European Quarry Landscapes
Paisajes de Cantería en Europa

Collected essays from the first meeting of the European Quarry Landscapes Network
Edited by James Douet
El programa LIFE es el instrumento financiero de la Unión Europea dedicado al medio ambiente y a la naturaleza. El proyecto del Ayuntamiento de Teruel, único seleccionado en Aragón, en la convocatoria 2011, es uno de los proyectos, que han sido seleccionados en el eje de Política y Gobernanza Medioambiental. En concreto, por su aportación en el marco de la prioridad “Medioambiente Urbano”.

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Presentation
The preservation of our quarries, an opportunity for development

The environmental restoration of the clays quarries in the area of our city will mean a significant improvement to the quality of life for our citizens and a new attraction for tourists. There we will find a place of diversion, in touch with nature, a very few meters from the historic centre. Truly green lungs for Teruel.

I consider that with the activities in the natural area Las Arcillas, justice is being done, since a debt is owed to the neighbourhoods of San Julian, Arrabal and the Carrel. Over hundreds of years, the clay with which the city was built was extracted from these localities. Back in in the Middle Ages, the 13th, 14th and 15th centuries, our craftsmen were making the bricks that gave form to the Mudejar towers and beauty through the glazed ceramics. Since 1986, they are World Heritage. But also, throughout the entire twentieth century, the bricks that were used to rebuild the city came out of these neighbourhoods.

The case of Teruel is not exceptional, since there are any landscapes in different countries of the world that have been affected by stone quarrying. These are landscapes that are well worth special attention for their preservation and even in some cases their inclusion in the list of World Heritage of UNESCO.

It is for this reason that Teruel promoted the creation of the European Quarry Landscapes Network, which takes a firm step forward thanks to the collaboration of all the entities involved in this very interesting project, whose principal objective is none other than to recognise the value of our rich heritage and to convert it, once more, into an opportunity for development.

Manuel Blasco Marques
Mayor of Teruel

The hosts and delegates of the first meeting of the European Network of Quarry Landscapes in Teruel, October 2014. The Mayor of Teruel, Manuel Blasco Marques, is centre front row with Project Director Florencio Conde at the left end.
The history of the city of Teruel has been engraved in the landscape of Las Arcillas, an erratic group of hills and dales of the reddish colour so characteristic of the clays that mark the old urban limit of the city.

From the 13th century, a singular architecture and an important ceramic production emerged, fruit of the mix of cultures which was able to blend “Andalusian know-how” with the tastes of a Christian and feudal majority. The Mudejar art is the result of the fusion Arab and Christian elements, which reflects the coexistence of both cultures.

From this comes the declaration of Teruel’s Mudejar heritage as World Heritage by UNESCO in 1986.

To speak of Mudejar heritage and ceramic activity is to speak of quarrying and the exploitation of the quarries, one of the activities which has the largest impact on the environment. The extraction in the area of Las Arcillas, which went on over centuries, marked the evolution of the urban landscape.

Therefore, the work of preserving redundant quarry sites is not just recommendable, but fundamental, because they are part of our common heritage, by which the natural and cultural heritage belongs to everyone. Each one of us has the right and responsibility to understand, value and conserve its universal values.

There exists, in the city of Teruel, a natural space of original beauty, an uncommon cultural landscape, that constitutes an example of a cultural territory defined by man and industrial activity (along with the erosion, rain and the passage of time).

The environmental restoration that is being developed by the Ayuntamiento de Teruel with the support of the LIFE + Programme of the European Commission, in the area of the clay quarries, is bringing about a significant improvement to the quality of life of the people of Teruel and a new attraction for tourists. There we will find a place of diversion, in contact with nature, a few meters outside the historic centre.

The first results of the work of recovery and restoration of the antique clay quarries can already be seen. The new aspect is consistent with the objectives and philosophy of the European programme,
centred in the area of urban environment, contributing to sustainable mobility and therefore mitigating climate change through the realisation of numerous environmental measures.

In the dynamic created to generate the transformations in the city, involving the connection of the surroundings with the city, above all through the less favoured neighbourhoods of Teruel, the Ayuntamiento has put in train the recovery of municipal paths and trails, building a cyclist axis connecting the historical centre with the setting of the quarries and, most importantly, anticipates a reforestation by the end of the program of more than 15,000 units.

Florencio Conde Luis
Project Director
Introduction, James Douet

The historic stone quarries of Europe are rich cultural landscapes that include important rock formations and special natural habitats. The European Quarry Landscapes Network is an association of groups, specialists and organizations which study, use and care for historic quarries. It was created by an initiative of the city of Teruel, Spain, in 2014. A seminar in October that year brought together quarry experts, historic stone specialists and landscape enthusiasts from all over Europe. Presentations were made covering numerous aspects of the study, protection and development of historic quarries, many arguing strongly that the conservation of the historic and geological interest as industrial landscapes can be compatible with their use for a rich variety of new cultural and social activities.

At the end of the meeting the Declaration of Teruel was signed by the participants to give a clear statement of the importance of the quarry landscapes of Europe and the determination of the Network to contribute to their appreciation and recognition.

The objectives of the European Network of Quarry Landscapes were defined at the Teruel conference as:

- promote understanding of the history, conservation and management of historic quarries to maintain their cultural and geological heritage
- encourage formal recognition of the historical heritage of Europe’s quarries
- develop new ways for historic quarries to provide social and economic benefits to local communities
- share best practices in the conservation and use of old quarries, the continued use of their historic stone resources, greater access to the general public, academic research and the dissemination of technical information.

The Mayor of Teruel, Manuel Blasco Marques, signs the European Quarries Network, with Florencio Conde Luis (left), Project Director.
A selection of the presentations from the 2014 conference is published here, complemented by five additional chapters from colleagues unable to attend the meeting, to present for the first time a comprehensive review of the situation of historic quarry landscapes in Europe.

The fourteen chapters of this publication fall broadly into three groups. The first part considers how historic quarries can be identified, recorded and protected. It brings together work from three earlier collaborative initiatives, the QuarryScapes and Historic Quarries projects, both part-funded by the EU, and the Spanish Construrock network.

Different landforms created by quarrying are examined in the middle chapters, which relate them to the historical techniques of stone extraction in various geological regions of Europe.

The last chapters are devoted to examining some of the divers cultural and natural uses to which quarry landscapes are today being put. These include wildlife conservation, historical and ecological education, as museums, and providing inspiration for art, music and sculpture which respond to their particular natural and human qualities.

Various important issues cut across the presentations and run through the whole book. Foremost is the urgent need to recognise the values of historic quarry landscapes so that they are not obliterated by thoughtless landfill, or obscured by well-meaning re-naturing. Secondly there is the urgent need for continued extraction of historic building stones from old quarries, which is vital for the sustained maintenance of Europe's architectural heritage. Protection of the special natural attributes of quarry landscapes sometimes contradict our appreciation of their unique qualities as cultural landscapes, an impression which persists in the European Landscape Convention. And as the city of Teruel has itself shown, old quarries can provide significant social, cultural and economic gains for their local communities, a benefit that this publication aims to make clear.

The European Quarry Landscapes Network

European Quarry Landscapes Network has identified sites which exemplify the recovery, preservation, dissemination and social and economic use of the landscape created by stone extraction. The database of sites identified in the EQLN focuses on those quarries whose use also contributes to cultural activities, to the creation of educational resources, to heritage conservation, and to local economic development and tourism. The numerous excellent examples of landscape remodelling and re-naturing of former quarries by the cement and aggregates industry are not therefore as relevant, except in situations in which they coincide with these social and economic objectives.

Quarrying landscapes begin as large excavations formed by the extraction of natural stones (granite, marble, slate, limestone, sandstone, clay, etc.), useful in the construction and decoration of buildings, for sculpture, in the manufacture of bricks, tiles and ceramics, the production of cement or for obtaining aggregates.

In practice there are many similarities between the landscapes of quarrying and those formed by surface mining. Occasionally we find the two together, as on the island of Bornholm (Denmark). Both quarrying and mining landscapes have been shaped by the extractive industry, often using similar techniques, leaving comparable topographies and environmental challenges.

Large individual quarries can form important landscapes for themselves, such as the clay excavations in Teruel (Spain), the enormous crater of the Delabole slate quarry (UK) or the large sites created for modern cement production and extraction of aggregate, such as at La Martinencxa (Spain). Nevertheless, the extraction of stone over many years usually creates quarry districts, such as the Parc de Luberons (France), made up of many sites, some of individual interest and other smaller ones which contribute to the special character of the area.

The earliest stone quarries were to make tools. As building techniques improved stone was extracted for architecture, both building stone (limestone and sandstone) and decorative stones of high value such as marble. The great antiquity of stone extraction in Europe shows up in the many sites from the classical period (Pentelikon supplied the marble for the Acropolis), although large-scale extraction with its much higher landscape impact did not start until the modern era.
The nineteenth century saw a boom in the use of roofing slate creating giant quarry districts with international markets, only to be drastically reduced a hundred years later, leaving abandoned quarries with vast waste heaps in the mountainous areas where the slate is typically obtained.

Another historic change affecting quarrying was the invention of Portland cement (the name itself derived from a famous English quarry). The demand for limestone to make concrete from the early twentieth century lead to a major expansion of quarrying for cement manufacture. Aggregate extraction also increased dramatically with the accelerating urbanization and road construction, so that sand and gravel pits have become a feature of the landscape since the Second World War.

A parallel decline in the use of traditional stone followed the deployment of new construction techniques, reinforced concrete and rationalist architecture, changed the geological pattern of stone extraction as well as the landscapes of quarrying. In the last fifty years the extraction of dimension stone such as pietra serena, the sandstone of Florence, has recovered thanks to greater attention to the maintenance of Europe’s architectural heritage and its historic cities.

This distribution of quarry landscapes reflects these historical trends imposed on the geological map of Europe. Most numerous are the sites of limestone quarries, connected directly with the demand for cement, and there are fewer sandstone quarries. Marble quarries are often very large and may have a long working tradition dating back to classical times, leaving an important mark on the landscape as in Carrara (Italy) and Estremoz (Portugal). The huge slate quarries are now mostly abandoned, but the rich narrative of the slate industry, along with its strong scenic qualities, has resulted in a series of cultural initiatives and various museums, notably the National Slate Museum in Gwynedd (United Kingdom).

New uses for conserved quarries
We can identify a number ways in which old quarries may be conserved which also recognize and preserve their landscape qualities while providing new, socially valid uses.

Landscape interpretation: These facilities encourage the public to explore ancient quarries directly and appreciate their cultural and natural qualities. The centre is normally built into a network of trails that help visitors to discover the landscape and provide information in the form of brochures, panels, itineraries, guided tours and so on. The best examples include the large natural parks like Volkanpark Osteifeld (Germany), the Parc naturel regional du Luberon (France) and the National Park Hoge Kempen (Belgium), but there are also smaller places like S'Hostal (Spain). The underground quarry Maladrerie in Caen (France) provides guided visits to the old galleries.

Museums: Museums in historic quarries are divided into large facilities dedicated to the history of exploitation, such as Moseløkken Stenbrudsmuseum (Norway), the National Slate Museum Wales (UK), the Kalkwerk Lengefeld (Germany) and Museu do Mármore (Portugal), and smaller museums dedicated to the craft traditions of the workings of natural stone. Examples include the Musée de La Pierre (Belgium), the Museo di Pietra Serena (Italy), the Musée de l’Ardoise of Renaze (France), or the annual Rencontres de la pierre organised in les Carrières Bon Temps (France). The exhibition at the Nightingale mine, part of the Westphalian State Museum of Industrial Heritage, follows the natural geology of the site to integrate the interpretation of the old coal mine with the later sandstone quarry.

Tourism networks. These share the promotion of historic quarry sites as tourist destinations. The European Route of Industrial Heritage (ERIH), the largest international network promoting industrial tourism, includes nearly a dozen historic quarries museums, especially in Germany, France and Britain. ERIH is a well known brand and a well developed mutual promotion system.
The Cantera de los Naranjos, S’Hostal, Menorca, Spain, part of the LÍTHICA landscape project which through careful planting and management has created a popular site visited by both local people and visitors to the island. Photo: Anna Maria Lisi

In Portugal, the RUMYS project (Rutas Minerales de Iberoamérica y Ordenación Territorial) has established specialized routes between quarries, including granite Rota da Pedra (Vila Real), while the Rota Tons de Mármores - Shades of Marble Route, a project by the regional entity of tourism lead by the tourism entertainment firm “Spira”, encompassing the territories of Alandroal, Borba, Estremoz, Sousel and Vila Viçosa, and aims to present Alentejo’s industrial heritage through the rich marble assets of the so-called Estremoz Anticline. The promotion of this important industrial activity and the exposure of the territory that hosts it are its main objectives. Different circuits transport visitors on a journey to the “strange world” of the Alentejo marble. These routes include local development strategies, research, inventories and tourism promotion.

Auditoriums and theatres: In these historic quarries, advantage is taken of the natural acoustics and powerful atmosphere of the spaces left after the end of extraction to mount musical, theatrical or artistic performances. The spectacular lighting shows in the underground Carrières de Lumières in the Val d’Enfer quarries (France) were initiated by Jean Cocteau in 1960. Today, the Carrières de Lumières is managed by an important cultural producer, Culturespaces, with exhibitions like ‘Klimt and Vienna’.

In the quarry of St Margarethen (Austria), the Symposium of European Sculptors has been held since 1959, and more recently it has initiated a Mozart festival. Seasons of concerts, opera and theatre have taken place for many years in Fertőrákos Kőfejtő (Hungary), as well as tours of the quarry itself. There is a summer music festival in the natural amphitheatre created by Donosa marble quarry (Spain).

Parks and environmental education: Most of the restoration projects undertaken by aggregate and cement industry after the cessation of extraction include environmental education and nature interpretation. Good examples of this are in the Parque Regional del Sureste (Spain), the Ecopole du Forez (France) and Mosaic Austerfield Trust (UK). At more dramatic level there is the Eden Project (UK) which attempts to replicate entire ecosystems within a set of geodesic domes that occupy an abandoned kaolin quarry.
Sports and outdoor activities: Few old quarries are taken advantage of in a coordinated way to hold sporting activities, although they have often been incorporated into hiking or cycling itineraries. There is an Olympic mountain bike route in the old Yepes - Ciruelos quarry (Spain) of the cement company Lafarge, where a national competition takes place, the Open Lafarge de Castilla-La Mancha. The new program in Teruel (Spain) incorporates bicycle routes through the quarry in order to integrate it into with the city landscape. La Cantera Los Arenales (Spain) has a special area designed for cyclists on the floor of the old quarry.

International quarry conservation
Historic quarries are recognized by different regimes of international landscape conservation, cultural well as natural.

UNESCO World Heritage List
Two quarry landscapes already form part of World Heritage sites, Portland (Great Britain: Jurassic Coast 1029) and Fertőrákos Kőfejtő (Hungary: Fertő Fertő / Neusiedlersee Cultural Landscape 772). However, at least five quarries are also included in appear on the lists of provisional applications - Tentative Lists - two as important quarry landscapes in their own right

- Gwynedd, UK: The Slate Industry of North Wales, 5678
- Carrara, Italy: The Carrara marble basin, 5004,

while three lie within broader cultural landscapes that include mining:

- Norsk Kvernsteinsenter, Denmark: Monuments and sites of the Vikings 5581
- Lengefeld, Germany: Cultural Landscape Mining Erzgebirge 5775
- S'Hostal, Spain: Mining Heritage 5139.

The documentation that accompanies inscription proposals contains very valuable definitions of the landscape values attributed to the quarries, and the most appropriate conservation regimes to ensure that these values are maintained and sites are managed sustainably.

The thematic study of quarrying landscapes prepared with TICCIH (The International Committee for the Conservation of the Industrial Heritage), *Stone quarrying landscapes as world heritage sites*, is an international analysis of quarry landscapes which proposes guidelines to help ICOMOS evaluate these quarrying sites put forward for inscription on the UNESCO list.

The Global Stone Heritage Resource (GHSR)
This is a project to establish a new international designation which recognizes the natural stone resources that have been especially influential in human culture. It is managed by the *Historic Stone Task Group* (Working Group of Historic Stone) of the International Union of Geological Sciences. The list of quarries catalogued in the database includes the designation GHSR Carrara, Pietra Serena, Portland, Caen, Estremoz, Macael, Markina, Pentelikon and Solenhofen.

Natural Landscapes
There is a choice of designations of natural sites at European level which apply to the landscape of the quarrying. They are usually old abandoned quarries, or modern sites that have been restored after the cessation of industrial extraction. These include:

- Nature 2000
- The Landscape Award of the Council of Europe

Geoparks
Sometimes quarries are included in the network of 42 *European Geoparks*. The Luberon Geopark (France) and Volkanpark Osteifeld (Germany) contain important stone landscapes. No Geoparks specifically refers to the extraction of stone, focusing instead on mining and mineral extraction.
Stone quarries are found more or less everywhere there has been human activity, from the earliest hominids up to the present day. Quarries can therefore give us insights into important aspects of the daily life of our ancestors in terms of how they exploited and used natural resources. They may provide important pools of knowledge of ancient technology, social organization, trade and communications. Since many quarry landscapes were exploited over thousands of years, quarries can also be indicators of important events or changes in society. For instance, traces of quarrying may reflect changing technologies over time, and such changes can often be linked to key historical transformations in society.

One of the key objectives of the 2008 EU-funded project QuarryScapes, which studied quarry landscapes in the Eastern Mediterranean, and was to establish a general methodology for describing such sites. This resulted in a web guidelines from which the present article is inspired, from which several figures are taken. The guidelines also contain a method for macro-level analyses of quarry landscapes and issues related to statement of significance.

Quarry sites and landscapes often display a high level of complexity, and it may be difficult to identify different features and thus interpret the sites holistically. This in turn leads to problems in acknowledging their significance, resulting in poor conservation measures and a general neglect of such sites as important cultural heritage. A multidisciplinary approach is thus highly recommended when studying quarry sites. For instance, the geological characterisation of the stone resources is as important as the documentation of the archaeology, in order to reach an understanding of not only how quarrying was done but also why. It is also crucial to acknowledge that many quarry landscapes are multi-period, containing many layers of quarrying, perhaps with different technologies and even changes in the use of the stone resource in question.

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Fig. 1: Three quarry landscapes. Top: high-mountain millstone quarry landscape, Selbu in Norway. Open cast, trench quarries, mostly 19th Century. Middle: open cast marble quarry at Thassos, Greece. Hellenistic to Byzantine. Bottom: open cast sandstone quarry landscape with huge spoil heaps, Gebel el Silsila, Egypt. Old Kingdom to Roman Period. Photo: T Heldal
In short, a survey of a quarry landscape involves two main steps:

- Identifying and characterizing key features of quarrying: the geological resource, production evidence, transport systems and social infrastructure
- Analysing the features and defining time layers and quarry complexes within the landscape

Such an approach may provide the necessary tools for identifying values and key measures for conservation.

Empirical characterization

The geological resources

The stone resource was the target of quarrying, and investigation of it may reveal important information about why a specific stone was exploited, where it was used and how it was quarried.

The scientific characterization of the rocks that have been extracted is important for connecting a stone resource with its place of consumption (rock provenance), and as a tool for understanding selection criteria and technology in ancient quarrying activities. In some cases, visual characterization is enough for establishing provenance, but often more sophisticated geochemical analyses are needed.

However, the ancient quarrymen were more concerned about the quality and workability of the rocks: soft or hard, quality in use, durability and aesthetic appearance. Such physical properties are decided by the mineral composition of the rock type in question, the shape and texture of the minerals and the structure of the rock (massive, layered or schistose). We may separate three aspects of quality:

- the quality of a rock for quarrying and processing, such as hardness, brittleness, resulting in specific technological solutions for quarrying
- the quality of a rock for different uses, such as durability of a building-stone and performance of a millstone
- the aesthetic quality of a rock, such as colour and structure, often linked to the value of ornamental stones.

