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QuarryScapes guide to ancient stone quarry landscapes: documentation, interpretation, and statement of significance

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Quarry Scapes

Conservation of Ancient Stone Quarry Landscapes in the Eastern Mediterranean

QuarryScapes guide to ancient Stone quarry landscapes

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QuarryScapes: Conservation of Ancient Stone Quarry Landscapes in the Eastern Mediterranean

QuarryScapes is the first project of its kind for addressing the importance of ancient quarry landscapes and raising the awareness of the urgent needs for protecting such sites. QuarryScapes will develop scientific and practical methodologies for documentation, characterisation and conservation of ancient quarry landscapes, raise the awareness of their significance and vulnerability and contribute to legal protection measures and sustainable management. Through case studies in Egypt, Jordan and Turkey, the project will address development of theoretical and practical methods pertaining to the major steps in the process of conservation: from recognition, investigation and assessment of significance, to understanding the risks, developing sound conservation and monitoring concepts, and suggesting mechanisms for sustainable management. The project is subdivided in ten work packages.

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Preface

This document is a compilation of a guide designed for and published on the QuarryScape web site www.quarryscapes.no. It draws from the other deliverables in the project, particularly from the Work Package 8 - Integrated scientific analysis of the empirical data. The guide is made from the recognition that has grown throughout the project that the focal point in conservation of ancient quarry landscapes lies in how to build “a case for conservation”; how to identify, document, analyse and finally get to a statement of significance for quarry landscapes.

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1. Introduction

The QuarryScapes project was built on the background that
"The spectacular monuments and cities of the ancient Near East are testament to an industrial past where large-scale stone procurement remains unsurpassed. Yet, stone quarries are forgotten as key archaeological sites, rich in material remains of crucial significance if we are to understand the social and technological practices of an age when stone was quarried and transported par excellence. Largely invisible, undocumented and unprotected, these ancient quarry landscapes are being destroyed from actions such as modern development and quarrying."

The inspiration for QuarryScapes project came from the necessity to put these ancient industrial landscapes on the map before it is too late and to raise awareness of their research potential across a broad spectrum of audiences, from archaeological researchers to the interested public. The project has included specific research on eleven quarry landscapes in the region (Turkey, Jordan and Egypt), particularly for developing a general, multidisciplinary methodology of documentation and evaluation of such sites. In addition, the project has carried out one national inventory of quarry landscapes, an inventory of risks and threats and an outline of conservation concepts for a particular quarry landscape.

During the progress of the project, it has became clear that one of the key problems with quarry landscapes is not the lack of such sites (quarries are literally everywhere!), but how to point at the historical importance of them and thus make selection of sites and parts of sites for protection.

This guide is an attempt to collect the experiences from the project and translate them into a guide which hopefully can be applied in a range of cultural and historical contexts. Therefore, it particularly focuses on subjects seen from "an expert" perspective, meaning archaeologists and/or geologists working in the field for providing the input to stakeholders and decision makers in order to build a case of conservation. Although the project has included practical innovation activities for specific sites, it is difficult to address local interests, legislation systems etc. in a general way that can be applied cross-culturally. Thus, the guide will not address "non-expert" values (economic, social, aesthetic, etc.) which we consider to be more culture and place specific and therefore less transferable across cultural and national borders. Furthermore, we do not address legal aspects/national legislations for the same reasons.

The guide only address subject we see as special relevant to quarry landscapes. We do not attend to make a guide for landscapes or archaeological sites in general, as there are numerous other works on that. It is our hope that the guide can provide additional information for cultural heritage authorities and professionals who (hopefully) in the future will have to relate more to such landscapes than in the past.

The guide contains three chapters, addressing the following:

- Identification and description of features of ancient quarrying
- Interpretation of such features and visualisation of them
- How to reach a statement of significance from an expert perspective

In addition, we have included a list of bibliography that we consider particularly important, and a glossary of terms.

