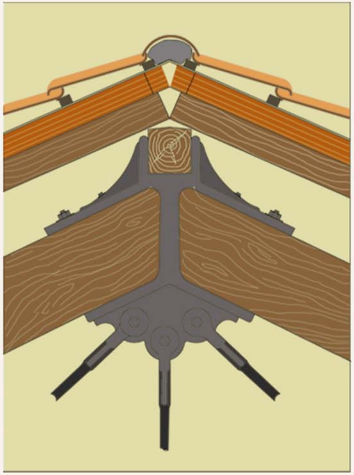

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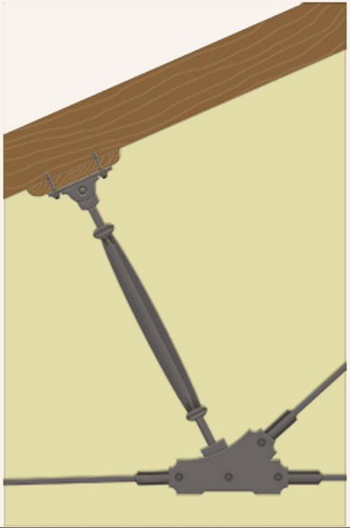

3