These aspects are not necessarily complementary. Huge resources were sometimes spent obtaining stone from rocks that were difficult to produce, and far from any existing infrastructure. In particular, this applies to ornamental stones that were highly valued, such as the Imperial Porphyry during the Roman Period, exploited far into the Eastern Desert in Egypt. Through history and pre-history, there are many other examples of stone resources of such unique quality or appearance that extreme efforts were made to exploit them. At the other end of the scale, many of our cities are built from stone resources that were adequate for building-stone, sufficiently close to cheap transport and easy enough to quarry. Few cities had the luck of Aphrodisias in Anatolia, were the nearby marble resources were excellent for both building-stone and sculptures and ornaments.

The reason for selecting a specific stone resource may thus be analysed from a quality and value perspective. For what purpose was a specific rock quarried at a specific time? We may define three main groups of stone commodities: building-stone, utilitarian stone and ornamental stone.
Fig. 2: Top: Roman columns remaining in a quarry at Evia, Greece (Marmor Karystium, or Cippolino Verde). A famous decorative marble from Antiquity. Middle: building-stone sandstone quarry surrounding the city of Aix en Provance. Bottom: utilitarian stone quarries (querns and millstones) found at Hyllestad, Western Norway. Viking Period to modern. Photo: T Heldal
Building stone includes stone resources that were basically quarried to obtain construction materials for roads (paving) and buildings, i.e. the stone forms an integral part of the construction, and not primarily for decoration. ‘Masonry stone’ is a term that is also used, but in a somewhat more narrow context (excluding for instance rubble for local housing). The ‘ideal’ building stone resource is found near the place of use, easy to quarry and work and sufficiently durable. Typical quarry landscapes of building stone are found in and around cities.

Ornamental (or decorative) stone includes stone resources of particular value due to rare colour/structure, symbolic value or other particular aspects. Such quarry landscapes are often disconnected in space with their consumption, and that much effort was often put into the exploitation of such important resources.

Utilitarian stone may be applied as the collective term for stone resources exploited for making domestic utensils, such as tools, weapons, grinding stones, millstones and whetstones. Such rocks were sought after basically because of their physical properties – e.g. their quality in production and use. Such quarry landscapes may have a wide variability; from local sources near settlements to huge ‘industrial’ landscapes made from the exploitation of particularly important resources.

In many cases, quarrying requires input of other natural resources used in the production process. Defining the quarried resource as the primary, we can collectively name such secondary resources. These may be stone resources for stone tools, wood for smithies, stone for construction and roads or grinding stones for food production. Secondary resources may be directly applied in the production process, or indirectly for sustaining the people doing it. Secondary resources may have been exploited elaborately, such as the building stones used in the construction of forts and settlements in the large Roman quarries in the Eastern Desert in Egypt, or modestly, and they may be imported or obtained locally. In principle, we separate between the use of secondary resources (as quarried or obtained for a specific purpose) and use of spoil material in the quarries for i.e. construction, but the border may be diffuse and should not be strictly drawn.

From natural to human-made landscape
The exposure of stone resources in the landscape is the result of multiple geological processes; from the formation of the rocks, through their transformation by weathering and landscape-forming processes. The geometry and outcropping pattern of the resource establishes the physical conditions of quarrying, to which extraction methods to a large extent must be adapted. Consequently, it also represents the condition of how the morphology, resulting from the transformation of the natural landscape by quarrying, appears visually. Putting it on the edge, the human transformation of the landscape can be described as the morphology resulting from quarrying minus the resource’s occurrence in the landscape before quarrying was initiated.

Since quarrying is about removing pieces of rock from the landscape, being able to reconstruct the situation before quarrying is an important part of characterizing quarry landscapes. In the case of an underground (or gallery) quarry leaving a distinctive cavity in the resource, such interpretations may be easy to do. In many other situations, however, it is far more difficult. For instance, if the resource occurs as scattered blocks on the surface then the resulting quarry landscape may be visualized as small, scattered heaps ofdebitage and spoil. Although the former may appear more visible and apparently larger, it is not necessarily more important or technically sophisticated. Numerous important quarries have been overlooked due to their invisibility.

A simple division of stone resource geometries, as appearing in the bedrock, is in five classes: layered (sedimentary, some metamorphic and volcanic rocks), massive (many plutonic rocks), veined (diabase and other dyke rocks, some travertine), lens (some metamorphic and igneous rocks) and irregular (not fitting the other categories). In addition, rocks can be exploited from superficial deposits, such as

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in situ boulder deposits, scree deposits and other deposits involving sediment transport (i.e. river beds). Depending on the initial situation, quarrying will develop differently, as proposed in Figure 3.

Fig. 3: Various geological and morphological situations of stone resources and the resulting quarry layout.
Production evidence
Production in a quarry can be described as a process in four steps. The first is the extraction of rock from the bedrock, producing a stone block. The second step involves the reduction of the size of the block producing a core. This is further reduced or worked into one or several object blanks (or roughouts). The last step involves the last finishing to the final product. The number of steps displayed at a quarry site, their spatial and technological connections and the start and end points of the process are important input for understanding quarrying from a technological and organisational perspective. The presence of fine sand after grinding in Egyptian obelisk quarries demonstrate for instance that finishing largely took place in the quarry. Moreover, sometimes we see ‘shortcuts’, such as in many millstone quarries were blanks were cut directly from the bedrock (see Fig. 2, lower photo).

Spoil from quarrying
Spoil (or rock waste) may be defined as the lithological leftovers from the quarrying. Each of the steps in the process of quarrying leaves behind spoil material characteristic of that specific process. Ideally, a quarry that displays many steps of production involving changes of techniques will have a variegated ‘construction’ of spoil heaps, while quarries with few steps and/or a single technique of working will have a uniform composition. Also, if all steps in the production are carried out in one place, the spoil will be mixed and perhaps display a cyclic vertical stratigraphy. Likewise, if movement from one step to the other involves physical movement of the blocks or cores, we may see a lateral separation of characteristic types of spoil – i.e. ‘extraction spoil’ with large fragments and ‘work areas’ containing fine debitage. Such perspectives have an important impact on the interpretation of the social organization of quarrying.

Characterizing the spoil fragments includes describing fragment size, size distribution, shape and tool marks on them. In the ideal Roman limestone quarry, exploiting a massive resource with few natural fractures, carving would be the dominating rock-removing technique, leaving small fragments of spoil from all the steps involved. Likewise, a Roman granite quarry involving splitting in the extraction and block reduction and thereafter carving, will display extremely variegated spoil from the first two steps (including large block fragments) and fine debitage from the last.

Characterization of the horizontal and vertical spoil stratigraphy is important for interpreting the evolution of a quarry and relative dating of events in it. When horizontal movement is a strong aspect of a quarry (for instance when quarrying a layer of valuable stone) the quarrying will leave behind a trail of spoil heaps, the oldest (beginning of quarrying) farthest away from the remaining quarry face. If the quarrying involves an overall downwards movement (level by level) the spoil heaps surrounding the quarry will display a cyclic vertical stratigraphy.

Spoil heap shapes and their relationship with the quarry faces are important to characterise. They can give important information about the number of people and teams working simultaneously in a quarry.

The spoil heaps in quarries are excellent places for the preservation of material culture; in an active quarry the deposition rate is much higher than any non-catastrophic geological process, which leads to capture and preservation of charcoal, ceramics, tools etc. However, since removal and re-deposition of spoil heaps is often necessary during quarrying for getting access to rock outcrops, care must be taken in the interpretation.

Blanks and roughouts
In most cases, the ‘products’ of a quarry are not ready to use. They are 'blanks', 'roughouts' or 'dressed blocks' which were later brought to a workshop or a building site where completion took place. An ashlar block may have been finished to the point of its rough shape and dimensions in the quarry, but the final working may have been mostly carried out at the construction site. The degree and process of finishing (or lack of it) in the quarries clearly tells us a lot about the organization of stone production. If the products actually were finished to completion in the quarries, it tells us that all the organisational layers of people involved in stone working were present at the site.
The question of finishing or not in the quarries thus depends on several factors that usually fall into the realm of economic and functional explanations: on the one hand it is important to avoid costly transport of excess stone and stone with failures that may break at a later stage of finishing. So, at least production in the quarries must be brought to a level of good knowledge of the quality of the blanks. On the other hand, complete finishing in the quarries requires more skilled people and longer production time. The way this is balanced depends on the cultural context to which the quarries belong and to distance from infrastructure and permanent settlements.

Transport
The transport of stone blocks and products is an important element of all quarrying activities. However, whatever the output of the quarrying was, the remains of elements related to transport are important to characterise. They can be divided into groups:

- internal logistics (inside the quarry until finishing/semi-finishing)
- stockpiling and loading
- overland transport
- quay/harbours/waterways.

The internal logistics in a quarry may be defined as all transport between the production steps, and from the final step to a place of stockpiling or specific loading area if that exists.

In many quarry landscapes, the logistical system for the transport of heavy stone products can constitute the most visible features in the landscape, and could even have been the most effort-demanding side of the quarrying process. But even if the transport systems are less visible, such as for lighter stone products, they are not necessarily less important, and may contribute with important information about the exploitation in general.

Social infrastructure
The social infrastructure of quarrying are the features made for sustaining the people involved in quarrying, and provide cover and shelter for them during the production. It also includes features necessary for the actual production, such as a smithy for sharpening tools, for defending the quarry site, or that display ritual or spiritual activities.

Identifying and characterising the ‘social infrastructure’ within a quarry complex as a means to interpret the social organisation of quarrying can be problematic, given that such remains are usually fragmentary and difficult to visualise.

Finding time depth
Quarry landscapes are often composed of multiple layers from more or less continuous activities over a long time. Unlike settlements, the different time layers do not form well stratified layers, but rather a complex system of use, re-use and frequent re-location of material culture. Individual quarry sites are commonly re-visited during several periods, spoil material moved to make space for new quarrying, and roads/other infrastructure more or less continuously moved. In addition, many quarry landscapes, particularly those which did not have permanent settlements of a work force, tend to have little datable material culture. However, finding the time depth of a quarry landscape is one of the most crucial research questions when it comes to evaluating its significance. Naturally, the earliest phases of quarrying are less visible (and more difficult to identify) than the younger, but not less significant.

Given such limitations, finding time depth in quarries can be achieved by several methods, in addition to historical sources:

- through direct dating: charcoal and other organic remains can be found in settlement areas and trapped in spoil heaps
- through indirect dating: ceramics, inscriptions and other epigraphic data
European Quarry Landscapes Network

- through consumption: one of the most valuable methods of dating quarrying activities is through consumption of the rocks, being buildings in a city or other well-dated objects
- through technology: the interpretation of tool marks may reveal the use of specific tools and tool materials (stone, iron) that can be dated
- through relative dating of events: such as overlapping layers of quarrying activities.

Analyzing quarry landscapes

Putting together the empirical data
Drawing together and characterising the empirical data, as categorised above, allows us to build a composite picture of the ancient quarrying process and its social context. Multi-disciplinary perspectives are clearly key in this analytical phase, given that the objective is to define and characterise all the empirical data in terms of how it constitutes the material resources that make up a quarry landscape. Interpreting the technology used to extract a resource may often be built from analysing a range of data sets, often indirectly associated, particularly when the tools used in the quarrying process are absent. Tool marks on quarry faces, partially worked objects, the constituents of spoil heaps and comparative analysis, can be effective ways to interpret the production process.

An analysis of micro-level data that informs about the logistics of how stone was transported from a quarry is important for visualising and delineating the boundaries of an ancient quarry landscape. In some instances purpose-built roads were necessary to even out the topography, yet in others, a transport route may only be indicated by cairns and sightlines. Analysing the presence/absence of such transport infrastructure is important in assessing environment, longevity of the production process and often the role of the state in such operations.

Such an analysis should aim at suggesting answers to the key questions: why was the stone resource selected and for what purpose? How was it quarried and worked? How and where was the stone transported? Who did it and when?

Visualising a quarry landscape
Ideally, a ‘quarry’ may be described as a unit of stone production, continuously exploited for a specific purpose in a specific period. Naturally, far from all quarries are ideal, some exhibit one or more hiatuses in the production, and some contain several layers of exploitation for different purposes. A quarry unit may be the result of one day’s work or tens of years. Individual quarries may start as separate units and later grow together into one large, in which the individual components remain invisible for us.

As presented in Figure 4, a quarry unit features (ideally) a stone resource (or part of such), remains from the various steps of production (quarry face, spoil heaps, work areas, unfinished products, tools, etc.), logistic features and remains of the social life around the quarrying (ceramics, shelters, etc.). There may or may not be evidence of exploitation of secondary resources. There is an input of people and resources for sustaining the production, and an output of more or less finished stone products. To a smaller or larger extent, the unit is a part of a larger organisation and social context.

In most cases, quarry landscapes are multilayered and multifunctional. Thus, following the definition of elements related to quarrying and the analyses of them, such layers/functions need to be identified as groups or systems of quarries. The term ‘quarry complex’ can be defined as ‘a collection of quarry units related to each other in time, space and/or function’. The identification of quarry complexes is an aid in visualising similarities and differences in a quarry landscape, acknowledging that there may be different ways of articulating significance for different quarry complexes. A simple way of viewing a quarry landscape is thus as a collection of quarry complexes.
The criteria on which a complex is defined depend on many factors, and may be one or combinations of the following:

- time/period
- resource (rock/commodity)
- production (technology)
- function/consumption (products).

A division by time/period requires control and knowledge of the chronology, which may have been achieved directly by exact dating techniques or indirectly through i.e. consumption patterns. An indirect way of approaching chronology may be by defining complexes from production technology. In several cases, quarrying activities have been going on for thousands of years, illustrating unbroken human interaction with a specific resource through changing historical periods. Thus, it may be of particular interest to visualise such longevity of exploitation, and not split it up in chronological layers. The use of complexes as a tool for understanding thus have to be adapted to the local conditions and the most relevant research and conservation issues at each site.

Conclusions
Although there are no definitive standardised way of investigating and analyse quarry landscapes, it is useful to follow certain steps in the empirical characterisation. The methodology given in the present article is one way of doing it. First, identify and describe groups of features observed in the landscape, from geology to production and social infrastructure. Then, analyse such features with the purpose of revealing operational chains, and finally, define quarry complexes and how quarry landscapes are composed of such. This may be brought further by adding macro-level analyses, as proposed by
Bloxam⁴, for building statements of significance, and for evaluating risks and threats to sites, as shown by Storemyr⁵. Adding such information and analyses together, we may develop good tools for making conservation strategies applicable to quarry landscapes.

Acknowledgements
There are several people who have played important roles in developing the methodology in the present paper. In particular, thanks to Elizabeth Bloxam and Per Storemyr. Moreover, thanks to Adel Kelany, Patric Degryse, Ian Shaw, Reidulv Bøe, Gurli Meyer, Øystein Jansen and Tor Grenne for good company at field work. Thanks to EU FP6 and NGU for financing the work.

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Historic quarries database and heritage values, Christian F. Uhlir

Historic quarries (HQ) as material sources for monuments, architecture and consumer goods are part of our archaeological and industrial heritage and the related space can be described as a cultural landscape. HQs are endangered by a wide range of risks, including garbage dumps, modern quarrying, the enlargement of urban areas, vandalism, looting, etc. Recent investigations on antique quarries in Egypt show that about a third have been already destroyed within the last three decades (Storemyr, 2008).

At the moment, their heritage value is not properly recognized nor have adequate protection concepts been developed (Storemyr, 2006). Identifying heritage values is a work in process, and ‘labelling’ objects as cultural heritage is also a continuous procedure, modified by changes in culture and society.

There are applicable criteria for identifying the heritage value by UNESCO and the EU. Three of the key criteria used by UNESCO for assessing the values of a cultural resource in terms of World Heritage Status, scale, importance, uniqueness or representativeness, based on the concept of authenticity, have produced much debate into how these could be applied to such cultural landscapes as quarries, which are dynamic and can comprise material culture that can represent several historical periods.

After the Nara Document on Authenticity (UNESCO 1994), a more open and flexible approach to the concept of authenticity and cultural landscapes was adopted. This represented ‘the combined works of nature and man’ allowing for the distinctive character and components of a landscape across multiple periods to be recognised, and for the inclusion of ‘industrial landscapes’, which may have evolved over several millennia, to be considered as World Heritage Sites.

Fig. 1: The renovated quarry within the open air museum of Adnet, showing trenching as an ancient excavation technique. Photo: C Uhlir
At a European level, methods to characterise the historical significance of dynamic landscapes have recently arisen from ratification of the European Landscape Convention in 2004. The Convention has been a key instrument in recognising that ‘landscapes’ are the integration of both natural and cultural values, or in other words, ‘... an area, as perceived by people, whose character is the result of the action and interaction of natural/or human factors’ (Bloxam & Heldal, 2008).

**Historic Quarries** was a European cooperation project (2008-2009) led by the CHC – Research Group for Archaeometry and Cultural Heritage Computing of Salzburg University/Austria with the following partners: Bavarian State Library/Germany, Comenius University Bratislava/Slovakia, Symposium Lindabrunn/Austria, National History Museum Budapest/Hungary, Wroclaw University/Poland, Geological Survey Vienna/Austria.

The project was implemented to collect sample data and to build up a database on a large number of individual HQ sites and related monuments in Central Europe. The data comprise historical, technical, site and stone related (petrographic) data, complemented by images of the sites (historical views and current use of the sites) and information about the historic destination of the extracted material (historic monuments, distribution in Europe).

**Definition**

A historic quarry is a defined mining area within a suitable resource of natural stone containing remains of the different mining processes such as tool marks, dumps, semi-finished goods, infrastructure, the remains of workshops, tools as well as accommodation and social facilities.

**The database**

The petrographical, geotechnical and geochemical data of quarries used in history as reference groups for provenancing monuments are partly published and partly possessed by various working groups or hidden in ‘grey literature’. These data which include also photos, graphics and maps should be made accessible to the entire research community by the interdisciplinary database [www.saxa-loquuntur.org](http://www.saxa-loquuntur.org).

It consists of two main databases. The quarry database describes general quarry information, localization, material, geological information, dating of quarrying phases, quarry morphology, signs of treatment, historic infrastructure, semi-finished goods, archaeological findings, authors and literature. The sample database for quarries and monuments describes sample information, material, macroscopic -, microscopic -, geochemical -, X-RAY data, material technical properties, authors and literature. Because of the flexible structure of the analytical section, new methods can easily be included.

For communication in between archaeological sciences and natural sciences, a simplified interactive rock thesaurus was developed on the base of the IUGS rock nomenclature. Controlled vocabulary, editable by content administrators, for various entries was established. Interlinking between the sample database and various monument databases enables a full interdisciplinary monument analysis.

At the final stage, the databases can be queried by simple and advanced search methods. The information system ([www.historic-quarries.org](http://www.historic-quarries.org)) will provide visualisation tools for geochemical data, a photo board for the comparison of thin sections, and a cartographic visualisation of the search results. For the description of social and cultural activities a project specific ‘wiki’ is associated with the database.

Currently the quarry and sample databases contain mainly information and data of Roman used marbles from the Alpine and Carpathian region and core data on selected quarries of Poland and Hungary. Within the course of the project the area of the former Austrian Hungarian Empire will be examined.

**Core data**

As result of a first data exploration within the project area, about 10.000 sites have been identified. For sources, mainly databases of national surveys and historic material collections were used. To
manage this huge amount of data within the time frame of the project, a dataset called ‘core data’ has been developed. This data set involves the name of the quarry or quarry district, the physical localization by coordinates and the hierarchical system of the country (Loc.Name/village/county/county), general material information, a rough chronology of the quarry activities and related literature. These core data sets are the base for further data exploration within follow-up projects.

For each country, full datasets was collected for ‘outstanding’ quarries. The identification and selection of outstanding quarries was done by evaluating their historic significance using a system which was developed for physical cultural heritage by Lipe (1984):

**Associative / symbolic value**: A quarry itself and cultural remains found in a quarry can deliver important cultural information on the past and can be connected with the collective memory of the people of adjacent areas.

**Informational value**: Using a multidisciplinary approach various experts of different scientific fields investigate quarries showing the status quo on resources and the overall locality, providing results that are suitable for further investigations.

**Aesthetic value**: The aesthetic value of a quarry can be seen in combination with natural and man-made influences on a resource in respect of its present-day appearance and its development over time.

