

## THE REUSE OF MARBLE WASTE HEAPS IN THE ESTREMOZ ANTICLINAL

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### ABSTRACT

Nowadays, the original image and structure of the territory have been permanently changed, by human action, due to the intense industrialization. The quarries represent the industrial activity that causes more transmutations in the landscape, modifying it in a more invasive manner. The present research describes a case study in Portugal where is located the highest concentration of marble quarries, flanked by *escobreiras*, large waste heaps. The work highlights the importance of the waste reuse concept in landscape and architecture, preserving the industrial memory and the identity of the place. The research, through an exhaustive analysis of real examples of quarries rehabilitation, investigates innovative methods to regenerate the Portuguese abandoned landscape. The investigation is expected to prompt the implementation of projects to revitalize the discarded spaces, and to reuse the local waste material for the creation, *in situ*, of architectonic and landscape elements, and to increase the knowledge on waste reuse procedures.

**Keywords:** Estremoz Anticlinal, marble quarries, waste heaps, waste reuse.

**Thematic clusters:** 2: City and Environment. **Topic:** Heritage and Cultural Landscape.

## 1. Introduction

In present days, the original vision and composition of the territory and the natural landscape has been permanently altered, by human action, due to the intense industrialization. The quarries represent the industrial activity that causes more impact and metamorphosis in the landscape, modifying it in a more invasive manner. The effects of the extreme brand of man on the territory are much more evident in this case and the outcome of this situation is not only the incorporation of the industrial buildings on the territory, but also the absolute transmutation of the morphology of the landscape along with its economy, social structure and environment quality.

The present research explains a case study in Portugal, namely the Anticlinal of Estremoz, where is located the highest concentration of marble quarries, flanked by *escobreiras*, huge quantities of wastes, accumulated in colossal piles of material which can assume different shapes, dimensions and configurations.

The core of the work is to highlight the importance of the notion of waste reuse in landscape and architecture, preserving the historical, industrial memory and the identity of the place. The research, through an introduction to the mutation of the landscape concept and an exhaustive analysis of real examples of quarries rehabilitations, investigates innovative methods to regenerate the abandoned industrial landscape of the Anticlinal of Estremoz. The reuse of the enormous mounds of marble wastes is included in this research study for the landscape regeneration it is possible to examine new solutions which involving the *escobreiras*, in the process of the recuperation of the territory, instead of considering them as brutal agents of degradation and, consequently, demolishing them.

For this purpose, the research shows the interest in converting an industrial and discarded site into an active redesigned place, having aesthetic quality and new different functions, avoiding the perpetual phenomenon of the abandonment of the waste territory. This concept is the focus of the objective of the work, namely that of requalifying the landscape of the Anticlinal of Estremoz through the reuse of materials and shapes that already exist in situ to preserve the memory and the identity of the place.

*Will it be achievable to create buildings, for touristic scopes, inside, above or attached to the huge waste heaps, analyzing at the same time, the economic, geological, environmental, and engineering factors?*

*Will be possible to transform a disused and devastated industrial landscape into a quality and attractive place to visit?*

From these central key questions of the investigation, one understands the interdisciplinary of the theme

According to the considerations cited above, the research is expected to prompt the implementation of projects to revitalize the abandoned industrial spaces, to promote innovative methodologies of requalification, reusing the local and waste material, for the creation, in situ, of architectonic and landscape elements, and to increase the knowledge on waste reuse procedures.

Section 2 describes the evolution of the landscape over the years. Section 3 discusses the quarry topic, related to its reuse and some examples of rehabilitation. Section 4 addresses the initial phase of the research proposal, introducing the Anticlinal of Estremoz. Finally. Section 5 draws the main conclusions.

## 2. The Evolution of the Landscape Concept until the present days.

The landscape is a powerful element that has continually changed its meaning and vision along the years. It has adapted to the various historical phases and the opinions that human beings had about it. In this regard, the landscape, in the past, was considered only a superfluous element and a minor component in the artistic scenes (Jakob, 2009). Today, instead, its importance is changed, and the landscape appears indispensable in many disciplines such as architecture, art, engineering, geology and geography (Ribeiro & Lautensach, 2009). With the industrialization, the landscape lost its natural aspect and the human activity strongly influenced this loss. The contemporary epoch exalts the importance of the industrial processes and, for this reason, it seems that the landscape does not fit in this "new scenario" (Budd, 2002). With a nostalgic feeling, this new situation "eclipsed" the value of the landscape hard-won until the industrialization era (Veríssimo Serrão, 2011), (*From the authors*, n.d.)