The guide pay special attention to the need for multidisciplinary approaches; for instance, the geological characterisation of the stone resources is equally important as the documentation of the archaeology, in order to reach an understanding of not only how quarrying was done but also why. The guide follows a scheme presented in QuarryScape Deliverable No. 10 (Figure 1), starting with the empirical characterisation (identification of features, micro-level analysis and how to construct a quarry landscape), moving to the macro-level interpretation and finally to constructing a statement of significance. Of particular importance is a methodology on how to view quarry landscapes in relation to different key perspectives – their place in socially constructed landscapes; the contact between quarry landscapes and others such as the places of consumption; the projection of key historical events in the quarry landscapes; and, quarry landscapes as dynamic landscapes.

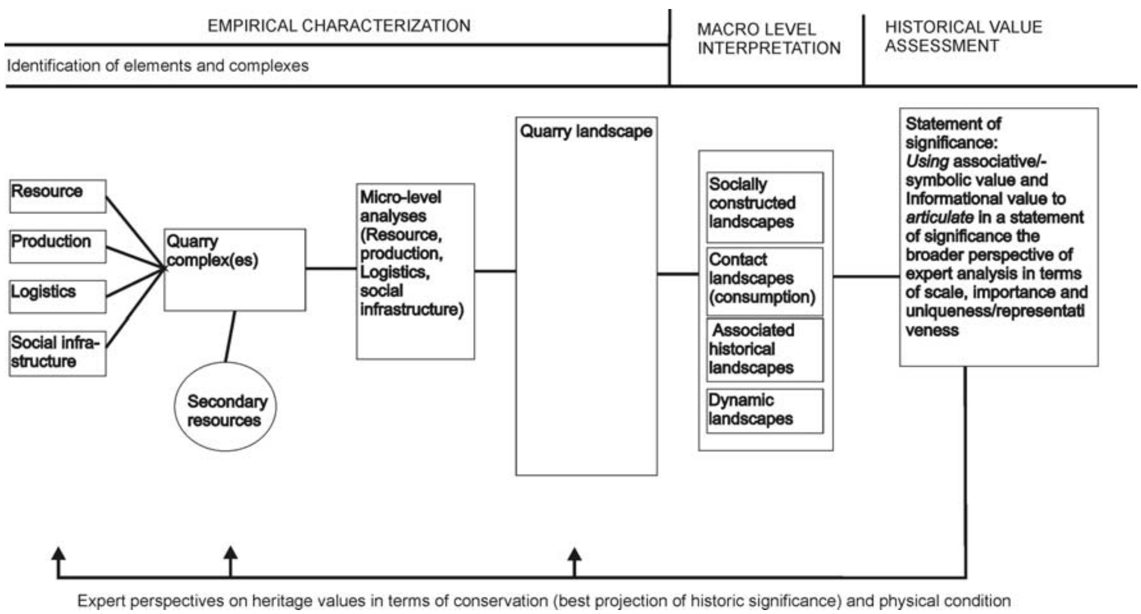

Figure 1. A procedure for "building a case of conservation" for quarry landscapes.

The guide is built around a short main text, but illustrated with fact sheets and example sheets that contain more detailed descriptions or examples from the different case studies in QuarryScapes. The guide largely build on the report: *Identifying heritage values and character-defining elements of ancient quarry landscapes in the Eastern Mediterranean: an integrated analysis.* But also other other deliverables from the project have been used as a background. Those who look for the baseline of research behind this guide should look closer at the other deliverables. They can all be downloaded from www.quarryscapes.no.

2. Identifying and describing features of ancient quarrying

Characterising the stone resource

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. Stone resources should be investigated as:

- *evidence of consumption* (geological characterisation): the rocks can link the quarries with the places and products where the stones have been used, being buildings, tools or other items (fact sheet 1).
- *a commodity*: Stone resources can be divided into principal commodities reflecting the purpose of use, such as *Building stone* (used for constructing buildings), *Utilitarian stone* (used for everyday utensils) and *Ornamental stone* ("rare" resources used for embellishment of buildings, sculpture and elite/exclusive objects) (fact sheet 2).
- *a physical material*: Key physical properties of rocks such as brittleness, hardness of the minerals and porosity decide the technology necessary for quarrying and processing (fact sheet 3).
- *a landscape forming entity*: The distribution and geometry of the deposits of stone resources is the starting point of how landscapes are transformed by quarrying (fact sheet 4).