**Economic value**: From the economic point of view, often cost-benefit analyses are made. Thus decisions on cultural resources concerning conservation, research, exhibitions, decay and destruction of a quarry landscape also have an economic dimension.

**Social and spiritual value**: This value is related to reverence for the place. It is connected with use of the sites for social events of various kinds (Mason, 2008).

For the selection of outstanding quarries, specific quarry parameters like material, time and space dimensions and the connection with outstanding monuments will also be used.
Fig. 3: Stonemasonry masterpieces. Left: The Gothic grave monument of K. Jagiellonczyk, Krakow, made of several variants of Adnet Marble. Right: The Baroque staircase at the Mirabel castle in Salzburg, made of Untersberg Light Marble. Photo: C. Uhlir

Case studies

For case studies within Austria the quarry districts of the Untersberg - and Adnet Marble have been chosen (see Table 1). The material of both quarry districts was presented at the IAEG XII Congress, 2014 in Turin, Italy, as best examples expressing Austria’s Physical Cultural Heritage (Moshammer et al., 2015).

<table>
<thead>
<tr>
<th>Quarry District:</th>
<th>Untersberg Marble</th>
<th>Adnet Marble</th>
</tr>
</thead>
<tbody>
<tr>
<td>Localisation:</td>
<td>Fürstenbrunn/ Grödig/ Salzburg Umgebung/ Salzburg / Austria</td>
<td>Adent/ Tennengau/ Salzburg / Austria</td>
</tr>
<tr>
<td>Quarry Names:</td>
<td>Kiefer Bruch (Hofbruch, Neubruch, Gelbruch), Mayr Melnhof Brüche, Veitlbruch</td>
<td>Tropf Bruch, Lienbacher Bruch, Motzen Bruch, Rotgrau Schöll Bruch, Winberger Bruch, Eisenmann Bruch, Kirchenbruch, Langmoos Bruch</td>
</tr>
<tr>
<td>Lithology:</td>
<td>Coniac-Santon arenaceous limestone, with variations of: medium to thick bedded, fine grained, beige, yellow, rose, clastic limestone; medium to thick bedded, gray to multicolour, conglomeratic or breccious limestone</td>
<td>Rhaetian-Liassic shallow water limestone, with variations of: Massive grey, red, green, yellow, coral limestone; Thick to thin bedded grey, yellow, violet, and red biomictic limestones;Thin- to thick-bedded micritic limestones rich in siliceous sponge spicules; Thick- to medium-bedded, reddish to yellowish-grey crinoidal limestone, Decimetre-bedded, marl-poor, blotchy red micritic limestone; Decimetre-bedded, pink-red to red crinoidal limestone, Medium to thin bedded, mostly nodular, red limestone, Red to grey breccias with clast sizes ranging from millimetres to more than one metre.</td>
</tr>
<tr>
<td>Physical data:</td>
<td>Density: 2,69 g/cm², Porosity: 0,355 %</td>
<td>Density: 2,7 g/cm², Porosity: 0,72 %</td>
</tr>
<tr>
<td>Technical data:</td>
<td>Uniaxial compressive strength (dry): 122,84 MPa; Uniaxial compressive strength (water saturated): 105,45 MPa; Tensile strength: 7,2 MPa, Ultrasonic average: 5722 m/s</td>
<td>Uniaxial compressive strength (dry): 176,11 MPa; Uniaxial compressive strength (water saturated): 164,72 MPa; Tensile strength: 7,1 MPa, Ultrasonic average: 5779 m/s</td>
</tr>
<tr>
<td>Chemical data:</td>
<td>CaCO₃: 97-99%, FeO: max. 1%, MnO: max 1%; Al₂O₃ = 1%</td>
<td>CaCO₃: 98%, FeO: max. 1%, Al₂O₃: max 1%, MgO: max 1%</td>
</tr>
<tr>
<td>Formation / Unit:</td>
<td>Gosau Formation / Northern Calcareous Alps</td>
<td>Oberhaet Limestones, Schnöll Formation, Enzesfeld</td>
</tr>
<tr>
<td><strong>Chronology of use:</strong></td>
<td>From Roman to modern times with production peaks in Renaissance, Baroque and Wilhelminian era</td>
<td>Limestone, Adnet Formation / Northern Calcareous Alps From early Middle Ages to modern times with production peaks in Gothic, Renaissance, Baroque and Wilhelminian era</td>
</tr>
<tr>
<td>------------------------</td>
<td>---------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Archaeology:</strong></td>
<td>Roman: tools, semi finished goods, sculptor didactic play; middle - modern age toolmarks, post holes and ramps; relics of large workshops rail system and wire cutting of late industrial age</td>
<td>Middle age: endless relics of small pits and toolmarks, schmid bruch quarry - example of traditional mining technology, ramps and post holes, semi finished goods.</td>
</tr>
<tr>
<td><strong>Morphology:</strong></td>
<td>Small to large niches, caverns and large dumps</td>
<td>Small pits and small to large niches, many waste heaps</td>
</tr>
<tr>
<td><strong>Related Monuments (examples):</strong></td>
<td>Salzburg: Cathedral, Residence fountain,..... Austria: Pest column / Vienna, Parliament / Vienna, .... Germany: Walhalla Monument / Regensburg, Glyptothek / Munich... Poland: University fountain / Wroclaw, Dominican Church / Krakow Czech: Palais Lichtenstein / Praha,.....</td>
<td>Central Europe: countless baptisteries and epitaphs. Salzburg: decoration material in most churches and palaces Austria: Parlament/Vienna, epitaphs and decoration in most churches Germany: Hofkirche/ Munich, Residence/ Munich Poland: Grave monument/ Krakow, Letonia: Grave monument/ Vilnius</td>
</tr>
<tr>
<td><strong>Social activities:</strong></td>
<td>International summer academy, sculpturer symposium, Untersberg Museum</td>
<td>Artist Workshops, Trail training course, Sport shooting range, Information trail and regular guided tours, Adnet Museum</td>
</tr>
</tbody>
</table>

Table 1: Compiled data sets of the Untersberg - and Adnet quarry districts.
Discussion of the historical significance of the Untersberg and Adnet quarry districts, Bloxam and Heldal (2008) developed a method to draw up a ‘statement of significance’ of a historic quarry landscape:

- Empirical characterisation
- Macro-level interpretation
- Historical value assessment

The HQ information system is designed to provide sufficient information on the empirical characterization of a quarry landscape within a geological source. It also links to various micro-level analyses done by experts on a site (see literature in Table 1). The interpretation of that data on a macro-level aims to understanding the data sets of a quarry area in their broader historical and geographical context. In other words, the data needs to be connected to other historical developments and places to draw up a statement of significance.

Fig. 4: The modern underground workings within the Mayr-Melnhof historic quarry area at the Untersberg mountain, south of Salzburg. Photo: C Uhlir

Fig. 5: Interpreted airborne laser scans of the historic quarry areas of Adnet (left) and Untersberg (right) in Salzburg/Austria
The following approaches can be used:

- a socially constructed quarry landscape can be assessed by analysing stone-working traditions, social organisation of the excavation works, ancestry of the quarry workers etc.
- the contact landscape can be assessed by describing the area of consumption and forms and changes of the use of a particular source over time. This will allow statements on historical trade patterns as well as changes of the material’s value in history.
- the analysis of the dynamic of a quarry landscape allows the forms of reuse by other activities to be described, which of course can partially or entirely destroy traces of former quarrying activities.
- the associated historical significance of a quarry landscape is related to political and ideological transformations as well as technological developments in history.

Regarding the above-described methods for both quarry areas, the significance is evident. Already a review of the literature in the database provides sufficient information for a statement of significance. Both quarry landscapes where in use for nearly 2000 years. Ancient stone-working traditions as well as their changes in late industrial times are perfectly preserved in both quarry areas. The social organisation of the excavation was in the case of Adnet related to the local community of farmers from which masonry dynasties developed. This small-scale ancient excavation works left a highly structured landscape of great aesthetic value. In the case of Untersberg, the extraction was for most of the time under governmental control and the history of excavation perfectly documents political changes.

The contact landscape for both areas covers Central and Eastern Europe and spectacular stone transport routes up to Lithuania are described. The material was used during all art historical periods and there are a large number of outstanding monuments built from both materials.

Of course, modern extraction partially destroys traces of ancient stone working traditions. Alternative uses, like workshops for artists and Summer Academy and a small outdoor museum in Adnet, enhance the educational value of the place, and do not interfere with the historical value. With the establishment of small local museums on both sites, the associative and symbolic value was identified by the local communities.

Conclusions
The Historic Quarry Information System and the database in the background can store a large range of multidisciplinary data. Of course, during the project only a limited amount of data sets was established. But the described evaluation method for identifying outstanding quarries will speed up the integration of data on quarries of high heritage values within Central and Eastern Europe. The system provides already sufficient information for an initial historical value assessment of individual sites. The information system is a perfect platform for the development and integration of local and national projects.

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References


Securing Heritage Quarries – developing a strategy, Ian A Thomas

Stone working is by far the World’s oldest industry, long pre-dating settled agriculture. Traditionally it has provided the main source for early tools and later, for building materials as well as an essential prerequisite for metal refining, glass, ceramics, refractories, abrasives and many chemicals, and even now plastics, computer chips and composites. It continues to account for the bulk of minerals extracted and by tonnage, the greatest commodity transported.

A scheme for recognising internationally important quarries has been proposed (Cooper et al 2013). Although not yet adopted legislatively, nominations are being made testing the criteria, the first put forward being Portland stone, England, with North Wales slate in the pipeline. It is suggested here that there is also a strong case for intra-national designation, reflecting national, regional and local significances, with sites accorded appropriate protection.

Status of historic quarries
It is therefore more than surprising, indeed one might justifiably say, scandalous that the development of this industry has received such scant attention from historians, archaeologists and conservationists, particularly when contrasted with other fields of activity. Even within the extractive industry sector, the winning of coal or metal ores have received appreciably greater scrutiny. In his analysis of 196 archaeological reports, Peacock (1998) recorded stone being encountered in 98% but only geologically verified in 3%; apparently none of the accounts referred to quarry sources.

Dissecting the subject further, within the stone sub-sector, we see that certain aspects have generated far greater interest than others, whether by way of statutory protection or research - notably including prehistoric tool-making, abrasives (querns/millstones/grindstones), slate extraction, lime burning and winning stone from underground mines. Taking underground mining of stone as an example, it has probably produced less than 0.1% by volume of material extracted, but probably more than 60% of recorded research. Of all rock types, sandstones, which make 40% of all quarry sites, fare especially poorly in the spectrum of research; and coverage of sand and gravel is almost non-existent.

Why so little interest?
Many reasons have been reported although never systematically charted. They appear to include a varied and complex array. The scale and omnipresence of the industry can itself be daunting with active quarries, for example, in every English county, some operations extending over several square kilometres. The volume of material to be shifted and sifted in comparison with the likelihood of interesting finds is often overwhelming. The lack of variation of extractive and processing technologies over almost two millennia not only makes chronological distinctions challenging, but probably again reduces the appeal to conventional archaeological researchers; this might be overcome by the application of novel techniques, such as optically stimulated luminescence, biological indicators of time since working, metallurgical tests, tree ring analysis. Of the 40,000 quarry sites of all dates plotted by the British Geological Survey (BGS) in England, a guesstimate by the author suggests that well over 90% were opened up after 1800. By contrast, archaeological endeavour is heavily biased towards medieval or even earlier activities.

What are the threats to historic quarries?
Heritage quarries face threats both similar to those attached to other culturally valued features, but they also encounter some which appear to be unique. Stone working, being often intermittent, perhaps over centuries, has a tendency to destroy its own past. Even where features are not destroyed or removed, artefacts may be effectively lost under extensive waste tips. In the United Kingdom, the planning regime introduced in the 1940s, accentuated in 1995 by requirements to review mineral planning conditions on a periodic basis, has led to the wholesale removal of all evidence without any obligation to pre-record. In parallel, since about 1968, the UK government has encouraged the reclamation of derelict land; initially directed to former collieries and factories, details of quarries have also been wiped out in the process. For example in the 1970s, around 1.5 sq miles of 19th - early 20th century unrecorded lime works were lost around Dove Holes Buxton. Some
considered this to be state-sponsored vandalism. Also after 1960, many former semi-urban workings have been prime targets for landfill operations. Since the introduction of the Landfill Tax in 1996, this threat has begun to recede, only to be replaced by a massive push to redevelop ‘brownfield’ (formerly built-on) in preference to ‘greenfield’ sites. Flooding of workings represents another form of loss, in two important cases, Bath and Dudley, where old underground workings have begun to threaten the stability of subsequent surface buildings. This has been rectified by large scale grouting and infilling of voids. Fortunately, in the former case an exemplary major research project recorded a considerable amount of evidence before it was embedded (Willies 2011).

Linshaws Quarry, West Yhorkshire. Photo: Creative Commons

The invasion of vegetation and wildlife in general, even over as little as two decades, can become the most insidious threat to field research or reopening quarries. The former medieval workings at Barnack, Cambridgeshire, now designated as calcareous grassland habitat, are a case in point. Where the biodiversity is sufficiently well entrenched to achieve statutory protection, it can halt any further extraction, notwithstanding the need for authentic building conservation materials. Indeed the most notorious recent example comprises the proposals to reopen the 1 ha Linshaws Quarry for fissile sandstone roofing. Matters came to a head when, despite strenuous efforts in its support from English Heritage, this application was blocked on account of it being located on the very edge of a 65,000ha nature reserve (Wood 2008). Ironically, the Linshaws proposal was itself made in response to an officially sponsored research project (Hughes 1996) aimed at promoting supplies of such roofing materials, the absence of which was resulting in totally inappropriate restoration of historic buildings including many in the Peak National Park.

Recent related developments
The Linshaws decision in turn provoked a series of responses. Firstly the UK government commissioned a research report into planning issues surrounding building stone extraction in England and Wales (Thompson et al 2004). The government reacted to the findings by introducing new planning guidance. In parallel, English Heritage initiated the Strategic Stone Study, an ambitious project to gather data on historic and operational building stone quarries, linking them with a
database of buildings and their stone sources. The output covers almost all of England excepting some south-eastern counties; for each area, ‘atlases’ provide a companion narrative to the database (e.g. Thomas 2011). This represents the combined efforts by large numbers of local specialists and the BGS, coordinated by English Heritage (now ‘Historic England’). Although the atlases make general references to the more important stone sources in each area, there is no attempt to rank quarries in order of significance or any suggestion to apply protective designations.

In the 1990s, a series of reports produced for English Heritage’s Monuments Protection Programme (MPP) included investigations into ‘the quarrying industry’. Attempts were made to grade sites with remains into three higher categories, based on their priority for statutory protection; these ‘national’ level sites accounted for 41% of the total. Most of the remainder were graded of regional or local value. Although 67% of quarries listed were thought to have commenced after 1540 (i.e. ‘Post-Medieval’ and ‘Modern’), only one, Llanymynech (ironically partly outside England), was accorded the highest national rating; the thirteen others in this grouping were all older. At least three nationally significant features were not even logged, namely Bardon Mill, Leicestershire (by far the largest Victorian stone processing building in the UK), Hopton Wood, Derbyshire (three complexes of masonry works) and Hapsford Mill, Somerset (water-powered stone processing). The last of these is now a residential property; the first is under threat; at the other, almost all the buildings were demolished in the 2000s without prior recording. Unlike the Strategic Stone Study, the MPP was largely founded upon published sources, apparently engaging minimal consultation with local or national quarry specialists.

In the early 1990s, Regionally Important Geological Sites (RIGS) were designated on a semi-formal basis in most of Britain. One of the determining criteria, although very unevenly applied, sought to capture geological locations (including quarries) of historical significance.

Since the early 1950s, planning authorities, in their Development Plans, were obliged to safeguard areas containing nationally and locally important mineral deposits from prejudicial development. Few instances of building stone resources being so protected are known, none of which appear to differentiate national and local levels. Thomas and Cooper (2015), reviewed safeguarding practices. For discussion, they developed a scoring system driven by the significance of past building usage to measure the importance of resources at national, regional and local levels. This approach has been trialled in simplified form across the Peak National Park (Thomas 2014).

Over the last 30-40 years, there has been a growing but far from comprehensive awareness of the heritage value embodied in quarried sites in England and Wales. Quarry research has tended to depend very heavily upon the assiduous efforts of a dedicated handful of specialists working alone and as a result, generally does not necessarily reflect the significance of the spread of the industry nationally.

In part to remedy this situation, as one of a series of subject- and region-based research frameworks commissioned by English Heritage, the National Association of Mining History Organisations (NAMHO) has analysed archaeological and historical research coverage of extractive industries in England, and in particular identified themes which deserve further attention in the form of a research agenda (Newman 2015). In the sections on quarries, Thomas (2015b) advocates a hierarchical approach which is not only a tool for prioritising research, but has valuable cross-over into justifying the protection of sites for the future. In Wales, Thomas (2015a) has also catalogued the development of the quarrying industry other than slate and Gwyn (2015) has described in detail the situation in the slate industry.

Definition and criteria
The concept of stone quarry landscapes was introduced by Peter Stanier in his 2000 book Stone quarry landscapes: the industrial archaeology of quarrying and, albeit implicitly by recording their value, advocated their safeguarding.

The term ‘Heritage Quarry’ was coined by Terry Hughes in 2003 and the idea was later endorsed by Thompson et al (2004) when he suggested the designation of ‘Quarry of Special Conservation Interest’. 
This is considered to be too open-ended. Although as yet they have no formal definition, Heritage Quarries should encompass those sites where quarrying or directly associated processing has taken place which has some form of historic value. Criteria for consideration might echo those for other heritage assets. For example they might be designated on account of their historically early activity, longevity, association with other cultural heritage assets, or perhaps have status as a fundamental supplier to an important industry, their potential to sustain our built heritage assets or have created a prominent landscape feature.

The various projects and initiatives just reviewed offer a number of potential inputs to a system for designating Heritage Quarries, but none of them reflect the totality of attributes which demand consideration. For example, the MPP scheme only ranks archaeological assets; the resource safeguarding proposals are confined to building stone and gauge potential based on past performance. ‘Heritage Quarry’ definition demands consideration of a broader range of characteristics, but should not extend to include bio- or geo-conservation assets.

For illustrative purposes only, Table 1 presents a trial scoring system applied to a selection of prominent Welsh quarries (excluding slate), applying twelve parameters. The entries are based on general knowledge rather than specific surveys; in particular some entries in columns 4, 5 and 10 are speculative. It is suggested that, under such a scheme, a score of at least 50% (30 points) and preferably over 60% (36 points), be achieved for ‘national’ status.

<table>
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Scores 1-5: 1= little/negligible; 5 = most significant

1 extent of site
2 extent of market served over time
3 association with important architectural, community or civil engineering features or an industry
4 potential for sustaining building conservation works
5 industrial archaeological remains
6 general setting eg dependent community or port
7 representative of a type, present or past
8 uniqueness within its type
9 significant element in the landscape
10 longevity - active over long period(s)
11 evidence of particularly early (at least pre-1800) working
12 support from documentary evidence

Table 1: illustrative scoring for selective welsh heritage quarries [excluding slate].

Conclusion
In summary, the considerable, in some cases vital, value of quarries as cultural or historic assets has been grossly neglected. ‘Heritage quarries’ may display intrinsic qualities such as important archaeological features. They may have strong contextual stories to tell in relation to their customers or local communities. They could offer valuable reference pointers to restorers; perhaps controversially, they may also be capable of meeting a continuing need for conservation materials. A system for recognising and grading heritage quarries to offer protection on par with other cultural or natural assets is long overdue. The methodology offered here, although by no means perfect, is put forward to stimulate debate in the hope of progress towards formal protection.

It is suggested that as a ‘good practice’ guideline the resources which underpinned all World Heritage Cultural sites should be tracked, reported and protected. Similar analyses should form an integral component to all Conservation Area Assessments and restoration plans for significant historic buildings.

Just as the protection now given to Registered Parks and Gardens in England has been carefully drafted so as not to exclude planting of new stock, so a special protocol will be essential to allow, in appropriate cases, ongoing but controlled quarrying. Furthermore, once registered, heritage quarries should be protected as the ‘primary/inalienable conservation interest’ against, for example, later counter claims of biodiversity significance. The prospect of a site being overrun by vegetation and wildlife should be regarded as ‘contrary development’ for which specific authorisation should be required.