Being the principal object of the research, the work pays attention to the extraction sites. In this regard, the quarries modify the territory using a more "destructive" approach. They transfigure the entire morphology of the landscape, jointly with its structure and environment (Cipriani, 2012). For well-known reasons (related to the geological or the economic sector), we witness the abandonment of numerous quarries. They lose the initial state, and they are the representation of the recess. Therefore, the quarries are the most significant examples of the "third landscape", spots of degradation, used for industrial scopes and successively brutally discarded (Dumesnil & Ouellet, 2002), (Clement & Lucchesini, 2013), (Clement, 2011). The cities continually expellees these rejected landscapes for their conflict with urban aspects. The wastes located in the territory also represent this conflict. Based on these affirmations, the architects are responsible for the integration of these wastes in the urban process and development (Di Marco, 2016). This is possible through recycling operations, protecting the environment and preserving sustainability (Marini & Santangelo, 2013). For this reason, it is necessary considering these devastated territories as part of the contemporary landscape because it intends working with the most precarious part of the city.

The term "recycle" suggests reusing the abandoned material without meaning, purpose and values. It represents a method to reduce wastes, generating a new understanding of the "lost" landscapes (Tarpino, 2012). Considering these types of territories means to identify them as places with abundant history and, consequently, the rehabilitation project can explore the landscape, not as a "white page", in which is possible to design every type of architectural intention, but as an element with influenceable preexistences (Veríssimo Serrão, 2011). Based on this original purpose, the initial idea of the landscape has been positively reconsidered, including the expression "waste" in its repertory (Cervellati, 2000). Consequently, the discarded material is capable of interact with the landscape, and it is not always an opposing factor to throw away (Marini, 2008, 2010).

## 3. Quarry reuse and some Rehabilitation Projects.

The extractive industry is a part of human activities. Since the prehistoric epoch, man used the quarries to excavate material for the fabrication of instruments and to obtain construction matters. They represent the

extraordinary resources of the earth. Along the years, one always reused the extraction sites for functional scopes. The abandoned pits became, as needed, funeral sites to bury dead, catacombs, religious spaces to celebrate rites and to escape from oppression. In the time of war, the quarries represented shelters where to hide, and safe environments where to stay. For this purpose, they often were frescoed to confer a better aspect of the cavity, and they were equipped with all the necessary utilities to live. Successively, thanks to the growing attention to the landscape, the extraction sites were also reused for ecological and aesthetics scopes. Beautiful gardens were conceived in these abandoned and uninitialized spaces (Aliberti, 2015).

Even if the activity of mining the minerals is old as the presence of man on Earth, the issue of the regeneration and the recovery of the discarded industrial sites is one of the fundamental debates of the contemporary time. A large number of former quarries makes the thematic of their recovery and reuse urgently, jointly with their securing to prevent the inevitable aspects of instability. There are several approaches to give a new sense to these unused areas. For example, it is possible to create museums within the hypogeum cavities, visits and thematic expositions, public and leisure spaces, or use services for the city. Reverting a former extractive spot, intends to identify the opportunities and, at the same time, the frontiers offered by the quarries, nature, and the material features (Preite, 2017). Therefore, through rehabilitation interventions, society will consider the abandoned areas for a multitude of collective uses (D'Amato, 2005). In this regard, several examples of quarries reconversion and latest recovery experiences can be illustrated, graphically, to comprehend the current trends. By recent studies, the most common reuses of quarries have converted the industrial area into leisure parks, public gardens, sports equipment, cultural and artistic places, technological sites and productive spaces for the agriculture (Milgrom, 2008), (*From the authors*, n.d.) as it is illustrated in the following table.

**Table 1:** Selected quarry rehabilitation projects. Source: From the authors.

Country	Quarry Rehabilitation Project
Croatia	<b>Montraker:</b> International summer school of sculpture located in an active and Vrasar stone quarry. Project and realization in 1991.
Denmark	<b>Hedeland:</b> Regional park with natural areas, sports facilities, amphitheatre and other equipment in a former gravel and clay quarries (Caramagno, 2004). <b>Rordal Lake Park:</b> Park for aquatic sports with open-air theatre in a gypsum quarry (Brodskom, 2001).
France	<b>Bois-le-Roi:</b> Public Park with a bathing area in a sand quarry (Trasi, 2001), (Caramagno, 2004). <b>Cergy Ponds:</b> Park located in Cergy/Neuville with lakes for aquatic sports, swimming pool, tennis and golf courts, equestrian trails and naturalistic areas in a sand quarry (Fondazione Benetton Studi e Ricerche (FBSR), 2006). <b>Crazannes:</b> Rest area <i>La Pierre de Crazannes</i> with an open-air museum in a marble quarry (Trasi, 2001), (Caramagno, 2004). <b>Firminy:</b> Stadium and Youth and Culture Home in a coal quarry designed by Le Corbusier (Trasi, 2001), (Caramagno, 2004). <b>Portel winery:</b> Winery and quarry museum in a gypsum quarry (Brodskom, 2001). <b>Beinheim port:</b> River port on the Rhine for barges, commercial boats in a sand and gravel quarry of alluvial origin (Brodskom, 2001).