Secondary resources may have been important in the quarrying activities. Such resources include stone for buildings and other constructions at the quarry site, stone for tools, clay for pottery, etc. Such resources and their use are important to identify and characterise (example sheet 1).

Identifying and describing features and material culture from quarrying

A **quarry site** may be visualised as *the material remains* from the various processes involved in the exploitation of it. Such remains include features related to the actual *production* (extraction and further working of stone products), the *logistics* (internal and external transport of stone objects) and the *social infrastructure* (features related to sustaining the people involved in the quarrying). Each of these elements of quarrying, alone or combined, provides important information about the timing, purpose and size of the quarrying activity.

Production in a quarry can be described as a process in four steps (Figure 2). 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/worked into one or several *object blanks* (or roughouts). The final 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 material remains from the production process should be recorded and interpreted, and are divided into:

- quarry morphology: layout and structure of quarries (fact sheet 4)

- quarry face: solid rock surface made by quarrying and displaying evidence of quarrying techniques (fact sheet 5)
- tool marks: marks on the rock surface and/or stone fragments made by tools (fact sheet 6)
- tools: remains of tools applied in the quarrying process
- spoil: discarded rock fragments from the various steps in the quarrying process (fact sheet 7)
- work areas: areas designated to block reduction and/or more elaborated work
- objects: remains of more or less finished objects resulting from the production (fact sheet 8)

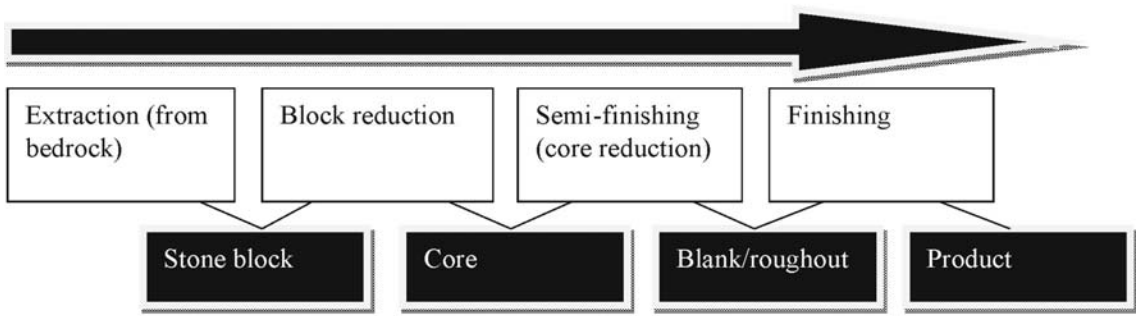

Figure 2. Quarrying defined as a process in several steps

Logistics of quarries involve the *internal transport* of stone between the steps in the production process and the *transport of stone from the quarry* to a place of further processing and/or use (Figure 3). The logistical system in a quarry may vary from being the most elaborated constructions on the site to almost non-existing, depending on the size and weight of the stone products being transported. Material remains from quarry logistics include (fact sheet 9):

- Road: paved or non paved road made for the transport of stone blocks
- Ramp: constructions for moving stone blocks from one level to another
- Slipway: track or cleared area for lowering blocks down a steep slope
- Causeway: construction made for evening out irregularities in the terrain
- Track: non-constructed functional road made by clearing a solid surface
- Path: non-constructed narrow track made by traffic by humans or animals
- Stockpile: remains of stockpile of semi-finished or finished products made ready for transport
- Vehicle tracks: marks made by stone transport vehicle on roads or other features
- Harbour: place for loading stone products onto rafts or boats
- Stone-built features: structures or heaps of stone made for aiding transport of stone, including cairns for marking transport routes
- Carved features: postholes, mooring sockets and other features made by carving for fixing devices or ropes aiding the transport