About the author: Ian Thomas is the former Director of the National Stone Centre, Wirksworth, Derbyshire UK. The views expressed above are not necessarily those of the author or statutory bodies.

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Construrock, a scientific network for monumental architectural heritage and the preservation of historic quarries, J M Baltuille Martín and E Álvarez Areces

The study of monumental architectural heritage has usually been approached from specific views, artistic, archaeological or architectural, leaving others whose analysis and assessment would lead to a broader understanding of the problem and, therefore, to more accurate results corresponding to the needs of the ‘heritage asset’ in the broadest meaning of the term.

One of these views we are referring to is the study of stone material, not only from the perspective of its ‘state of health’ (pathologies, treatments, etc.) or its ornamental beauty, but also making an assessment of it as the basic construction item of heritage. The intrinsic characteristics (composition, granulometry, size of grains, orientation, matrix, cement, etc.) will define the petrophysical behaviour. This will lead to appreciation of whether it is adequate for construction, its behaviour against environmental hazards (alteration, crusts, resistance to water flow, etc.). Finally, its localization, characterization and the study of quarries or rock massifs where the stone material was extracted, the study of the extraction techniques used and the estimation of the volume of extraction will enable us to have access to the original material used for later works or restorations (Laborde Marqueze et al., 2013). With an understanding of all the ethnographic and technological information (cutting signals, mason marks, ripping techniques) that they hold, we will be able to find information about the socioeconomic structure where the ‘heritage asset’ arose.

Unfortunately, in most cases, all that information is lost since we are unaware of or have forgotten the existence of those quarries which end as degraded and culturally lost spaces for the social areas in the surroundings.

In 2004 this earlier approach was shared by some twenty Spanish researchers (geologists, architects, archaeologist, mining engineers, chemists, historians, etc.) who, coming from different professional fields (public research institutions, universities, technological centres), decided to design a database, called CONSTRUROCK, where all information available for them on natural stone, architectural heritage and civil engineering works could be stored. It focused on four basic sections: historic quarries, geochemical and mineralogical characterization of materials, technological tests of stones and construction works with the aim to allow anyone to access it through the internet.

In 2011, the CONSTRUROCK Network was set up by ten research groups from many other centres. The Network is presently composed of thirteen members from across the Spain (Fig.1) and is coordinated by the Spanish Geological Survey.

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6 In the case of the restoration of structural functions, the substitution will be carried out using natural stone of petrophysical characteristics similar to the original. The selection will be based on discernability, suitability, compatibility and durability criteria, using as far as possible material from the geological surroundings of the cultural asset (pp.99).
Objectives
The CONSTRUROCK Network, regulated by the Articles of Association approved on March 8, 2010, has defined the following objectives:

- creating and managing CONSTRUROCK, a database of ornamental and construction rocks used in the construction of the National Historic and Monumental Heritage and in new construction works. The field and georeferenced character of the information will turn it into a basic element for planning and it will be able to be integrated, among other coverages (geological, geophysical, natural disasters, etc.) in geographical information systems (GIS)

- examining in depth the petrologic knowledge of the stone for a better understanding, prevention and treatment of pathologies that might affect it

- localizing, cataloguing and studying the historic quarries used in the construction of the Historic and Monumental Heritage as well as collaborating with the competent authorities in the design and development of a protection regime for these quarries

- searching quarry sites for alternative rocks for their use in heritage restoration

- promoting and spreading the importance of natural stone in construction, concerning both the historic heritage and new construction works. Becoming a useful tool for restoration and preventive conservation works, a reliable characterization of the stone material will allow the development of monitoring and control procedures for the factors that determine the deterioration risks (Laborde et al., 2013)

- participating and/or leading research projects on natural stone and its link to the historic and monumental heritage and new construction works with regard to any aspects related, whether
they are their own or awarded on a competitive basis and at an international, national regional or local level

- presently, the Spanish Geological Survey is developing the project first National Register of Historic Quarries used in Architectural Heritage. The great wealth of the national architectural heritage, the variety of lithological facies used in its construction and the reasonable existence of a high number of quarries make it the knowledge, protection and ward of these heritage items an essential aim. Following this line of research the Spanish Geological Survey is developing the project Geoscientific Information System applied to Monumental Architectural Heritage, which stresses the relationship between geology and heritage and which will be an excellent tool for land planning and the preventive conservation of architectural heritage (Baltuille Martín et al., in press)

- any other works whose subject are related to natural stone and its use in the construction of the historic and monumental heritage and the new construction works.

Construrock database
The creation of a database where all available information is stored means a unique step in the field of knowledge related to historic quarries as well as an essential tool for their future protection. At present the Construrock database contains 3,629 records and is coordinated by the Spanish Geological Survey, which is in charge of managing and updating the information.

In addition, the main goal of this database is getting to know the localization of historic quarries, becoming a reference tool in the need of intervention on the architectural heritage. The characterization of the historically used natural stone and its geographical and geological location is a priority not only for any intervention on heritage but also for improved knowledge. The areas of stone extraction for the construction of the architectural heritage of a country are considered to be of great interest since they are responsible for its artistic identification in some way (Gutiérrez Claverol et al., 2012).

The database is structured in the following main sections:

Physical-Mechanical characterization tests of natural stone
- Compressive strength
- Flex resistance
- Speed of sound
- Resonant frequency
- Static and dynamic moduli of elasticity
- Breaking strength for anchors
- Abrasion
- Linear coefficient of thermal expansion
- Slides
- Knoop hardness

Hydric characterization tests and alteration of natural stone tests
- Actual density
- Bulk density
- Total porosity
- Open porosity
- Water absorption at atmospheric pressure

- Ageing by SO\textsubscript{2} action
- Resistance to salt crystallisation
- Ageing by salt mist
- Frost damage test.
- Thermal shock test

Petrographic characterization, chemical and mineralogical characterization
- Macroscopic description
- Microscopic description
- Basic chemical composition
- Mineral phases: primary, secondary and accessory

Historic quarries or geological units
- Localization
- Exploited substance
- Variety
- Type of exploitation
- Ripping techniques
- Geological data (age, orogenic phase, description, deposit morphology, direction and dip, etc.)
- Additional information (samples, studies carried out, bibliography, construction works related and its localization)
- Construction work
- Localization
- Type of work
- Original period

In the database, the geological information is related by means of the localization of historic quarries, technological information, characterization of stone materials and historic architectural information, recording and classifying the architectural heritage in which the different materials have been used. In the future, this database will go on being updated with the data entered by the members of the Network, and it can become a model that can be exported to other nations and architectural heritages, such as the European countries.

The need for a *reversible protection regime* for historic quarries,

As mentioned above, one the main goals of the Construrock Network is to locate historic quarries or lithological units that have been exploited in the past for the construction of the architectural heritage. Their record implies knowing the localization and, therefore, the availability of original stone material for substitutions in future restoration works, but also creating a catalogue. Further on, with the collaboration of authorities, a legal regime can be designed that confers protection while granting, if necessary, permission to extract a certain quantity of original stone for use in restoration works on the architectural heritage built with that kind of stone (*reversible protection regime*). Obviously, the modern extraction of the stone will be accomplished with respect for the historic fronts and tools marks, such as grooves by pick, marks by the use of wedges, carved ashlers attached to the massif, etc.

Nowadays, both the Spanish Law for Historic Heritage (Ley de Patrimonio Histórico Español - LPHE, 16/1985 dated June 25th, in its articles 14 and 15) and the article 334 of the Spanish Civil Code establish the historic assets to be protected, including ‘the mines, quarries and waste heaps, as long as their raw material remains united to the geological site ...’ . In the event of its application, it could be conservationist, allowing the occasional and well-regulated use of the stone in the case of its being needed for work on historic buildings.

At a national level and in certain exceptional cases, the choice made has been the recovery of these spaces or the creation of local protection regimes regulated by urban planning drafted by local administrations. This is the case of the El Mèdol roman quarries in Tarragona. In other cases, private or associated actions have been taken to promote recognition with greater or lesser success, such in the case of the granite quarries in Gerena, Sevilla, the Marés quarries in *Pedrerès de S’Hostal*, Menorca or the quarries from Caliphate period in La Chanca, Almería.

![Fig2: Historic quarries near Trujillo (Cáceres), two-mica granites used in the construction of the local architectural heritage. At present they are overflowing with waste materials making it impossible to observe the historic exposure and tool marks](image)

However, as in other European countries, Spain still lacks the protection regime for these spaces, which in many cases show a very advanced stage of deterioration and neglect, often being used as
local landfill sites, filled with disposals that preclude the analysis and observation of preserved historic exposure and tools marks (pick grooves, marks of wedges, carved ashlar attached to the massif, etc (Fig.2).
Proximity to populated areas makes them very vulnerable to illegal and uncontrolled dumping as well as to the urban development, precluding their recording and cataloguing. For that reason, there is an urgent need for a register with the aim to enable the protection of these locations of geological, archaeological and historic interest, and as a land planning tool and for their assessment for their future protection under the conditions of reversibility as previously mentioned.

Conclusions
The future prospects for the CONSTRUROCK Network is the administration of the database, going on with data entry by its members and spreading it as widely as possible through an open access context such as the Internet; promoting the importance of natural stone in every construction context, both in historic and modern architecture; being aware of the need to know the nature and behaviour of stone materials, since we have at our disposal a huge built heritage of civil and architectural works which must be preserved (Garcia de Miguel, 2009). And finally, generating synergies in the field of stone and heritage for a better understanding of construction stones and the historic quarries from where they were extracted; and collaborating with the competent administrative authorities in the future design and development of a reversible protection regime consistent with the peculiarity of these spaces.

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CHARROCK - characterization of geomaterials, Lidia Catarino and Dolores Pereira

CHARROCK was recognized as a research group at the University of Salamanca, Spain, in 2005. Since then it has been growing in members and in research lines. Now the group incorporates members from other institutions in Portugal and Spain as University of Coimbra and the Spanish Geological Institute with a total number of nine members.

CHARROCK is the acronym for Characterization of Rocks because the objectives of this research group are:

- to characterize natural stones from a scientific point of view;
- to characterize natural stones from an architectonic heritage point of view;
- to preserve historical quarries;
- to link with national and international networks to work on a common goal.

This last issue is serving us to link our group with other national and international networks (e.g. CONSTRUROCK and Heritage Stone Task Group) dealing with preservation of the architectonic heritage, recognition of the heritage stones, but also cataloguing and preservation of historical quarries.

CONSTRUROCK involves research teams from universities, research and development institutions and natural stone related companies. Its aim is to catalogue all natural stone and quarries in Spain, focussing on both new and historic buildings. These objectives have a common final goal: to identify, for the purpose of protection, those quarries involved in the construction of the Spanish architectonic heritage. A catalogue of the major quarries, their identification and protection status will permit the quarrying of heritage stone resources for restoration if needed.

The Heritage Stone Task Group (Cooper et al., 2013) exists since 2008 as a Task Group of the IUGS and in February 2012 its Terms of Reference were approved at the IUGS Executive Committee Meeting in San Sebastian, Spain. It presents also links to Commission C-10 Building Stones and Ornamental Rocks, International Association of Engineering Geology and the Environment (IAEG C-10). One main objective is to recognize with the designation of Global Heritage Stone Resource (GHSR) all those natural stones that have been used to build our architectonic heritage and that have a strong relation to our cultural heritage.

Preserving historical quarries is a major issue to ensure the availability of natural resources for restoration. Via the GHSR designation, prominence will be gained for those natural stone resources that have been used in artistic and architectural masterpieces, heritage construction, as well as utilitarian (yet culturally important) applications.

Natural Stones, heritage and quarry landscape

In order to accomplish its objectives, CHARROCK started to investigate the quarries around Salamanca. The old city of Salamanca was declared Unesco World Heritage Site in 1988 and different quarries around Salamanca were used to extract the natural stone for the historical buildings. First, sandstones as Salamanca sandstone and Villamayor sandstone were used and later granites and slates.

The Villamayor sandstone is also named Golden sandstone due to the patina that produced an ochreous/golden colour on the façades of monuments of Salamanca. It was quarried for the construction and ornamentation the Old Cathedral, the New Cathedral, San Esteban church, the rich façade of the Salamanca University and many other aristocratic buildings of the city. The Villamayor quarry was active in the Middle Ages and in other periods of the building in Salamanca. There is a historic quarry within the city maintained for touristic and educational purposes, where marks of the craft tools used to extract the stone and some remains of the latest exploitation can be seen.
Now the stone is being quarried by small and family companies, without a modernized processing. This sandstone is the main stone material used for the restoration of monuments in Salamanca and it would be of great importance for future generations to protect its quarries and the craft of masonry.

An example is Canteras Regias where the shallow exploitation remains, but the previous exploitation were recovered and we only see the green of cornfields.

Fig. 1: The entrance of the ‘Canteras Regias’ quarry and the aspect of the actual exploitation

Salamanca sandstone is a Palaeocene rock long used for building purposes. In Salamanca it was used to build the lower part of most historical buildings, previous to the use of granite, for protection against erosion and weathering, since they are more resistant than the Villamayor sandstones used for the higher parts of the monuments. Although in some cases this solution has been successful, in others the results have been less satisfactory. Salamanca sandstone is in fact an opal cemented conglomerate. It is not extracted anymore, except for occasional restoration work. There are quarries spread around the city, but most are disappearing. Five kilometres away a quarry is preserved but only because it is part of a historical site, Los Arapiles, where Napoleon and the French troops lost an important battle against Wellington and the British and Portuguese army in 1812. An annual memorial takes place there.

The granite of Martinamor named ‘Piedra Pajarilla’ is a leucogranite with a texture in the shapes of flying birds, texture that results from clustering of racially arranged acicular tourmaline crystals. These accumulations are either spread randomly through the rock or showing distinctive clusters that remind one of the shapes of flying birds, hence the name. This granite is a hard and consistent stone that has been used for more than 400 years (1515-1932) in Salamanca and surrounding areas, mainly for the base course of historic and aristocratic buildings. The Martinamor quarry is now part of a private farming land and efforts have to be made to preserve it as a historic quarry.

Fig. 2: Current aspect of the granite quarry of Martinamor and an example of marks of exploitation
Other natural stone projects of CHARROCK are related to Verde Macael serpentinites, exploited in quarries close to Granada. The first documented use of this stone was at the monastery of El Escorial in Madrid in the 16th century, but also in many architectural elements such as columns, plaques, medallions and other decorative details. In the city of Granada it is visible in buildings such as the Cathedral (16th-18th century), the Royal Chancery (16th century), the Church of San Juan de Dios (18th century), the Monastery of La Cartuja (16th century), the Palace of Charles V (16th century.) and the Monastery of St. Jerónimo (16th century). There is also evidence of the use in Madrid, in emblematic buildings such as the monastery at San Lorenzo de El Escorial.

Outside Spain others examples of GHSR have been proposed. In the west side of Iberian Peninsula, Estremoz province is a very important quarry in Portugal where very qualified white marbles are extracted and recognized worldwide. The exploitation of the Estremoz marble started sometime in the 1st century CE, when Roman urban development in Lusitania required huge amounts of ornamental stone. This place presents outcrop continuity and intense mining activity since the Roman Period and pieces of art made with white marble of Estremoz were exported abroad and can be found in museums and archaeological sites throughout Europe and North Africa countries.

The Estremoz Anticline is the primary marble district of Portugal. It consists of a 40 km long and 5-8 km wide anticline, with a dominant NW-SE orientation and is part of the Ossa-Morena Zone (OMZ). Most traces of ancient quarrying have been destroyed by modern extraction. Studies made before 1976 have located ancient quarries at São Marcos, Lagoa, Monte d’El Rei, Carrascal and Vigária, as well as at some other less well-specified locations (Borba, Vila Viçosa, Bencalet,Pardais, Rio de Moinhos, Barro Branco and Glória).

The preserved quarry features show that blocks were removed by cutting narrow vertical trenches on all sides while splitting was done by hammering a series of horizontally placed wedges at the bottom of the block. The historical and widespread application of these marbles in national and international monuments is a condition to propose them as Global Heritage Stone Resource for their international recognition.

‘Petit Granit’ is extracted in Belgium since medieval times. It is a Lower Carboniferous (Tournaisian) grey-bluish crinoidal limestone that becomes shiny black when polished. The stone characterizes many façades of the urban architecture of Brussels and other Belgian cities, and since the second half of the 19th century it has been used in various countries in Europe and overseas. The quarries landscapes are recognized already. Around fifteen quarries are active these days, employing almost 1000 people and thus is an important part of the natural stone economy in Belgium. It has been nominated as GHSR for its use in construction and sculpture (Pereira et al. in press).

Conclusions
When conservation and restoration of architectonic heritage is involved, the correct and original material should be used. Some of the quarries from which these stone come have stopped extraction activities. This could lead eventually to their disappearance and lack of replacement for restoration. Recognition of quarries as part of landscape heritage would help to the preservation of them and the consideration as historical quarries. But quarries can be part as well of other local activities, for example related to tourism. Recognition of quarries as part of landscape heritage would help to improve the knowledge of important quarrying areas.

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Further reading


The Global Heritage Stone Province concept, Dolores Pereira and Carlos González-Neila

Landscapes change because they are the expression of the dynamic interaction between natural and cultural forces in the environment. They are the result of consecutive reorganizations of the land in order to adapt its use and spatial structure better to changing societal demands. But landscapes can also be related to cultural issues and traditions that mark the character of a community. This is the case of quarry landscapes. European quarries are rich cultural landscapes that also enjoy special natural conditions and habitats, and rich geological and fossil evidence. Stone quarrying is an ancient industry but still a very important one. Stone is at the beginning of European art and architecture, and quarries are essential today for the conservation of this heritage.

In Europe, quarries have been worked since ancient times. Though sometimes abandoned or used as dumps (mainly demolition waste), they are rich, evocative landscapes, combining man and nature in a unique manner.

Quarrying has been linked to the evolution of transport systems. When roads and transportation evolved, moving the blocks of stone from the quarry to the construction site was not an easy task, and some quarries were abandoned for more easy ones to explore. This was the case in several parts of Spain, such as Salamanca, where natural stones from different quarries were used to build Salamanca’s architectonic heritage, which was the main issue to be recognised by UNESCO as World Heritage in 1988.

The existence of various natural stones that share geographical location, historic buildings and/or geological history gave rise to the concept of the Global Heritage Stone Province (GHSP, [1]), developed by the Heritage Stone Task Group (HSTG) of the International Union of Geological Sciences and the International Association for Engineering Geology and the Environment (IAEG) Commission C-10 Building Stone and Ornamental Rock. Some or most of the natural stones within a province should also be recognized as Global Heritage Stone Resources (GHSR). A GHSR is a designated natural stone that has achieved widespread use over a significant historical period with due recognition in human culture. To be accepted as a GHSR, natural stones have to fulfil a set of requirements [2].

Around 70 natural stones are expected at the moment to be candidates as GHSRs. Within this list we find a number of stones widely used in the construction of the historic buildings of Salamanca: Piedra Pajarilla (Martinamor Granite) and the Golden Sandstone (Villamayor Sandstone). Other natural stones were used in the construction of historic buildings as well - Salamanca Sandstone, Mozarbez Slate and the Vaugnerite of Ledesma - and one of them is widely used in civil construction today (Los Santos Granite) [3]. The exploitation of all those natural stones left a complete quarry landscape in the province.

The Global Heritage Stone Province and the quarries landscape of Salamanca Piedra Pajarilla is a leucogranite whose main feature is the presence of luxullianitic texture in the shape of flying birds, hence the origin of its local name. It outcrops at Martinamor, a village about 15 km from Salamanca. Piedra Pajarilla is known in addition to Martinamor Granite but it does not have any commercial name, as extraction ceased in the first half of 20th century with the quarries now abandoned and part of private cattle farms. Nevertheless the quarries remain very well preserved and the denomination of Piedra Pajarilla as GHSR could help to facilitate availability of the stone for specific restoration-conservation interventions [3].
Figure 2. Martiamor historic quarries of Piedra Pajarilla. The quarries do not have any protection, but they still show the remains of traditional extraction methods.