<p><b>Germany</b></p>	<p><b>Westpark:</b> Urban Park in Munich suburb with showrooms, exhibition spaces, greenhouses and amphitheatre in gravel quarries (Trasi, 2001), (Caramagno, 2004).</p> <p><b>Emscherbruch:</b> Landscaped park with recreational areas (skating rink, mountain bike) in the Ruhr basin in coal mines (Fondazione Benetton Studi e Ricerche (FBSR), 2006).</p> <p><b>Rheinelbe:</b> Naturalistic Park with garden school, seat of IBA Emscher Park, in a coal mine (Caramagno, 2004).</p> <p><b>LandschaftskunstGoitzsche:</b> Recovery of lignite mines for touristic-bathing purposes, near Bitterfeld and Pouch (Schierz, 2001).</p> <p><b>Karsdorf Vineyard:</b> Vineyard and afforestation in Karsdorf in limestone quarries (Fondazione Benetton Studi e Ricerche (FBSR), 2006).</p>
<p><b>Holland</b></p>	<p><b>Broken Circle and Spiral Hill:</b> Land art pieces in a sand quarry in Emmen (Arbogast et al., 2000).</p> <p><b>Zanderij Quarry:</b> Terraced Park with botanical collections in an aggregate quarry (Aguado &amp; Carrascal, 2001).</p>
<p><b>Portugal</b></p>	<p><b>Braga Stadium:</b> Stadium in a stone quarry on the north side of the Monte Castro in Braga</p>
<p><b>United Kingdom</b></p>	<p><b>Eden Project:</b> Thematic Park in St. Austell, in a kaolin quarry, with greenhouse, experimental gardens on the planet's biodiversity and open-air amphitheater (Muzzillo, 2002), (Holden, 2003).</p> <p><b>Druridge Bay:</b> Territorial Park with artificial lakes, seaside resort and naturalistic oasis in a coal quarry in Cresswell (Zoppi, 1989).</p> <p><b>Blue Water:</b> Shopping Center in a limestone quarry in Greenhithe (Fondazione Benetton Studi e Ricerche (FBSR), 2006).</p> <p><b>Blue Circle:</b> Wooded areas and golf course in clay quarries (Spens, 1994).</p>
<p><b>Romania</b></p>	<p><b>Field of sculptures:</b> Open-air ethnographic museum in a limestone quarry in Măgura (Bernardi, 1997).</p>
<p><b>Spain</b></p>	<p><b>Fossar de la Pedrera:</b> Memorial Park in a stone quarry in Barcelona (Caramagno, 2004).</p> <p><b>Hill-quarry in the Denia port:</b> Commercial and touristic centre in a limestone quarry, located in a port area, with a hotel, auditorium, parking and terraced gardens (<i>Biennale di Architettura</i>, 2004).</p> <p><b>Tindaya Mountain:</b> Exhibition space and land art intervention in a marble quarry of Tindaya Mountain (Caramagno, 2004).</p>
<p><b>Sweden</b></p>	<p><b>Memory Forest:</b> Cemetery Park in Enskede in a gravel quarry (Felicori &amp; Zanotti, 2004).</p>
<p><b>Switzerland</b></p>	<p><b>Musital Quarry:</b> Naturalistic recovering of a limestone quarry (Caramagno, 2004)</p>
<p><b>Italy</b></p>	<p><b>La Mortella Gardens:</b> Gardens in a trachyte quarry in Ischia, spaces for artistic manifestations and concerts and International Center for young composers (Boyden, 1998).</p> <p><b>Isola Giarola Quarry:</b> Area for recreational, naturalistic and productive (fish farming) purposes in a sand quarry near Piacenza (Muzzi &amp; Rossi, 2003).</p> <p><b>Ca' Trebbia:</b> Agricultural recovery in a gravel quarry near Piacenza (Muzzi &amp; Rossi, 2003).</p> <p><b>Gym Free climbing:</b> Rock Gym in a stone quarry in Rome (Caramagno, 2004).</p> <p><b>Fornace Park:</b> Agricultural and wildlife Park in Cambiano with spaces for scientific and cultural activities, clay Eco museum in a clay quarry (ANDIL Associazione Nazionale Industriali dei Laterizi, 2005).</p> <p><b>Quarries Hotel:</b> Tourist settlement and anthropological ethno museum in white tuff quarries in Favignana (Fondazione Benetton Studi e Ricerche (FBSR), 2006).</p>