Villamayor Sandstone is arkosic sandstone with a high content of iron cement at some localities [3]. This peculiarity confers a specific patina providing the name of Golden Sandstone to the natural stone and conferring the title Golden City on the centre of Salamanca. This natural stone has also received several other names: Piedra Franca - Honest Stone - probably due to the easiness of carving when wet. This natural stone was used in many building façades when the Baroque style was prominent in the building of the historic city.

The main quarries are in Villamayor de la Armuña, a village 5 km from Salamanca. Some remain active and the stone is readily available for construction and restoration-conservation interventions. However, economic crises affecting construction work can endanger the availability of the quarries if they continue for too long, except if a preservation order is obtained, either by the GHSR and GHSP figures or the European Quarry Landscape protection that the area deserves.
Figure 3a. Historic quarry of Villamayor sandstone. Salamanca cathedral was built with stone from this quarry. At present the quarry is not active but it is maintained for educational purposes. Photo: D Pereira

Figure 3b. Villamayor sandstone quarry in 2013. At present this quarry has ceased extraction due to the economic crisis in the construction sector. Photo: D Pereira

The Salamanca Sandstone is a late Cretaceous-early Palaeocene deposit consisting of clastic, silica-bearing strata. This conglomerate was used in the construction of the upper part of the Roman bridge of Salamanca, but later on the conglomerate ashlars were often used on the lower parts of building façades, thus being exposed for long periods of time to wet conditions. This has meant that many historic buildings have been damaged and are now in need of restoration-conservation interventions.
Some of the other, stronger natural stones presented here could be used as replacement. In any case, Salamanca Sandstone is not quarried anymore (Figure 4).

![Image](Fig 4. Quarry of Salamanca sandstone in Arapiles. Two inselberg made up of the conglomerate stand out of the peneplane. This area is well known for the 1812 Arapiles battle, when Wellington defeated Napoleon’s troops. But they were also source for natural stone blocks for construction of Salamanca historic buildings and Roman quarries have been documented. The site does not have any protection. Photo: D Pereira)

Vaugnerites used in the construction of architectonic heritage in Salamanca are Variscan monzodiorites and quartz monzodiorites. They were quarried in Calzadilla del Campo, close to Ledesma, 34 km west of Salamanca (Figure 1). They show a typical vaugneritic texture consisting of large, elongated biotite and amphibole crystals. There has been almost continuous production across a period of 300 years. Vaugnerites have been used in the construction of the base courses of historic buildings in Salamanca and the complete historic building of Ledesma, but also in the reinforcement of the Roman bridge and the Old Cathedral of Salamanca [3]. The quarries from which this stone was extracted are not active except for punctual restoration activities (Figure 5).

Several other granites were used in the construction of historic buildings in Salamanca: Los Santos Granite, Sorihuela Granite, Vitigudino Granite [3]. All are still being used, their extraction is part of the main economy of the area and their quarries are one of the main features of the landscape of the province (Figures 6a and 6b).
The greenish slate of Mozárbez was extensively used in the construction of Salamanca’s buildings. The village is 15 km from the city and several shafts remain in the surrounding countryside as testament.
to the important extraction activity. The slate was used for the pavement of the New Cathedral and Plaza Mayor [3] as well as protection underneath the more porous sandstones when these were used as the base course for historic buildings. At present, the slate is used only for local construction in Mozárbez village.

Conclusions
Quarry landscapes are part of the cultural heritage of Europe. Many societies were based on quarrying activities for centuries and the use and manner of extraction are reflected in many of the abandoned quarries. These should be preserved. Many historic buildings were constructed using local natural stones and some of them, for one or other reasons, have been neglected and quarries are abandoned. Piedra Pajarilla and Golden sandstone have been proposed as GHSR. They were used to build the architectonic heritage of Salamanca, a UNESCO World Heritage site since 1988, and the abandoned quarries should be protected for restoration purposes or to wait for an improvement in the economic situation of the construction sector.

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References


Quarry landscapes from the Ice Age to the present, Tom Heldal, T. Grenne, G. Meyer and Per Storemyr

Norway is known for its wooden houses, grass on the roofs, a country of wood-carving people. Stone is something you throw at your enemy or have to remove from the fields before ploughing. Is it really so? Of course not. As other regions, Norway has a rich tradition of stone production, since people settled here in the north some 12,000 years ago, after the glaciers of the last ice age retreated. Stone quarrying for making useful products has left a significant heritage, transforming natural landscapes to those displaying quarrying through time. Since the 19th century, but particularly over the last 20 years, the significance of these landscapes, and their importance in displaying historic and prehistoric evidence of technology and knowledge, has gradually gained appreciation and interest from researchers.

The Norwegian quarry landscapes can be viewed as a travel through time. Sometimes, they reflect a certain period and technology, and sometimes they represent a surprisingly stable acquisition of resources through changing times, from forgotten technologies to technologies gradually adapting to a modern society.

Quarry landscapes of the Stone Age (10,000-1800 BC)
The first settlers in Norway were hunters and gatherers, and they needed good tools and weapons to survive. Local resources were used all over the country, and, rather quickly, specialized industries formed. Knowledge of the best geological resources for making high performance tools spread, and trade patterns were established.

There are no natural flint deposits in Norway, but pebbles and cobbles of flint were brought from Denmark by ice movements during the Ice Age, deposited along the coast and constituted an important resource for tool-making. There are also several deposits of good substitutes; such as high quality chert, rock crystal, jasper and rhyolite, as well as numerous occurrences of quartzite and vein quartz for everyday use. Thousands of years of use formed numerous 'industrial scaled' quarry landscapes, of which the chert quarries in Alta, Northern Norway, are outstanding, also because they feature one of the world's best examples of skilled, prehistoric use of fire-setting as a key extraction method.7

The Stone Age was also a period of highly crafted stone axes and adzes. Not all rocks are usable for this purpose. The rock must be hard but not brittle, leaving out most granites and other quartz bearing rocks. People soon focused on specific rock types: metamorphosed diabase and other volcanic rocks of similar composition. Certain areas with the right rocks became important production centres, in a very similar way as on e.g. the British Isles (Great Langdale ‘axe factories’) and in the Alps. One centre is the island of Bømlo, where greenstone from islets in the west became an important resource for axe production8.

These Stone Age industries did not create large-scale quarry landscapes. Traces of the exploitation may even be difficult to see for laypersons: Prehistoric people made small bonfires on the rocks to make them crack, and then they worked the pieces obtained with hammerstones. However, even though the actual quarries are modest, we should not look at the physical dimension of the landscape only. These sites were important; they were part of interregional trade networks and may have had strong symbolic significance. The relationship between these quarries and prehistoric culture as a

The Bronze Age (1800-500 BC)

With the advent of metal, production of stone tools did not simply cease, but gradually died out in favour of bronze. In many parts of the country, especially in the high north, bronze only had a very minor impact. Although few Bronze Age quarries have been found, we have to anticipate that the traditional stone resources continued to be used.

Grave mounds built from local rubble are known from the Stone Age, but it is in the Bronze Age that they gain momentum, as in other parts of Europe. And although we have very little information about actual stone quarries, it is clear that Bronze Age people were the first to employ stone on a monumental scale - in the grave mounds, and particularly as large, quarried and carved slabs of marble, sandstone and other rocks that could be split and worked into rectangular pieces. They were used for building the burial chambers.

Some of the best examples are found in the grave mounds of Central Norway (marble, sandstone), and the most intriguing, huge stone slabs may also originate from sandstone deposits north of Trondheim: Very similar stone can be found as large slabs in the famed Mjeltehaugen mound in Møre and Romsdal county, decorated with the rock art of the time. This may imply shipping of the stones along a several hundred kilometres long coastal route. It is a reflection, though faint, of the building

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of roughly contemporary monumental stone architecture further south (think of long-distance transportation of sarsen stone and bluestone to build Stonehenge).

Soapstone quarries of the Iron Age (500 BC-AD 1000)
Living mainly on hard and crystalline bedrock, people soon appreciated the numerous, small deposits of the soft soapstone, ‘democratically’ distributed all over Norway. Soapstone is the softest of rocks, you can scratch it with your fingernail, and in addition it has some vital properties.

Soapstone is composed of the mineral talc (which gives us talcum) and carbonates. Often, serpentine or chlorite may be present. Easily quarried and carved, soapstone can resist heat and when heated it can keep hot for a long time.

But there are indeed many soapstone deposits across Norway, exploited in different periods, all the way back to the Stone Age, when heavy clubs and delicate figurines were also made from the stone. We have no information about quarries from the Stone Age and Bronze Age; yet we know of a fantastic quarry from the early Iron Age (200-500 BC), situated in a high mountain area in Central Norway. It was excavated in the 1980s and again around 2000. The excavations uncovered a remarkable story. The quarry was probably used for a few hundred years only, and the visible quarry marks from the extraction of soapstone vessels and presumed moulds (probably for casting bronze) revealed a remarkable industrial scaled production with a very high level of standardization. Its location is also interesting, situated in an inland, high mountain area, traditionally thought of as ‘off the beaten track’. But the quarry is actually close to important ancient overland transportation routes and may also be seen in connection with exploitation of several other resources, in particular reindeer hunting and bog iron production, perhaps even copper mining (though for the latter there is as yet no evidence).

Later, soapstone quarrying took place in many areas, often closer to the coast. Better boats made it easier to move along the coast. Numerous quarries reflect the need for soapstone, in particular for cooking pots, in the Viking Age and Middle Ages. During the 12th century, there is also an increase in quarrying for production of bake stones (thin slabs to make flat bread); first in the well-known material soapstone, later in rocks more suitable for producing thin slabs without breaking when heated. Such talc-bearing greenschist quarries were large industrial sites during the 13th century, and in particular, the SW coast near the Hardangerfjord became an important centre of production, leaving a significant quarry landscape.

The Medieval builders (AD 1000-1537)
Stone rubble was traditionally used to make grave mounds, hill forts and all kinds of dry stone walls in Norway, but the art of making fine stone architecture with ashlar, mortar and decoration was introduced only together with Christianity in the 11th century. European-style churches and monasteries were supposed to be built of stone. So, where to find the resources? The soft soapstone got a new role to play, this time in buildings. Many quarries, especially those close to the sea, found new values. They were turned into large production sites; the need for fine stone to erect the numerous buildings was continuous from the late 11th century until the Black Death (1349-50) and to some extent to the early 16th century. But also other rock types were quarried; limestone, marble, sandstone, depending on the local resources available.

The Nidaros Cathedral in Trondheim, Central Norway, was raised in the 12th and 13th centuries. It was built of soapstone, soft greenschist and marble for finer masonry, and gneiss rubble for filling inside the walls. The construction left not only the northernmost Medieval cathedral in Europe, but also quarries spread out over a large area, some of them grew to large production units, Hence, the quarry landscape related to this cathedral alone is huge, and the knowledge about the quarrying and

11 Skjølsvold, A. 1969: Et Keltertids Klebersteinsbrudd fra Kvikne. Viking 201-238
logistics clearly add value to the monument itself. After several hundred years of neglect, restoration of the half-ruined cathedral started in 1869. In the hundred years to come, stone was taken from 70 quarries across Norway, creating a second ‘cathedral quarry landscape’. Many of these quarries have significant heritage values.

Rotary querns and millstones: quarry landscapes and cultural change

The rotary quern was introduced to Norway during the Roman Imperial Period (AD 1-375). But it took several hundred years until it became a regular item in normal households and from AD 700 on, almost every quern, and later the larger millstones, produced in Norway was made of a specific rock type with good properties for the purpose: mica schist with nodules of harder minerals, predominantly garnet. Due to the mixture of soft and hard in these metamorphic rocks, which occur many places in Norway, the quernstones and millstones could wear in use and still maintain a relief allowing the grains to pass between the upper and lower stones.

![Image](image)

Fig. 2: Selbu, Central Norway, is a good example of a millstone quarry. From the Medieval period to the early 20th century millstone production left around 1300 quarries covering a distance of 30 km. The area contains a rich heritage from the production, logistics and the sustenance of the people involved in the quarrying, and provides a key example on how farmers, through hundreds of years, developed a unique outfield industry. Photo: T Heldal

From the early Viking Age (around AD 800) quern and millstone production took industrial proportions, an industry that lasted for 1100 years, utilizing the same material. The huge quarry landscapes left are valuable examples of how the interaction of humans and geological resources can

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survive through enormous changes in society. The Hyllestad millstone quarries\textsuperscript{13}, on the west coast, display almost 600 quarries\textsuperscript{14} worked from AD 700 until 1929. Quern- and millstones were carved directly from the bedrock, leaving circular 'scars' on the rock surface. The site forms now a part of a serial nomination of Viking age world heritage sites.

Hunting for the precious marble - Baroque quarry landscapes
From the 14th century until 1814, Norway was in union with Denmark and shared the king in Copenhagen. There are no marble deposits in Denmark so in the 18th century he initiated a hunt for marble in Norway. Marble was an attractive resource, important in displaying wealth and power, just as in the Roman period. The search led to marble production in SE and SW of Norway, almost every block of which went to Denmark and royal constructions, including the Marble Church in Copenhagen\textsuperscript{15}.

Some of these quarries are still well preserved, but most have been destroyed by later lime production. They constitute an important background to Copenhagen's architecture and are candidates for protection and even possible resources for future restoration and to care for this architectural heritage.

Get yourself a decent roof! Of slate.
We know that roofing slate was used already in the Middle Ages, but it was not until the 18th century that production grew to be a significant industry in Norway\textsuperscript{16}. Most of the roofing slate is not actually slate in geological terms, but rather schist that could be split to slabs of different thicknesses. There are numerous quarries all over Norway displaying the history of roofing slate (and, later, for paving and other building products), and in some areas the quarries compose vast quarry landscapes with hundreds and even thousands of quarries. The Alta quarry landscape is one example covering many square kilometres where more than 1100 quarries have transformed the landscape during 150 years of production It is still going on, and even the tradition of organising the quarrying as a cooperative enterprise is alive. Other important quarry areas include Oppdal, Otta and Hardanger.

Industrial revolution in the quarries
The industrial revolution introduced technology for efficient production of granite and other hard rocks. This took off in Norway in the last part of the 19th century, and quarry landscapes were formed around the larger cities: Pink granite and syenite in Oslo, gneiss and granite in Bergen, hard sandstone in Trondheim and white marble in Ålesund. In this period, some quarry areas grew very large, involving hundreds of individual quarries\textsuperscript{17}. By 1900 as much as 5000 people were employed in this particular granite industry. The stone was used not only in Norway, but also exported, and one may find it in harbours of South Africa, streets of Buenos Aires or the facade of the Ritz Hotel in London.

Another example is larvikite, a widely used syenitic rock displaying a bluish play of colour in the feldspar crystals. Quarries grew all over the area near the town of Larvik in the southern part of the country\textsuperscript{18}.

\textsuperscript{15} Jansen, Ø. & Heldal, T. 2003: Marmor fra de Lillienschioldske marmorværker i de danske slottsanlegg. Årbok for Bergen Museum 2002, 52-58
\textsuperscript{16} Helland, A. 1893: \textit{Tagskifer, heller og vekstene}. Norges geologiske undersøkelse 76, 178pp
\textsuperscript{17} Oxaal, J. 1916: \textit{Norsk granitt}. Norges geologiske undersøkelse 76, 220pp
Fig. 3: The large scale quarrying of grey Iddefjord granite in SE Norway for building and paving stone increased significantly towards the end of the 19th century, leaving a quarry landscape measuring many tens of square kilometres. Photo: T Heldal

Fig. 4: Modern larvikite quarry, SE Norway. After almost 150 years of quarrying, numerous exhausted quarries define a unique monumental landscape, together with the large-scale quarries still in use. Photo: T Heldal
Marble quarrying has also been important over the last 150 years. Around the town of Fauske, Northern Norway, a centre of marble production was initiated in 1879, and the marble soon became world-renowned, in particular as regards colour and technical quality. It was extracted using state-of-the-art technology, including large-scale wire sawing. Some of the numerous marble quarries in Norway are now unique historic sites.

Quarry landscapes and cultural change
Studying quarry landscapes through time give us important insights into everyday life, technology and knowledge in the past. With querns, millstones and vessels, they tell us an important part of the history of food production in Norway - and that the Vikings were not just warriors and boat-builders, but also developed highly skilled stone crafts. The quarries tell us much about Medieval stone building and the geological skills of the Medieval mason. They tell the story of industries in rural areas, as well as the hunt for prestigious marble for the privileged classes. Moreover, they are an important part of the industrialisation and the growth of national architectural expressions.

Protection and conservation
The national legislation on cultural heritage in Norway automatically protects sites older than the Reformation (AD 1537). This has secured the protection of many ancient quarries, especially those from the Stone Age until the Middle Ages. But many more Medieval and early-modern quarries are lost or have little protection, despite the fact that recent research and mapping projects have revealed many quarry landscapes of high value. Few are included in the official registration database of the cultural heritage authorities. Hence, time has come to use the new knowledge to make an overall registration and conservation plan for the Norwegian quarry landscapes. But in order to efficiently protect quarries from destruction by modern development, we also need local involvement, as well as new ways of communicating the significance of old quarries to the public.

As regards the latter, the best we can do is to make key quarries available by trails and signposting or as outdoor museums. There is presently only one outdoor quarry museum in the country, the ancient millstone quarries in Hyllestad - a landscape that is nominated as a World Heritage Site. This nomination is of great importance not only for communicating the significance of the millstone quarries, but also as a means to put all the other quarry landscapes on the map.
Quarries as ‘memorials to the unknown labourer’: the slate quarrying landscapes of Gwynedd, Wales, David Gwyn

In her Welsh-language novel *Traed Mewn Cyffion* (‘Feet in Chains’), published in 1936 but describing events that are meant to have taken place between 1880 and 1914, the author Kate Roberts, a school-teacher and publisher, vividly describes the life of the slate-quarrying communities of her native Moel Tryfan – a cultured generation, but also tough and independent-minded, as the novel makes clear. Jane Gruffydd, the main character and narrative voice, the wife and mother of slate-quarrymen, muses on:

... the quarry and its tip crawling down the mountain like an adder. From a distance, the slate waste looked good, shining in the sunlight. This was the quarry where Ifan’s father had been killed. Who emptied the first rubble wagon over that tip-end there? He was in his grave by now, that was sure. And who would be the last to tip a load of rubble over the top? And what was the use of dreaming like this? ... There was something sad in the whole prospect, the quarry, the village and the mountain all mixed up together.

The quarry she sees was one of many places in Gwynedd (north-west Wales; the Snowdonian massif) where slate was worked, to be processed into roofing elements and to be exported all over the world. By the end of the nineteenth century, the industry employed about 16,000 men. Slate quarrying was, in the main, very skilled work. A good quarryman needed to develop an understanding of the fissures in the rock face in order to drill and fire the charge-holes in such a way that would detach a workable block with minimum waste. Pushing a wagon of waste material along a railway to a tipping cob, by contrast, was the task often given to those who were too young, or insufficiently skilled or well-connected, to join one of the comparatively well-paid companies with whom the managers would strike a bargain to work the rock.

As Kate Roberts well understood, the landscapes of quarrying are evolved over time; they are created by the work of those who have no other memorial, and whose names can be forgotten even in a close-knit community like a Welsh village. It is now many years since the last wagon was pushed to the end of the tip but Jane Gruffydd’s musings illustrate a fundamental truth about quarrying, which is that its landscapes have been created by the active participation of its people – by their hard work over many generations, and by the skills they developed. Waste-tips and debris form an important part of these landscapes for this reason.

In this paper I wish to explore some of the problems which face any attempt to valorise a heritage such as this. A theme which has long been clear to all of us who have an interest in the history and archaeology of quarrying is that often the sites are undervalued at local or regional level, as places were ordinary people worked at unremarkable jobs. By the same token, some of the essays presented at Teruel in 2014 confirmed that national agencies are often no more helpful. Many jurisdictions throughout the world require that quarries, once they cease to be used, be ‘returned to nature’ or some such formula, and landscapes in which people have invested their labour and which may be rich in industrial archaeology are for this reason frequently effaced.

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Fig. 1: Alexandra quarry, Moel Tryfan, viewed from the air, showing the quarry pit and the tips of waste slate. Photo: Crown Copyright, Royal Commission on the Ancient and Historic Monuments of Wales
Clearly, not every such site will be of particular significance, and disused quarries certainly pose problems of health and safety. But it is remarkable that quarries have barely been considered in any systematic way as valorised heritage, which is one reason why the 2014 Teruel conference was so significant. Although sources of quarry-stone for high-status architectural and sculptural ensembles and élite buildings have been identified within World Heritage nomination documents (which are all already well represented on the list), no site has yet been inscribed by UNESCO specifically as a cultural landscape of quarrying. A significant thematic gap therefore remains.

What I wish to suggest here is that the European Network of Quarry Landscapes initiative can develop an insight of Dr Elizabeth Bloxham and Dr Tom Heldal, which is that quarry landscapes can be considered as ‘the memorial to the unknown labourer’ thereby authenticate the ‘human experience of industrialisation’. Their valorisation of the third millennium BCE stone quarrying in Egypt’s Northern Faiyum Desert, one of the world’s oldest ‘industrial’ landscapes created by large-scale stone quarrying, acknowledges the concepts used in the nomination of the Blaenavon industrial landscape in South Wales as a World Heritage Site. As they state, the global significance of Blaenavon was made broadly accessible by claiming some innovative ‘world firsts’, in early railway technology and in the production of mild steel, but the essence of the nomination:

... was how mundane features, within a transformed landscape, were articulated as having ‘outstanding universal value’. The components that make up the distinctive character of the Blaenavon industrial landscape were shown to have been shaped by large-scale raw material exploitation linked to the Industrial Revolution, which created an arena of the ‘human experience of industrialization’. The human dimension and social implications are foregrounded as demonstrating the ‘co-existence within it of heroic and mundane structures as the setting for profound developments in human cultural values’.21

The robustness and utility of the concepts developed for the Blaenavon World Heritage nomination are demonstrated by the fact that they can be applied as readily to an ancient quarry environment as to a landscape from the classic industrial period of the eighteenth and nineteenth centuries. In stone quarrying terms, we can say that although elites create a demand for stone, and invest capital in an undertaking, and that geologists, engineers and technicians invest their knowledge, what is crucial is that workers invest their craft skills, perfected over many years, their physical strength and often also their lives. Using the slate industry of North Wales as an example, another industrial landscape from recent times (indeed, still in process of evolution), how might we recognise quarries as ‘the memorial to the unknown labourer’?

Perhaps the word ‘labourer’ needs some refinement. Welsh slate was not alone among quarrying industries in maintaining a strongly hierarchical distinction between skilled workers and those whose contribution was primarily muscle. Often the latter were newly arrived immigrant groups; in the slate industry they tended to live in the more distant villages of the area and might retain some connection with the land by farming a smallholding, or were the men who had to live by the week in the discomfort of a quarry barracks. The varied settlement pattern of the Snowdonian landscape provides some clues here – not only the barracks themselves but also the mixture of small nucleated villages, of raw but distinctly urban environments like the towns Bethesda and Blaenau Ffestiniog, and of scattered fields, smallholdings and cottage dwellings, as well as the roads and railways which enabled many quarrymen to stay on the land and to commute to work. This is one reason why it is important to consider the whole social dynamic of ‘the quarry, the village and the mountain’. By the same token, perhaps we should also include the homes of the wealthy and powerful who owned the quarries. The neo-Norman extravagance that is Penrhyn Castle, home of the Douglas-Pennant family, lies within sight of Penrhyn quarry, and the contrast between them well illustrates the social gulf the industry fostered, and the bitterness that focused the bitter labour conflicts between 1900 and 1903.

Fig. 2: Penrhyn slate quarry. Photo: Crown Copyright, Royal Commission on the Ancient and Historic Monuments of Wales
The sheer scale of many Welsh slate quarries and the physicality of the sites also express the physical strength and craft skill needed to work them. Penrhyn quarry was perhaps the largest of all; this aerial view shows the present-day focus of working high up on the hill-slopes, but it is sobering to recall that the older part of the site, now partly flooded and effaced by a tip, was created from the 1780s to the 1960s mainly by hand-drills and black powder. Until recently there survived all over the quarry the remains of gwaliau, literally 'lairs', three-sided cabins where the slate blocks were hand-reduced, first by skilfully applying a heavy wooden hammer, then with a plug-and-feathers, and finally split with a chisel into thin sheets and trimmed square with a knife (figure 3). Here and at the rock-face the quarryman remained in charge, or at least had his own space. From 1900 onwards, once the quarry acquired an electricity supply, these had come increasingly to be displaced by large mechanised sheds, where no doubt the workmen felt that they were suddenly required to work on the manager’s territory and on the owner’s terms.

Managerial control and patrician investment are most eloquently exemplified in the huge quadrangular engineering workshops built for Assheton Smith’s nearby Dinorwic quarry in 1870, a striking blend of citadel and court. Now the National Slate Museum, the ‘yard’ as it was always known, with its central doorway and clock and bell, left workmen in no doubt as to who was in charge. Structures such as this are easy to understand in terms of valorised heritage precisely because of their heroic but forbidding mien, yet they only represent part of the story and need to be understood in terms of the overall dynamic of the work-place.

Fig. 3: Trimming a roofing slate with a knife; a view from the mid-twentieth century. Craft skill remains at the heart of slate-production in the quarries that are still being worked, even though some elements of the process have been mechanised. Photo: Crown Copyright, Royal Commission on the Ancient and Historic Monuments of Wales
The evident political and religious liveliness of Welsh quarry workers’ communities is reflected in the infrastructure that sustained them. Libraries, reading-rooms and above all the huge, often lavishly decorated, nonconformist chapels with their associated school-houses tell this story. The quarrymen’s dedication to culture is also evident in the most apparently un-heroic yet nevertheless inspiring structure, the caban, a hut or a worked-out chamber of which many examples are to be found in practically every slate quarry. Here quarrymen would meet at midday not only for food but also for discussion, to debate or to listen to music and poetry, under the watchful eye of an elected chairman. This was where collections would be raised to help a sick or injured workmate, or where a concert might be arranged to help a promising young man leave the quarry to pursue his studies at university or theological college.

It is also, I suggest, important to bear in mind that when we look for memorials to the quarry worker we take an international view. The readiness of quarry workers to move from one part of the world to another, taking with them not only their way of life but also their prized knowledge of a particular type of rock and how to work it, is attested from Prehistory. This can be identified in the archaeological evidence for the journeys they undertook, such as Roman shipwrecks where masons’ tools have been identified. In terms of the slate industry of Gwynedd, there is abundant evidence from documentary sources for emigration to the slate-quarrying areas of the United States. There is archaeological evidence also, such as the hamlet of Coulsontown, Delta, where houses survive that were built by Welsh quarrymen on the pattern of the stone cottages of Gwynedd— and as such totally unlike the prevailing timber idiom that Europeans arriving in the USA generally adopted. The small slate industry of Ireland is also known to have depended on managers from Wales, and here the visible evidence includes the engine house and bastion for a distinctly Welsh ropeway system at Killaloe quarry in Co. Tipperary base, and, in the nearby church yard at Castletown Arra, a Welsh-language gravestone for one Griffith Parry, who learnt his trade at Penrhyn quarry in Gwynedd.

The Nara document on Authenticity emphasises that the respect due to all cultures requires that heritage properties must be considered within the cultural contexts to which they belong. This is particularly important in the circumstance of any landscape shaped by the participation of non-elite populations, where many individual features will not be monumental, but perhaps also in their own way heroic. Jane Gruffydd and her family, earning a difficult living on the slopes of Moel Tryfan embody a quiet and unremarkable heroism that can endure hard and dangerous work. It is in this sense, I suggest, that quarry landscapes form a powerful memorial to the unknown labourer, when read with understanding, and interpreted knowledgeably. Valorisation of quarry landscapes reminds us that the mundane is often the most truly heroic.

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Figure 4. The quarryman as hero; the memorial to the men of Pen yr Orsedd quarry who served in the two world wars shows them both at work in the quarry and in the trenches. This part of the carving shows a group of quarrymen are at work in a mill. Photo: Crown Copyright, Royal Commission on the Ancient and Historic Monuments of Wales

About the author

Dr David Gwyn is an industrial archaeologist and a heritage consultant. He was editor of Industrial Archaeology Review from 2002 to 2010. His two most recent books are Gwynedd: Inheriting a Revolution: The Archaeology of Industrialisation in North-West Wales (2006), a discussion of the archaeology of his native north-west Wales in the post-Medieval period, and Anjou and Gwynedd: Slate Landscapes (2013), a comparative study of the two major slate-producing regions of the world, encompassing technology, social structures and heritage.
Historic black shale quarries of Foz-Côa, Northern Portugal, Luís Sousa, Mauro Búrcio, José Lourenço and Alcino Oliveira

Our species has always extracted and used geological resources, which has developed according to the technical capabilities and the architectonic solutions. As a consequence, areas of exploitation have grown up with damaging effects on the land occupation and, sometimes, the ancestral techniques and the traditional products became ignored. With the increase of stone production and the globalization of the economy, exploitation is controlled by the requirements of consumers located far away from the extraction area, sometimes leaving the local population with no more than the related environmental problems. Geological stone resources may not be considered as good despite their quality and international demand. Local authorities with competence in the authorisation of public and private works should encourage the use of local products. Only in this way can the geological resources be cared for and preserved through generations.

In this article, the geological characteristics and heritage values of the schist quarried in Vila Nova de Foz-Côa, in northern Portugal, are presented. Considering the singularity of this material and its historic, social and economic importance, these quarries can potentially be a heritage site. A first approach to the major characteristic of this quarrying landscape is presented.

This rock has been exploited in the past to obtain vineyard supports used in the cultivation of wine in the Douro Valley, the oldest delimited wine producer region of the world, classified as a World Heritage Site in 2001. The characteristic landscape with its narrow terraces constructed with the local stone is a fundamental reason for the inscription of the Alto Douro Wine Region on the World Heritage list:

> The most dominant feature of the landscape is the terraced vineyards that blanket the countryside. Throughout the centuries, row upon row of terraces have been built according to different techniques. The earliest, employed pre-Phylloxera (pre-1860), was that of the socalcos, narrow and irregular terraces buttressed by walls of schistose stone that were regularly taken down and rebuilt, on which only one or two rows of vines could be planted. (UNESCO inscription document)

Geographic and geological setting

The area where the schists of Foz-Côa are exploited, known as Pedreiras do Poio, is near the village of Vila Nova de Foz-Côa. This area is located inside the Vale do Côa Archaeological Park [http://whc.unesco.org/en/list/866], classified as World Heritage by UNESCO since 1998.

This area is part of the geomorphologic province called Meseta Ibérica. In the region, the geomorphology is conditioned by a huge tectonic accident with NNE-SSW strike, the Vilariça Fault, located 5 km western of the quarrying area. This structure is well marked in the Longroiva graben, it continues to the north through the Vale da Vila, near Vila Nova de Foz-Côa to the west, crosses the Douro River in Pocinho and follows to the north, into Spain.

The Vilariça Fault shows a horizontal displacement of about 5.5 km and splits the region in two great blocks. The western block ascended about 300-400 m after the Vilafranquian [4], is already extremely dissected by the erosion. The eastern block, where the quarries are located, is less eroded and still preserves the Ordovician in the synclinoriums of Castelo Melhor.

The quarries are located in the border of a WNW-ESE elongated hill, with the high zone resulting from the continuity of the Foz-Côa plateau NW from quarried area. In the quarrying area this plateau with 360 m height is indented by two water courses with strike WNW-ESW that flow into Côa River at 125 m level. Near the Côa River the water courses are very well-marked and the valley in general is steep.

Evolution of the exploitation

European Quarry Landscapes Network
The ancient techniques were based on human force, because the rock mass was explored and reduced using hand tools. The waste from ancient quarries is still visible and it can be seen that the fragments have small dimensions.

If in the past one of the noblest applications of this stone was for the vineyard, now this market is marginal. Cheaper materials are used in new and renewed vineyards plantations. On the other hand, as the area of vine cultivation has not increased and as this material does not deteriorate at a human time scale, the market for this type of product is low. It can be said that this material is a victim of its own success, as it is indestructible there is no need for it to be repaired.

Nowadays with modern equipment and techniques it is possible to extract large rocks blocks that are processed into the desired products. However the ancestral techniques are still used take advantage of the rock structure. The current production of the Fôz-Coa schist is mainly oriented towards rustic flooring, slabs, kerbs and wall covering, and more recently the stone is sawn in order to produce brushed, honed or polished surfaces. Its use for decoration in gardens and parks is also increasing. The production is almost entirely for export, mainly to European countries with rigorous climates where this stone keeps intact its mechanical properties. About 90% of production is exported and the current production capacity cannot satisfy all orders. The reserves of this type of stone are very large in this area.

The massive exploitation has the inconvenience of requiring larger areas and so now, instead of the tens of quarries that existed in the past, there are only three. The associated environmental impact is also higher, mainly linked to the increase in the volume of material deposited in waste heaps.

Heritage values
These quarries preserve an academic geological, natural, economic and human/industrial heritage. In these quarries geological structures, sedimentary sequences and metamorphism have combined to make the site unique, which also represents the opening and closing of a primitive ocean.
The heritage values of this area are linked with the quarrying activity in the last centuries. Until a few decades ago the extraction was done only with human force, without any mechanical aid. This ancestral technique is still used nowadays but must be preserved as a unique remark of ancient times. Thousands of posts are still used in the vineyards of the Douro valley, reminding us of its origin. In fact the oldest historic document about this material is related with the use of this material in the vineyards.
Work in the quarries was a livelihood in a very poor region where large landowners controlled the manual labour. However, the type of work and the conditions were not very nice, as you can imagine. Some historic documents, especially photographs, show working conditions and the mode of transport, by boat along the River Douro or by train. It was precisely the train that facilitated the spread of this rock throughout the Douro valley. Although the main use is for the vine cultivation, this rock can be seen in many historical buildings of Nova de Foz Coa village.

World Heritage site
The preservation of the old quarry sites must be accomplished as a memory of the human evolution. Many of these old quarries were recovered by the new ones in the main quarried area; however there are other old quarry sites with a high heritage value. The impressive open pits are the memory of centuries of a continuous labour where the evolution of the exploration by our ancestors can be seen.

Fortunately the present quarrying areas do not affect these ancient open pits that still preserve their complete form. These areas must be preserved as they are, avoiding illegal dumping of rock waste from others quarries, scrap or old tyres. The current threat is forgetting the meaning of these ancient mining sites, as the years pass and the workers who toiled here are dying. Without memory, any heritage can be preserved.

The creation of a museum should be considered in order to preserve the memory of this activity, since recent technological developments have changed in a radical way the extraction techniques and the types of products obtained. This area needs to be promoted by guided visits and so take advantage of the tourist dynamics associated with the rock carvings of the Archaeological Park of the Côa Valley and wine tourism the valley of the Douro River.

The next step of this work is already going on with the support of the local municipality which is engaged in the preservation of this exceptional heritage. The goals are: to identify all the ancient quarries; to explain the technological evolution in quarrying; to explain how the products were transported to the vineyards located dozens or hundreds of kilometres away from the quarries; and finally to know the economic and social importance of this activity; to promote this region.
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Further reading
Welcome to Madrid’s Parque Regional del Sureste - South-East Regional Park. The Park lies around the axis of the lower courses of the Manzanares and Jarama rivers, and belongs to the Community of Madrid Natural Protected Areas Network. The total surface area is 31.550 ha, distributed along 16 municipalities to the south-east of the city of Madrid and is structured around the axis of some of the most important rivers in Madrid and in the center of the Iberian peninsula, the Jarama river and its tributaries Henares, Manzanares and Tajuña.

This Regional Park also contains several protected wetlands and is included in the Natura 2000 European Network, forming the Special Protected Area (SPA) ES 0000119 ‘Cortados y cantiles de los Ríos Jarama y Manzanares (Cliffs and ledges of the Jarama and Manzanares Rivers)’, and a significant part of the Special Area of Conservation (SAC) ES3110006 ‘Vegas, cuestas y páramos del sureste de Madrid (Meadows, slopes and moors of Madrid’s south-east)’.

In this densely inhabited area, an intense quarrying activity developed throughout the last century, mainly consisting in the extraction of gravel and sand from the Quaternary deposits accumulated in the river valleys. This excavation activity, developed below the water table, has generated a cluster of lakes and ponds in these valleys made up of more than 120 water bodies with more than 400 ha of surface.

As well as aggregates extraction, other mining activities have been historically developed in the Regional Park or its surroundings. Gypsum exploitation has been common in the area, and there are still some existing remains from an ancient salt exploitation dated from the 12th century, made up of an old mining gallery and a settling pool, called ‘Salinas de Espartinas’. Another important mining site located in the Park was the so-called ‘Minas del Consuelo’, in the municipality of Chinchón, in which glauberite (sodium sulphate) was extracted during the 19th and early 20th centuries, through the Room and Pillar method.

The South-East Regional Park was created in 1994 with the main objectives of protecting, conserving and enhancing the natural resources. The zoning in the foundation act established a quarter of the surface as an integral reserve in order to protect the main values of the area. It holds eleven habitats of European interest, four of them set as priority habitats with very important and unique botanical values. Within those habitats we can find some salt and gypsum steppes and shrub lands, specially adapted to the local arid weather and to the soil features.

The geomorphological features of the area hold the two main landscape units, the valley with the river, riverbanks and fluvial terraces, and the gypsum cliffs, edges and slopes. The high diversity of ecosystems allows the presence of more than 300 bird species, similar to what can be seen in other Spanish protected areas like the Ebro Delta, Doñana, etc. The main bird group is the conspicuous aquatic fowls but there are also steppe birds, forest prey birds, and some interesting cliff-dwelling birds. After decades of absence, otters have come back to the rivers because of the improved water quality, and other mammals like water vole or badger live in the territory.
With 400 ha of lentic water ecosystems and 87 km of river that formed more than 330 ha, the entire area has become an important though still very degraded wetland. Due to its situation in the centre of a dry area such as the Iberian Peninsula, a bridge land for birds between Africa and Europe, it has become an important spot in the migratory routes of many avian species. The importance of the area is increased by the fact of it being a permanent wetland, with no drought periods in very dry years as happens to other Spanish wetlands, so the South East Regional Park can offer shelter to thousands of birds in strong drought seasons.

In addition to these natural values, we must highlight the important historic and archaeological assets of the park, as this area has been intensely used by humans for thousands of years, especially in the fertile valleys.

This remarkable ensemble of values is still endangered by the intensity of human activity due to the proximity of big towns, and especially by urban development, infrastructure construction, illegal waste dumping, and the mining and gravel extraction activities which continue in the territory.

Nowadays, extraction below water level by new aggregates workings is banned, but the ponds created by the old ones, with a great variety of shapes, sizes and depths, still have to be, in a great majority, recovered or improved. The companies extracting the gravel have mandatory restoration plans, but in the older cases these are insufficient. In the more recent workings or in the old ones with new reviews of the restoration plan, companies are making strong efforts to make their work compatible with biodiversity and landscape conservation and enhancement. Anyway, this is the history of the area so in the environmental education centres within the Park the origin, extraction techniques, evolution and restoration works are shown since it is necessary to tell people what we have and how we manage it.

Main objectives in gravel pit restoration
Based on the mandate of the foundation act of the South East Regional Park, great efforts have been made in the last two decades toward the restoration of some of the ponds. However, only 15% of the land is publicly owned, and restoration in private land cannot be undertaken by the administration, so the works have been accomplished in only a few ponds by the regional government of the Community of Madrid.

As a result of the gravel extraction, gravel pit ponds have some features that hinder the establishment of valuable ecosystems, like too steep slopes in the shores and no soft transition between the shore and bottom of the lake, that often have depths above 15 m. In contrast with the natural wetlands,
usually rich in shallow waters, and sandy or silty areas with alternation between flood and drought, marshlands and reed vegetation, these lakes and ponds have scarcely any shallow waters and marshes, with instead a sudden transition between shore and bottom that doesn’t allow the lakes to hold either riparian forests or shrub lands nor valuable aquatic ecosystems.