**Private House:** House in a tuffquarry in Favignana (Fondazione Benetton Studi e Ricerche (FBSR), 2006).

**Luneo Quarry:** Oasis WWF in a clay quarry with spontaneous renaturalization(Fondazione Benetton Studi e Ricerche (FBSR), 2006).

**Rubbio Quarry:** Studio and artistic laboratory with open-air amphitheatre near Vicenza (Rubbio, 2005).

**Sardegna Geo-mining Park** in Cagliari (Forsans, 2005).

## 4. Case Study and Research Proposal

### 4.1. Features of the site

The Municipalities of Estremoz, Borba and Vila Viçosa, in Portugal, contain the most significant exploration of marble. Those towns, belonging to the Region of the Alentejo, constitute the Estremoz Anticlinal, a geological formation of 280 km<sup>2</sup>. These municipalities are well known not only to a considerable number of quarries but also to the colossal piles of marble wastes, which flank the open pits. In opposition to the natural aspect of this area of the Alentejo, composed by a well conserved green context (thanks to its location inside a large aquifer), there is a predominant industrial abandoned part, formed by quarries and mounds of remains (Baganha, 2015). Because of the presence of quality “defects”, only a small portion of the extracted marble (about 9%) is commercialized and the resting amount (about 91%) is assembled in huge piles of residual material, named in Portuguese “*Escobreiras*” (Figure 1). The reasons are related to:

- The karstification of the marble, which influences the quality and the management of the exploration, increasing at the same time, the number of waste material.
- The existence of spots, which drastically decreases the market value of the stone, making it unusable.
- The intense fracturing of the rocks, which causes the presence of several blocks with not appropriate dimensions for the sale.



Figure 1: “*Escobreiras*”, huge piles of marble remains. Source: From the authors.

For all these reasons, the marble is used only in small amounts in several industries and for building use, road-paving material, production of artificial aggregates and soil pH corrections. The remaining portion of it persists in the landscape to “deface” it since the huge mounds of wastes cannot be placed outside the area

due to budgetary limits. Many costs can be added either concerning the transport of this residual material to landfills, nearby or far away, or about the work of the individual manufacturing operators.

## 4.2. Ongoing Research

The redevelopment of the industrial area of the Anticlinal of Estremoz has always been broadly discussed, according to two different approaches and concerns, on the one hand, the requalification of the quarries, and, on the other hand, the reuse of marble wastes with their conversion. The first one consists in operating in the local, and the second one consists of working off-site, exporting the material, which the *escobreiras* are formed.

The proposal, reported in this paper, in both cases, wants to work exclusively *in situ*, not exporting any type of material. These piles of wastes could be perceived in an unusual way, not as defects to overcome, but as unique elements to promote the redevelopment and the tourism of the region. Regarding this consideration, it is possible to assert that the rehabilitation of an industrial place, such as this of the Anticlinal of Estremoz, should consider the marks present on the territory for the design of new solutions to restore the landscape, giving a new meaning to what is popular. In this sense, also the historical memory and the identity of the place are maintained. The *escobreiras* can become iconic constituents of the stone territory to supply a changeable image of the landscape, coherent with its context.

The current investigation, in an embryonic phase, suggests, through the thoughts presented up to now, to redevelop the industrial landscape with the formulation of buildings inside the *escobreiras*, an original solution to incentive the tourism and the economic renewal of the country. This proposal will be joined with the surrounding and the abandoned quarries, after their requalification and securing. The operations of quarries redevelop, taking advantage of the natural characteristics, spontaneously developed in the site (such as vegetation cover, lakes and the presence of new animal and vegetal varieties), will focus the attention principally on the creation of green areas. This objective is helpful to promote the biodiversity and the ecology,

to generate touristic geo-spaces and areas of leisure and entertainment, sports and fun. These sites will supply the new buildings, constituted inside the *escobreiras*, and they will contribute to the creation of a large touristic system. Regarding the conception of the buildings, the ongoing research originated from one fundamental idea that, successively, it has expanded to two others. They are physical consequences of the first idea and they represent, considering the complexity of the present case, efforts to simplify the creative process. All of these have in common the notion to transform the heaps of wastes in real buildings having self-utility and self-identity, and the concept to maintain the exact position and shape of the marble piles.