Moreover, in the surroundings of the old workings, abandoned structures and buildings from the extraction activities are often found which have a deep impact on the landscape, creating danger for the visitors and also a source of pollution.

Although the main target of the recovery works is to transform a degraded area into a valuable and complex ecosystem with as many elements, species and ecologic niches and relationships as possible, and consequently an improved landscape quality, a second and also very important target is making these ecologic values compatible with an intense public use. Depending on the characteristics of each area, the present species and public use pressures, actions should be accomplished to manage this use like controlling accesses, creating picnic areas in the less sensitive points or setting bird watching hides in the appropriate spots.

So, when drawing up a gravel pit restoration project, especially when there are ponds in the area, four main groups of actions must be considered to achieve the goals of the restoration.

Treatment of old structures and remaining elements from the former activities like mining, agriculture, energy transport, etc. In most cases, demolition and debris removal will be the work to do, but sometimes these elements have a special historic, landscape or biological value (e.g., nesting places for some bird species like lesser kestrel or barn owl), and our actions must aim to consolidate and restore the structures, as at ‘Las Lagunas de Velilla’, dating from the early 1950s.
Earth movement and shore adaptation. Regarding the main objective, restoring the gravel pit as a naturalized ecosystem, this is the most important action and must be thoughtfully designed. It usually involves softening of slopes, creating winding margins and small bays, and even small islands when possible.

Other common actions are creating small beaches and shallow water areas to improve the habitat for waders, or of sheer shores for species like sand martins or the European bee-eater. Depending on the aquatic vegetation we want to get established, we may look for a specific depth. Very interesting species are those from the genera *Typha*, commonly called bulrush or cattail, which provide food, shelter and nesting places to many interesting bird species like purple swamp hen (*Porphyrio porphyrio*). Water depth for their good development is usually between 0,5 and 1,5 m, for with lesser depths bulrush can be replaced by common reed (*Phragmites australis*).

After reshaping the shores and surroundings of the pond, vegetation recovery is the next task. Adequate species and plantation techniques are important for the planting to succeed, but so are aftercare operations like watering in summer and some herbaceous plant clearing in spring. As some loses usually happen in such an arid climate, replanting of the gaps is important, too.

The last type of actions is related to the public use that is foreseen in the area, the impact that this use could generate and the public use management model we wish to set. As the Park is so close to big towns, some uncivil behaviour is common, including vandalism and waste dumping, so some restrictions to motor-driven access might be necessary, and vandalism should be taken into account when selecting places for other facilities like hides, informative panels, etc.
Depending on the extension of the area and the interest points and values, marked walking or cycling routes could be established and other elements like paths, resting places or benches.

The restored ‘Soto de las Juntas’ gravel pit
One of the most successful and paradigmatic cases of gravel pit restoration in the South East Regional Park is located in the ‘Soto de las Juntas’, in the municipal district of Rivas–Vaciamadrid, about 20 km from Madrid’s downtown.

This is a 90 ha land that was bought by Madrid’s Regional Government in 2001, and the first restoration project started in 2003. It has a 8 ha lake in the centre and is surrounded by the two main rivers in Madrid, the Jarama river and its tributary, the Manzanares river, both meeting at one end, a feature that confers to this land a special meaning in Madrid.

This highly degraded land was initially full of debris, and most of its surface was used for farming purposes, without leaving any space for the riverbank forest. As a result of the former quarry use, the remaining soil in the non-agricultural areas was strongly compacted and with a broken relief in some areas, not allowing natural vegetation to get established, and the shores of the small lake were too steep with straight borders.

Some previous studies aimed at better knowledge of the current flora and fauna so as to prevent possible damage to any sensitive species during the work. The first step was the demolition of a big old farm building and a useless electric line. Thousands of tons of debris were removed from throughout the area, some rural roads and paths were created or improved and a debris hillock against flooding along the Manzanares river was partially removed.

A very important reshaping work was to improve the coastal index, as shown in the picture, and creating sinuous shores with an increase in shore length from 1.173,60 m to 2.215,54 m, 1,68 ha of shallow water bays and three small islands. Shore slopes were softened when possible with the objective of improving the conditions for vegetation and wildlife establishment, and especially aquatic birds nesting. In addition to those along the lake shores, more earth movements were done to
improve the topography, to create a more natural relief and make the birth of natural vegetation easier.

Fig. 5: ‘Soto de las Juntas’ restoration works: reshaped shores and vegetal cover established. Photo: SERPDR

Once this was finished, establishing vegetation was the next phase. Two kinds of vegetal cover were designed: a dense vegetation frame in the pond’s shores, and a sparse vegetation cover in small stands in the surroundings, to create a more natural landscape able to hold a greater biodiversity.

However, as it is such a dry area, and there is such strong competition caused by herbaceous vegetation, it is hard to get these last kinds of vegetal cover established so a lot of plantation work is still to be done.

In addition, some measures of public use management were accomplished in that early phase. A barrier for vehicles, a parking area at the entrance of the state, and five bird-watching hides were the first facilities installed along with informative panels, and some roads and paths were improved.

It is estimated that about 80,000 visitors came to ‘Soto de las Juntas’ in 2013. This large number means that a strong effort in maintenance, cleaning and surveillance is constantly required. In addition, more plantation works have been done in the last ten years in other areas of the estate.
Fig. 6: ‘Soto de las Juntas’, September 2001. Photo: SERPDR

Fig. 7: ‘Soto de las Juntas’, May 2012. Photo: SERPDR
Some other actions are still to be done, like the adaptation of a small pond in the north end of the property to improve the reception capacity for amphibians, and the partial filling of the main lake for decreasing the depth in some areas, and the creation of new islands to improve the habitat of the aquatic birds.

The required financing for the accomplishment of these works will be sought in as many sources as possible, like the Community of Madrid’s budget, private companies’ donations, or European Funding from programs like Life+, Interreg, etc.

In conclusion, as decades go by, time erases or conceals the print of mankind’s actions, but a lot of human effort is required to make this change faster and satisfactorily directed, without forgetting that a lot of time is required anyway to get a natural ecosystem created or restored. Besides, it is also important not to forget that extraction activities, so important for the development of our society, are a part of our history as well as a permanent environmental alterations generator. Nevertheless, the awareness existing today about environmental issues benefits the adequate planning and general approach that can make extraction and nature conservation compatible.

About the author
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The Ruhr in western Germany has been Europe’s most industrialized region for more than 150 years. The coal and steel industry was based on the deposits of a large hard coal mining basin. Coal mining developed along the Ruhr valley from the south to the northern regions along the river Lippe. In 2018 the extraction of coal will come to an end because of political decisions within the European Union.

The Nachtigall or Nightingale colliery in Witten on the banks of the river Ruhr is known as the cradle of the region’s mining industry. But that’s not the whole story: three raw materials were found here in different layers lying on top of each other: coal, clay shale (Schieferton or Tonschiefer in German) and sandstone. They have been the basis for the long term success of this site, which has been in operation in a protoindustrial and in an industrial manner.

From the early 18th century (1714) coal was exploited by manual labour from small pits and galleries near the surface, which followed the coal seams. Then at the beginning of the 19th century thanks to new steam pumping engines the Nightingale colliery was the first in this mining area (the ‘Hardensteiner Revier’) to sink two shafts below the water table, named ‘Neptun’ (1832) and ‘Hercules’ (1839). In the end, the ‘Hercules’ shaft reached a depth of 450 m. The mine developed below and above ground and was worked in an industrial manner.

In the 1850s the aristocratic owner family von Elverfeldt sold the mine to the Dutch entrepreneurs van Braam and den Tex. Thanks to their investment the technical conditions could be improved and Nightingale became one of the most powerful and profitable collieries of the region. More than 500 miners worked here in 1855. Toward the end of the century large scale collieries were founded in the north of the Ruhr. When coal mining here became unprofitable, the mine closed down in 1892.

But the site started a new career when the entrepreneur Wilhelm Dünkelberg, a building contractor, took over the premises, connecting the Ruhr valley railway with a branch line. He erected two Hoffmann kilns for the production of bricks which were urgently needed at that time of rapid development of the region. For the raw material he used the local clay-shale deposits. Even in the 20th century, Dünkelberg continued his business with brick and sandstone to produce building stones. After the closure of these enterprises in the 1960s the place was then used as a scrap yard.

In the 1980s, the remaining buildings were protected as monuments and converted into a new type of museum, and the Westfälisches Industriemuseum, the Westphalian State Museum of Industrial Heritage, which was founded in 1979, took over the site. The Nightingale coal mine is one of the eight former industrial sites which constitute museum, the largest museum of industry in Germany, whose mission is to communicate research and preserve the culture of the industrial era from the earliest years to the present day. The two Hoffmann kilns and a square chimney have been preserved and now contain exhibitions about mining and brick-making. The pithead under one of the kilns has been excavated and become part of the exhibition. The engine house has been re-equipped with a MAN steam winding engine from 1887.
For most of the visitors, the Nightingale gallery is a special highlight of their visit. Built by the entrepreneur Dünkelberg at the beginning of the 20th century as a way to transport the clay-shale, it is now open to visitors. Furthermore it has been connected to the remaining mining galleries from the 19th century, which can be visited as well. Parts of the galleries are used as an exhibition area to show the mining world below the surface and young miners are also trained at this special place. Furthermore, visitors can watch and touch an original coal seam.

Focused on the history of this place the visitor can experience the different steps of industrialization, re-use and de-industrialization in the Ruhr area. Up till now the museum is able to exhibit coal extraction and brick-making in their original places.

A new exhibition: sandstone from the Ruhr

Three minerals have been typical for the development of the Ruhr region. The coal is accompanied by both clay-shale (for brick-making) and sandstone, and the way the local stone was exploited by the families which owned our site shows clearly how it was used. The private quarries along the riverside were a central part of their business until the 1960s. So, for example, the von Elverfeldt family built their castle and later the mine buildings and the traffic routes with the Ruhr sandstone of their quarries. In the early 19th century they owned three sandstone quarries and they employed some engravers. They produced posts, grinding stones and millstones as well as sleepers for the construction of the early railways. In the 20th century, Dünkelberg sold the stone for buildings, the construction of roads and engineering structures.
In the early 20th century even concrete structures were covered with sandstone masonry. And last but not least, the stone was used by the iron and steel industry as a raw material for fire-resistant linings for their furnaces. The local Ruhr sandstone was the best material to be found for construction purposes, because it is very strong - nearly as hard as granite - and resistant against sulphur acid from industrial pollution. So in the 19th and early 20th century dozens of quarries existed along the banks of the Ruhr.

The colour of the stone alternates between yellow/beige/brown and grey. It was used for building not only manors, castles and churches in the pre-industrial times but also for industrial buildings and transport infrastructure, such as road paving, walls of locks and railway viaducts (crossing the river Ruhr), tunnels and support structures. Until the 1920s, the erection of administration buildings (town halls) and monuments using sandstone was in fashion. Prussian officials talked about a ‘document in stone’ when they erected the lavish portal of a new lock on the Dortmund-Emms-Canal in 1914. So the sandstone has left its mark on the cultural landscape of the Ruhr Mining Basin, and even now it is ubiquitous.
Fig. 3: Former quarries stand behind the hydroelectric power station Hohenstein in Witten on the river Ruhr. Photo: © LWL-Industriemuseum/ A.Hudemann, 2011

Today only five quarries are still in production and the stone is used mainly for landscaping and the construction of terraces and walls. The stone is getting popular again and is now used mainly for landscape architecture and the construction of terraces and walls in gardens, but it is as well used for the repair of historic buildings and structures.

Fig. 4: The way to the new exhibition site in preparation. Photo: © LWL-Industriemuseum/ A.Hudemann M.Holtappels, 2011
A new exhibition at the museum, situated in front of the rock face of a former quarry with three exhibition rooms at the quarry site, is going to show the locations and history of the former quarries, and will include the work, the tools and machinery used in the quarry, the various objects made from the Ruhr sandstone, and the distribution and the use of the stone in architecture and construction. There is no better place to discover the rich history of the Ruhr sandstone. We are carrying out extensive research work to document for example the extension of the Ruhr sandstone within the industrial landscape of the Ruhr and to show its wide range of uses. The long tradition of quarrying and using sandstone in the region will be dealt with in terms of social and cultural history, geology, ecology and technical history, spanning the time from before industrialization until today and including its gradual disappearance. This will enable visitors to better understand how living and working conditions as well as the landscape in which they live changed over time.

Fig. 5: A tombstone for a miner who died in 1876 from an industrial accident. This is one of the objects made of Ruhr sandstone which will be shown in a “Lapidarium”. Photo: LWL-Industriemuseum/ Martina Weigl, 2011

Not many sculptors have appreciated the Ruhr sandstone, because of its hardness it is not easy to grind a smooth surface, although there are some good examples of gravestones and reliefs within the region. Today the museum invites visitors to experience the consistency of this kind of sandstone by organizing workshops for amateur sculptors. We can offer geological, minerological and ecological guided tours and the site is becoming an attractive and inspiring place for artists like painters or musicians.
A special feature to be found in the museum is the visible connection between geology and industrial production. All three minerals can be seen and touched at their original place and the deposits and their extraction can be experienced in the exhibitions. Near the museum’s site, a rock face created by quarrying shows a unique geological situation, protected as a national geotop: different strata of sandstone, clay-shale and coal seams, typical for this area but almost invisible underground.
The Ruhr GeoPark
The Nightingale Coal Mine Museum is an essential part of the central visitor centre, the Ruhr GeoPark. ‘GeoPark’ is an international label, which also protects and interprets geological sites all around the Ruhr area (4,500 sq km). The most important is the National Geotop at the Nightingale site. The Ruhr GeoPark has been developed as the first Geopark in the world which is situated in a conurbation based on the mining history. The visitor centre is interpreting the history of earth, geology and the use of minerals in this region. Visitors can discover a GeoRoute on their own or take part in guided tours. Some old quarries form part of the GeoRoute because the excavation of the stone opens windows to the history of the earth: the Carboniferous era 300 million years ago.

About the authors
Ingrid Telsemeyer is Senior Curator, LWL-Industriemuseum, Westfälisches Landesmuseum für Industriekultur, Dortmund.


Further reading
Creutzenberg, Willi: Die Steinhauer in Herdecke, Herdecke 1995


Ingrid Telsemeyer (Hg.): Zeche Nachtigall. Museumsführer, Essen 2005
The cultural project of the Lithica Pedreres de S'Hostal, Menorca, José Bravo

Menorca, the northernmost Balearic island, has two clearly different parts from a geological point of view. The northern half is composed of strata from the Palaeozoic, Triassic, Jurassic and Cretaceous periods, and the southern half of calcarenite from the Miocene, called marés in Menorca, very easily-worked sandstone used by man since remote times.

In the Menorcan landscape, stone is always present in the form of piled stone in livestock huts or as the walls zigzagging the whole surface of the island, as sculpted stone in megalithic monuments as well as in modern buildings.

The great abundance of sandstone, and the fact that it is very easy to quarry and work, have made this kind of stone the first building material in the island, in country houses, village houses, small palaces, mansions, military buildings and churches.

Sandstone quarries: a landscape in negative
The continuous use of sandstone through history has left a number of quarries dug into the landscape of the southern part of the island, both in the form of small handicraft quarries or as huge geometric spaces created by mechanised quarrying.

Up to the late 1950s, sandstone was quarried with hand-tools: stone cutter (escoda), wedges and mallet. The quarryman followed the softest streaks in the stone, so the resulting quarry is an erratic space where the hardest parts of the stone remain —those the hand tools cannot cut—, forming columns, walls or terraces.

As the southern part of Menorca is flat, the quarries sink and form a ‘negative’ landscape: small ravines where, after the quarrying stopped, orchards were planted or the native vegetation returned.

The first machines for quarrying arrived in 1960 and they changed drastically the working style and its impact on the landscape. Radial arm saws mounted on a railed cart extracted the blocks of sandstone by making a straight and continuous cut, regardless of the stone’s hardness or quality.

In the 1980s, the increase of tourism brought a boom in construction, and as a consequence of the massive use of concrete blocks, many quarries shut down and became debris dumping grounds, since they have by law to be filled in. In 1983, the s’Hostal quarries were included in the catalogue of historical monuments in the nearby city of Ciutadella, which meant they were officially protected. But the protection fell into oblivion, and ten years later debris dumping started in the s’Hostal quarries.

LÍTHICA: a landscape project in the s’Hostal quarries
Quarrying finished permanently in 1994 and in that situation, the sculptress and architect Laetitia Lara created the Lithica Association (now Foundation), based in her final project of Architectural Studies in the University of Paris; she rented the piece of land where the quarries lie, and was awarded a grant to remove the debris dumped there. It was the start of the new project that defines the quarries as a sculpture in the landscape, made by human hands, and, although shaped by chance, it acquires its meaning because of the transformation of the landscape.

As time goes by, the quarry, an open wound in the ground, turns into an element of the landscape, a reminiscence of the former human activity. It offers a new insight of the space, anthropological as well as artistic, related to Land Art as a concept of shaping the landscape.
Fig. 1: The totem is in a section of the quarry marked by the meeting of hand- and machine-cut extraction. The change took place around 1960 and produced quarries like right-angled cubes sunk dizzily into the ground. Photo: Lluís Bertran

One of the core ideas of the project is to consider the s’Hostal quarries as a huge maze, developed over time, and therefore to create a series of connected spaces which have acquired their own personality through their history, their different uses and the work of Nature. This personality has been developed afterwards by the project.

The s’Hostal sandstone quarries, nowadays run by the Lithica-Pedreras de S’Hostal foundation, lie in the western part of the island, a kilometre from Ciutadella. It is about 50,000 sq m divided in two zones.

In the first zone there are several hand-worked quarries of the 19th and 20th centuries forming a labyrinthine net. Some of them were used as rain-fed orchards and some others were covered by the native Mediterranean forest. In the second zone there are two mechanically worked quarries, two cubes 40 by 40 m and 20 and 28 m deep respectively, in use until 1994 when they were permanently abandoned.

From the beginning Lithica has kept the quarries open to visitors – nowadays about 15,000 a year – while the project was developed. During the first years the main activity was to remove the debris and to improve safety for visitors. Protection walls were raised around the quarries and new paths opened. The deeper of the two mechanically worked quarries was cleaned of rubbish and since then it has been used for concerts, festivals and all types of events. The first were held together with exhibitions and information about the ethnographic, artistic and landscape value of the sandstone quarries, highlighting the need to maintain and protect these spaces.

Botanical circuit

In 2000, thanks to a European Union grant, a new project started to create a botanical circuit in the labyrinthine zone of the ancient quarries to exhibit the Menorcan native flora and fauna within the ethnographic frame of the hand-worked quarries.
After finishing the quarrying in one zone, the quarrymen used to level the debris left, cover it with a layer of soil, and plant a rain-fed orchard. The quarries are protected from the wind and so they keep the moisture in the soil. This micro-climate and the deep debris layer – in a zone in Menorca where soil is scarce – make ancient quarries optimal places to plant orchards.

A labyrinthine path links the ancient orchards where a selection of native plants is grown as a botanical display, following the ancient quarrymen's tradition of planting orchards in the out of use quarries.

Other parts of the quarries, due to the amount of debris piled up, were unsuitable for cultivation and there the native Mediterranean forest – *prasioletum*, basically a mixture of wild olive trees and a liana (*prasium mayus*) – has been growing spontaneously, together with the remains of ancient plantations of almond, pomegranate, carob and fig trees, and vines. The resultant forest is a mixture of natural reforestation and former human activity.

A small quarry, after being cleaned and waterproofed, became a pond to grow aquatic and riverside flora, which increases the diversity of the garden. A seedbed was built to ensure our own supply of native plants for the gardens and to reforest zones of the surface very affected by years of quarrying activity, by the winds and by scarce soil. The new forest that is growing up in these zones will form a protective barrier around the quarries.

As part of the project we displayed signs to show the names of the plants and posters to explain the flora and fauna living in the quarries and the different processes of sandstone quarrying.

The project has been growing and it has become a labyrinthine garden where the different gardens and wild zones are interspersed.
Fig. 3: In 2006 a Medieval-style symbolic garden was built in one of the ancient quarries, with medical herbs, old roses and fruit trees encircling a fountain. There the sound of the water reminds visitors of the silence of a cloister. Photo: Pacific Camps

Finally, in 2014, as a celebration of the 20th anniversary of Lithica, a Cretan style labyrinth made of native plants was built in one of the ancient quarries, a concentrated educational path which helps to show the native flora.

Environmental commitment
From the very beginning of the project the Grup Ornitològic Balear (Balearic Ornithological Group) was allowed to use one of the quarries to set up a centre for the recovery of the wild fauna in Menorca. The centre takes care of a large number of wounded animals which, once recovered, go back to Nature.

Thanks to a European programme and in cooperation with other associations, a series of seasonal ponds has been built for the recovery of the *bufoviridis*, an endangered species of toad. We collaborate with the University of Salamanca on a study about the *lacertapiperspiciliata*, a small lizard of North African origin, very abundant in the quarries. And during the last ten years we have been monitoring and ringing the population of the *falcotinunculus*, a hawk that nests in the quarries.

Modern quarries
In the modern quarries, the intervention has been different. As they are two huge cubes with flat walls and ground, the works have been done with the same techniques as the quarrymen in order to not alter the personality of the space. Once all the debris had been removed, a stage was built in the confluence between the hand worked quarries and the mechanised quarry, with the stone blocks quarried when levelling the ground.

To make access easier, the incline to the mechanised quarry was levelled and the steps turned into a ramp. The stairs to access the quarry were hand-dug in the rock, and finally, in 2014, a huge 24x24 m stone maze was built as a symbol of the 20 years of working in the labyrinth.

Lithica as a stone centre
We regard the quarries as sculptures in the landscape, as inverted architectural works created by men over the years. This is why all the works have been carried out, from the very beginning of the project, within the traditional ways of stone quarrying, and always with native sandstone, and by treating the space from the point of view of the rock architecture.

The reception house and the protective walls around the quarries have been built with sandstone blocks. Ramps and stairs have been hand-dug and sculpted in the rock. Most of the walls have been built by using the dry-stone wall technique, the traditional technique in Menorca. In order to gain an insight into this technique, an exhibition centre was built in 2013 to show the different techniques and types of stone used in the island.
Through the sculpture courses run in Lithica, we keep alive the traditional stone craftsmanship and we offer a learning-space for sculptors. The sculpture workshops produce sandstone objects that we sell in the reception house.

Lithica has taken part in different congresses and exhibitions; we have presented our project at the stone exhibition in Verona, in Villa Mayor (Salamanca), etc., and the Menorcan dry-stone structures in different international meetings.

Cultural activities
Within the concept of Land Art, different artists – Josu Larrañaga, Bárbara de Rueda, Nuria Román – have made temporary artistic works in the quarries.

An important part of our work is educational: we organise guided tours for schools and individuals to show them both how to interpret the quarrymen’s work by reading the marks left by the tools in the walls, and how to recognise the native flora and fauna of the island. Every summer we organise concerts and festivals, which at the beginning could gather more than a thousand people. In the last years, due to organisational difficulties, we have decided to increase the frequency of events, but to decrease their size. This year we will hold the fourth edition of the music and dance festival in small format during July and August. This festival is steadily growing year by year. Every two years we organise a photo contest with pictures of the quarries.

Fig. 4: A night music festival in the Anfiteatro. Photo: Lluís Bertrán

Conclusions
Lithica is a live project still developing; there still are quarries full of debris that we want to restore in the near future; we have to improve some infrastructures to make visits easier and safer, as well as keep on with the activities in motion, especially with the spreading of the landscape values of the quarries.
In-situ research and landscape design in two Greek quarry landscapes, Nella Golanda and Aspassia Kouzoupi

The imprints resulting from the quarrying vary, and they are in a way expressions of the culture[s] and era[s] through which they operated. Quarries are cultural landscapes, and more precisely infrastructural landscapes, where man-conducted elaboration meets the perpetual earth-formation process. The materials extracted are on one hand natural products, of the slow but ongoing geological time-scale, characterized by tectonics, stratigraphy and chemical substance. On the other hand the quarry products are shaped by man, and the quarry site is a collateral product of the extraction progress. In the case of inactive quarries, time activates the process of erosion with the geological features exposed by man.

Our team, ‘Sculpted Architectural Landscapes®’, has been involved with the rehabilitation of quarry environments of different kinds. Any quarry reconvention process, should, in our view, deal with all these time-characterized qualities, and try to trace the ways man-made and natural processes have been entangled in each quarrying site. The presentation of one of our team projects follows the presentation of the first quarry project by landscape sculptor Nella Golanda. They are situated on two of the mountain masses that surround Athens, Mt Ymittos and Mt Pendeli. They thus consist of landscapes situated in the wider Athens urban environment that have been strongly affected by industrial-infrastructural human activity. This type of anthropogenic intervention, based on the resolution that these places are an extension of the urban landscape, creates a double challenge for redesigning these inactive quarries as public landscapes.

In a place like Greece, where the relation with the substrata of the earth surface is a practice which enters in our everyday lives through archaeological excavations, digging itself can be understood as an act of approaching structures which entail distant time. Therefore it is reasonable to say that excavating in the rock means digging in time: either digging-up significant man-made or natural findings of the past, or that the geological structures are by themselves time-counting structures.

Quarries are places where the substrata have been revealed, mostly as part of a productive process. Most often, quarries have been spatial expressions of the literal scale of the devices or techniques used for the useful material extraction, its processing and transport, and also of the standards concerning the extracted material as final product. The combination of these factors with the natural properties of the geology is what has usually shaped the quarries as spatial imprints into the landscape. However, the appearance of ancient quarries, with their tight relationship with the landscape, suggests a different understanding. Recent legislation tends to deal with the relation of still active or new proposed quarrying sites and landscape, as proposed for instance by the European Landscape Convention.

Fig. 1: Sculpted Theatre in Aixoní Quarry – Total Art Interactive Space (1984-1992)
Project Author: Nella Golanda – Urban Landscape Sculptor. Project Funded by: Glyfada Municipality, Athens. The project was one of the series of ‘landscape recovery’ projects initiated by the Municipality of Glyfada in conjunction with the Ministry of Regional Planning and Environment (1983)
The recent gravel quarry of Aixoni is in Glyfada, a suburb of Athens, on the slope of Mount Ymittos, close to where Herodotus mentions that Pelasgians used to dwell. The Aixoni area during the classical period was famous for its open-air theatre that hosted timeless works of great Greek writers, like the tetralogy ‘Telephea’ by Sophocles. Yet the exact sites of all these treasures of antiquity have not been yet identified. In the case of the reconversion of the 6000 sq m quarrying site into a public space, the eroded rocky ground of the excavating rock faces (the grained terrain of the quarry) was a depressing landscape, except its right section with the interesting rock formations. It used to be a crumbling quarry landscape, because of the friability of its material product, and was active until the 1950s.

Nella Golanda expresses her creative process as follows: ‘After a series of drawings and thoughts I decided to create a central point or ‘condenser’ in order to receive and reorganize the latent forces of the wider area. In this extremely bare and dangerous area for the visitors, I developed a large sculpted composition of 40 m length, variable height up to 10 m and 7 m depth, including six large sculptures of crystalline structure (functioning as a strong supporting wall of the quarry rock faces). Here, I strove to have the visitor confute the upheavals that had taken place in the quarry space, to have them pass it over as ‘natural’, in the same way we subconsciously accept an archaeological dig. In this case, the dig ‘revealed’ the large structure.

In the development of these sculptures I integrated axes leading to all the main characteristics of the landscape, such as the movement of the sun that dominates the area of the excavated area like the moon at night. At the same time, I managed to develop in the big sculpted construction a designed, unstable equilibrium which gives the impression that the new sculpted landscape is characterized by mobility; everything can happen, nothing is accomplished, but ongoing. The sense of mobility is enhanced with the presence of large waterfalls, giving the dimension of the fall, speed and marking subsoil. The sunlight during the day is received by the skylight systems which lead it deep in the heart of the sculpture. A sculpted foyer designed in a way that is the seventh sculpted section is detached and slides slightly down the mountainside. The area is planted with species typical of the region of mount Hymettus and has been formed into three levels.’

Re-approaching the poetic element of the wider area of Hymettus, the sculptured quarry can be used for staging multi-art productions that allow the active participation of the audience. The new sculpted space, possessing now exceptional acoustics, functions as an ‘experimental container/tube’ for innovative activities, interactive and unexpected art happenings. The Quarry was inaugurated in September 1992 with the international celebration of the 70th birthday of the composer of ‘polytechna’, Yannis Xenakis.

The rest of the theatre space (restoration in 6000 sq m) was designed as a container/hub where actions and reactions of contemporary arts could develop, such as the great artistic event in the summer of 1993 entitled ‘The mutation of Sculpted Theatre into a Sculpted Echogenic area’ with participation of famous international artists who designed various projects specifically for the site.

Fig. 2: Old Dionysos Quarries: Open Air Museum of Marble Quarrying Arts (1994-1997). Project Authors: Sculpted Architectural Landscapes ®: Golanda + Kouzoupi Project Distinction: 2000 Barcelona Finalist: Rosa Barba Award, 1st Landscape Biennale of Barcelona. Owner, and Reconversion Project Sponsor: DIONYSOSMARBLE S.A.

The Old Dionysos Quarries landscape is an area of 135.000 sq m on the north-western slope of Mount Pendelicon, the mountain which was a source to the famous Athens Acropolis marble. The
quarries we are referring to have a significant historical value but are not ancient: all the quarries of archaeological value on Mt. Pendelicon are situated on the south and south-western slopes of the mountain.

The most striking element of the old Dionysos quarries is a huge ramp or ‘slide’, an artefact of prime industrial infrastructure, which dates probably back to when the quarries were operating under the English firm Grecian Marbles Marmor Ltd, at the turn of the 20th century. The 300 m ‘slide’ defines an emblematic marble gravel embankment in the landscape, of aesthetic and industrial history value. This ramp, when operating, was linked to the end of the industrial branch of the local train line. It still rises to the inactive marble production sites uphill, forming two marble-block fastening platforms. The upper part of the slide is carved as a ramp into the mountain and its upper end has been formed as a cubic void, straight into the rock mass, where fastening and sliding control devices were situated. The other fastening position is formed by two sets of angle-shaped robustly built side supporting walls facing one-another: made of huge hued marble blocks, this platform is traversed and divided by the slide. The ramp is preserved almost intact, and the view from both platforms is breathtaking.

These quarries were producing huge marble blocks of great quality and rigid consistency, used amongst others for emblematic sculptures, but a great quantity of the marbles extracted were for constructing the marble edges of the pedestrian pavement of the streets of London.

Through their exploitation, the marble extraction faces reached a point where the stone was seriously fragmented, leading to a gradual decline of the extraction activity in that area. These old quarries were abandoned in the 1960s, but when the project of their reconversion was commissioned to us in 1994, we had the rare chance to work with the last generation of quarrymen which had been trained as youngsters to this site. These five old quarrymen, just a few years before their pension, knew seemingly miraculous ways of moving and handling immense marble stones on the mountain slopes. They also showed us traditional ways of stone-piling used by their primordial mentors: quarrymen from marble-producing islands of the Aegean. These techniques were, along with the properties of the awe-inspiring quarrying landscape, the keystones of our understanding of this exceptional site.

What we understood as the essential property of this landscape was the tight entanglement of natural and man-made processes. The traditional quarrying methods used left traces of beautiful, even marble faces, as the natural fissures of the mountain marble were used to extract whole blocks. This process brought about the creation of a man-conducted procedure which respected a pre-existing natural structure. The extracted blocks were transported into certain positions of the landscape, where they were hued and carved. This process produced another breathtaking element of the quarrying system landscape: enormous waste heaps of marble-gravel with roughly conical shapes, starting from the hewing spots, widening while descending the mountain slopes. These formations are a measure of the man-hours spent during the total hewing procedure, like a now-immobile hourglass.

Last but not least, traces of a few simple dry-wall structures which were used once as shelters for the quarrymen, perhaps seasonally as their team houses, were dispersed on the slopes, partly in ruins. As they decay, these shelters were forming other stone piles. The almost circular link between all these processes, and the way entropy and order link the different marble states which coexist on the site, is what we aimed to highlight the most into this landscape: from natural marble rock to cut and exposed marble face, to extracted marble block, to thrashed gravel [and, invisible on the site, exported product], to more or less organized manmade structures, to entropy-produced stone piles.

The quarrymen and us worked solely in situ, using dry-wall techniques and solving the structural and construction problems to reveal the harmony between all man-made and natural processes of this quarrying site’s formation. The ways the stone fragments were arranged by traditional quarrymen were re-invented by our team. The aim was to arrange the leftovers of the site at a partially destructed area of the old quarries which was abruptly cut by the new road introduced during the most recent period of its operation. We introduced a thick sculptural skin, a stable structure made of marble-stone arrangements, which covers the destructed part of the quarry. We revealed another part of the quarry, in proximity to the huge conic pile of gravel, which was buried under debris: a
A cubistic landscape was uncovered, characterized by the human scale of the hand-made process which had once produced it. The traces of the site’s industrial history are displayed as well, in a low-key mode, and revealed to the observers and wanderers who take the time to stroll and hike around the paths we introduced.

About the authors
Nella Golanda and Aspassia Kouzoupi, Sculpted architectural landscapes®.

Further reading


European Quarry Landscapes Network
Appendix: The European Quarry Landscapes Network

The first meeting to discuss the quarry landscapes of Europe, in October, 2014, attracted 31 specialists to Teruel. It was generously hosted by the Ayuntamiento of Teruel, as part of the Las Arcillas project to restore the former clay quarries on the edge of the urban area of the city, which is supported by the Life + program of the European Union.

The participants included representatives from geological institutes, the cement industry, universities, and heritage organisations, nature conservators, archaeologists, artists, landscape designers as well as members of the team behind the Las Arcillas project. Eleven presentations on the first day examined the main themes of the meeting, and ended with a general discussion of the issues facing quarry landscapes and how better care for their values could be combined with beneficial alternative uses. On the second morning the participants toured the urban centre of Teruel and visited some of the spectacular towers built by the Mudejar builders, using bricks and tiles made with clay from the local quarries, and then walked through the former excavations to see how the city is bringing these abandoned workings back into the life of the city.

At the final meeting, the delegates discussed a declaration in support of the valorization of former quarries and hoped for a further meeting to take the Network forward.

Florenco Conde presenting the Las Arcillas project at the beginning of the meeting.

Participants of the first meeting and founding members of the European Network of Quarry Landscapes, Teruel, October 2014

Enrique Álvarez Areces, Instituto Geológico y Minero de España (IGME), Spain

Timothy J. Anderson, Consultant archaeologist, Spain

José Bravo, Director de los jardines and Laetitia Lara, Presidenta, Lithica - pedreres de s’Hostal, Spain

Prof. Lidia Catarino, Research Group CHARROCK, Portugal

Prof. Philippe Cayla, Angers University, France

Juan Manuel Ceballos-Escalera, Director Conservador, Spain
Pilar Gegundez, Director of Environment and Resource Sustainability, Lafarge España, Spain

Dr David Gwyn, consultant archaeologist, UK

Stephen Hughes, Secretary of TICCIH and ICOMOS UK, UK

Dr. Christian Uhlir, Director, CHC - Research Group for Archaeometry and Cultural Heritage Computing, Austria

Norbert Tempel and Ingrid Telsemeyer, Westfälisches Industriemuseum, Westphalian Industrial Museum, Germany

Ian Thomas, former director, National Stone Centre, UK

Dr. Luis Sousa, Professor Auxiliar, Universidade De Trás-Os-Montes E Alto Douro, Departamento de Geologia, Portugal

Florencio Conde, Project director, Ayuntamiento de Teruel, Spain

James Douet, Project coordinator
Programme of the first meeting of the EQLN, Teruel, October 29-31, 2014

European Quarry Landscapes Network

Seminar, 30-31 October, 2014
Gran Hotel Botánicos, Teruel, Aragon, Spain

This is the inaugural meeting of the new European Quarry Landscapes Network, dedicated to internationally cooperation in the field of historic stone quarries. In the setting of the impressive old quarries of the spectacular Mudéjar architecture in the city of Teruel, twelve international specialists will present varied perspectives on the historic European landscapes created by stone quarrying.

Aspects to be examined include the study, interpretation, valorisation, conservation, protection, and re-use, as well as how their cultural and natural qualities can be compatible with music and theatre, tourism, education, sports and leisure.

A new report prepared by the International Committee for the Conservation of the Industrial Heritage (ICC) and the World Heritage Office (WH), will propose criteria by which quarries can be considered as World Heritage sites, leading to a consensus which can guide future inscriptions on the UNESCO list.

On the second morning delegates will visit the Mudéjar architecture and examine the quarries from which they were made, their history and ceramic decoration. In the final evening representatives of territories with quarry landscapes will sign an agreement to constitute the EQLN and consider its development and program.

The presentations are in English.

Accommodation
The meeting will be held at the Gran Hotel Botánicos
Camino de la Estación, 27
44001 Teruel
Comunidad de Teruel
Telephone: 96 62 39 57 - 630 01 70 67
http://www.granhotelbotanicos.com/
Reservations: reservations@granhotelbotanicos.com

Other accommodation can be found through the Teruel web site: http://www.turismoteruel.es

Inscription
To attend the meeting, please write with your details to the Project Coordinator, quarriesnetwork@gmail.com
Participation is free and includes refreshments and the conference tour.

Name: 
Institution: 
Address: 
Telephone: 
Fax: 
E-mail: 

For more information visit the EQLN website http://www.quarrylandscapes.teruel.es/
or contact Jaime Durán, Project Coordinator, Tel: +34 965220317.
E-mail: quarriesnetwork@gmail.com

Programme of the first meeting of the EQLN, Teruel, October 29-31, 2014

Wednesday October 29

09.30 Welcome and presentation of the European Quarry Landscapes Network (EQLN) by Manuel Alcazar, the Mayor of Teruel, Florencio Conesa, Project Director, and Jaime Durán, EQLN Coordinator
10.30 Dr. Christian Uther, Director, Research Group on Archaeology and Cultural Heritage (Archaeology) University of Salzburg, Austria: Evaluation of historical values and the Atlantic Quay Database
11.30 Ian Thomas, Honorary Resident, National Roma Centre, UK: Quay Heritage: developing a strategy to dialogue
11.45 Coffee
13.00 Prof. Philip Cazin, University of Nantes, President Association Limentis (Porphyry Stone Industry): Porphyry stone quarry landscapes
15.00 Prof. Luis Catarino, 6th Sciences Department, University of Coimbra, Portugal: CARPHOS (Combater des Gesteos de Saboia) research group
15.30 Prof. Luis Reus, Director of the College of Geology of the University of La Laguna, Spain: Tours of the site of the Windmill (La Manga) - Museum
16.00 José Manuel Casados Sánchez, 6th Sciences Department, University of Coimbra, Portugal: The role of multimedia in projecting the Roman quay (La Manga) - Archaeology, Popular Museum of the city of Coimbra, Portugal: The role of multimedia in projecting the Roman quay (La Manga)
17.00 Coffee
17.30 Short presentations
Juan Manuel Casados Sánchez, 6th Sciences Department, University of Coimbra, Portugal: The role of multimedia in promoting the Roman quay (La Manga)
Pilar Gago, Director of the World Heritage Site of Las Vegas de Cervantes, Spain: The International Network of Natural Stone Quarries
Deb. Anderson, Consultant on Archaeology, Spain: Limestone quarry landscapes: significant characteristics and implications
19.00 Field trip to the Teruel Peninsula: visit to the Tossal de la Concordia and the Tossal del Castellon de la Calzada
20.00 Dinner

Thursday October 30

09.30 Visit to the San Juan de los Vellés Monastery, the Museum of the Franciscans, and the Cathedral of Teruel
10.00 Field trip to the Las Vegas de Cervantes, Spain: Visit to the Tossal de la Concordia and the Tossal del Castellon de la Calzada
12.00 Visit to the Mudéjar architecture in Teruel
13.30 Lunch
15.00 Departure