The first strategy consists of aggregate the marble remains, through an appropriate material (such as cement or concrete), creating blocks, with controlled dimensions, which can be disposed of according to a given shape. The same blocks will be anchored to each other and, at the same time, many steel grids, which provide greater resistance to the mass of the residues. After this operation, the construction process advances with the excavation (beginning from the bottom) of the central part for the creation of “empties”, in which to perform the interior system of the building (*From the authors*, n.d.) (Figure 2a). The second case concerns the construction of touristic buildings, established on the top or attached to the piles of wastes. This

approach recognises the *escombreira* as an unnatural reinforced mountain, and as a “mini touristic village”, possessing also the usual services (Figure 2b). The building walls can be constructed reusing the wastes from the other *escombreiras*, present in the place. Finally, the last strategy looks at the solution with a more simplistic way and, for the creation of empties inside the central part of the *escombreira*, it actuates a “cut of the mountain”, instead of digging the material as it happens in the first idea. Specifically, this “cut” will be achievable with the insertion (from the top to the bottom) of two walls, inside the *escombreira*, to support the entire arrangement. Successively, the residual part between these two walls will be extracted and the void that will be created by this procedure will represent the interior part of the building (Figure 2c).

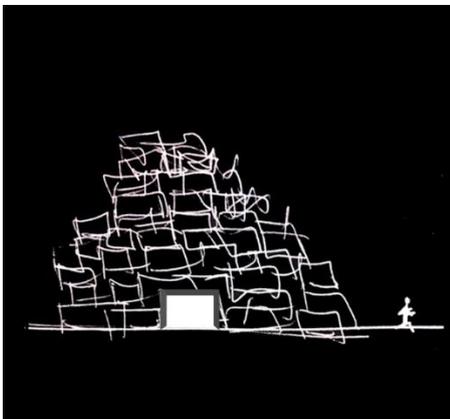


Figure 2a. Building inside the *Escombreira*, excavating the material. Source: From the authors



Figure 2b. Building on the *Escombreira*.

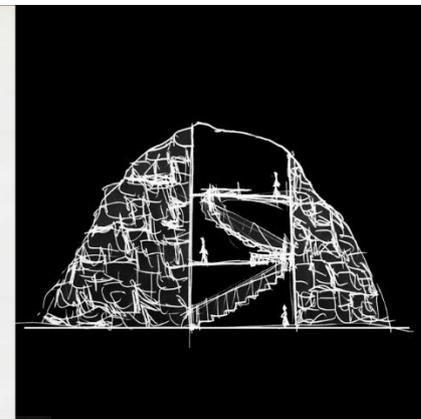


Figure 2c. Building inside the *Escombreira*, “cutting” the mound of wastes.

The pros of these solutions are:

- Sustainability thanks to the reuse *in situ* of the local waste materials, conserving the identity of the industrial area;
- There will be energy savings because the remains don't necessitate to be transferred elsewhere;
- The buildings will be naturally warmed or cooled due to the large thickness of the marble walls and other inherent characteristics.
- The buildings can be a nearly-zero emission of CO<sub>2</sub> and they will provide for the decrease of pollution supported by the presence of the existent vegetal covering, which fixes the pollutants in the air and produces oxygen.

The discarded area will be converted into a liveable and sustainable touristic-place reusing, in a contemporary mode, the notion of vernacular architecture keeping the tradition but also using the present technologies to obtain important energy savings. Several places in the world are affected by problems related to the huge accumulation of remnants (on any type of material and not only related to the marble stone) in the industrial context. The current investigation could be an innovative form to deal with this problematic, present in different surroundings, through the application of original approaches.

## 5. Conclusions

The paper, after having briefly showed the mutation of the landscape, caused by human activities, has paid attention to the quarries. This industrial industry embodies the main topic of the ongoing research and it has always understood as an activity which origins more metamorphosis of the landscape. The principal consequence is the transformation of the entire morphology of the landscape, with its economy, social structure and environment. The article, after giving some real examples of quarries, has described a case study in Portugal (Estremoz-Anticlinal), where exist the highest concentration of marble quarries and remains, accumulated in huge heaps of material (*escobreiras*). The intention of the investigation is to give importance to the notion of waste reuse and to maintain the identity of the place. New solutions to rehabilitate the quarries and to use the wastes piles, rather than to break down them, have been addressed. The article has shown, in fact, the interest in converting an industrial area into an active touristic place, having also aesthetic quality, with the introduction of touristic buildings inside the *escobreiras* and the integration of them in the context.

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