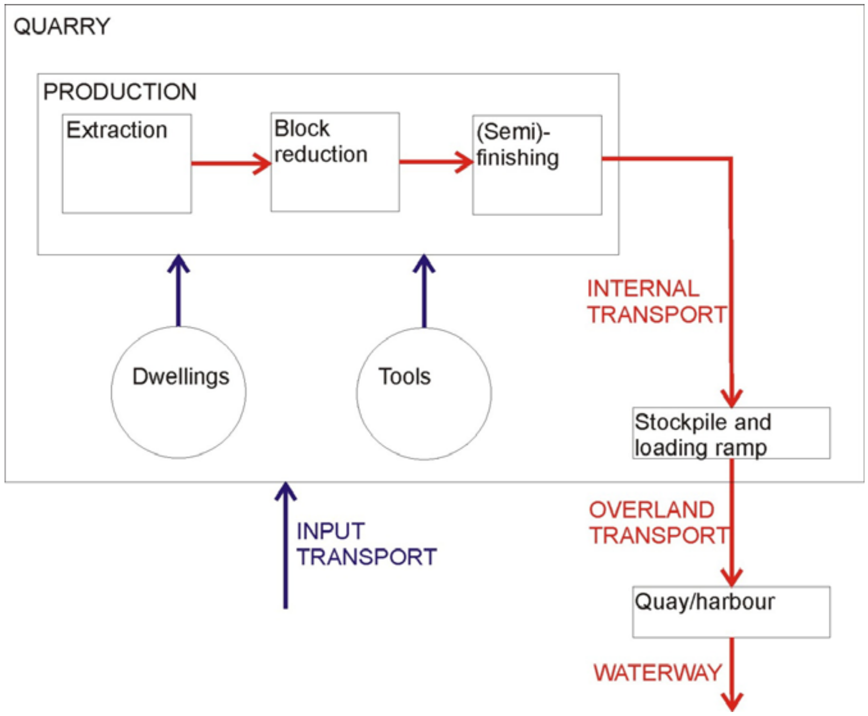

Figure 3. Example of logistical system in a quarry.

The **social infrastructure** of quarrying can be described as the features made for sustaining the people involved in quarrying, and provide cover and shelter for them during the production. It also includes features displaying ritual or spiritual activities. The material remains of the social infrastructure can be divided in three groups:

- (stone)-built features: any elaborated or ephemeral construction such as settlements, temporary dwellings, wells, ritual enclosures, defensive structures, storage areas and shelters (fact sheet 10).
- Domestic artefacts/organic remains: utensils and tools for food production and other domestic activities, remains from food preparation and storage, ceramics (fact sheet 11).
- Epigraphic data: inscriptions, graffiti and rock art made by the work force (fact sheet 12).

3. Interpreting and visualising quarry landscapes

Finding time depth

Quarry landscapes are often composed of multiple layers of activities from more or less continuous activities through 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 were commonly re-visited during several periods, spoil material was moved to make space for new quarrying, and roads/other infrastructure were more or less continuously moved. In addition, many quarry landscapes, particularly those which did not have permanent settlements of 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:

- 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
- 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

Micro-level analysis

Drawing together and characterising the micro-level 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. This phase of expert analysis needs to describe and characterise the empirical data in terms of what insights can be made into how quarrying was undertaken in the past. Given that empirical data is always fragmentary comparative analysis with other ancient quarry sites, along with indirect evidence, is also key to interpretation of the micro-level.

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 (example sheet 2).

An analysis of micro-level data that informs about the *logistics* of how stone was transported from a quarry is key to 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 (example sheet 3).

In terms of making inferences into the *social context* of ancient quarrying, there are key questions that we need to ask of this data. For instance, the size of labour forces, did they reside permanently at the quarry, levels of social organisation and the extent to which such activities may have been controlled by the 'state' or other type of centralised bureaucracy.

An example on how to apply such methodology in analysing a quarry site is given in example sheet 4.

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 separate and later grow together into one large unit, in which the individual components remain invisible for us.

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.)(Figure 4)(example sheet 5). 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.

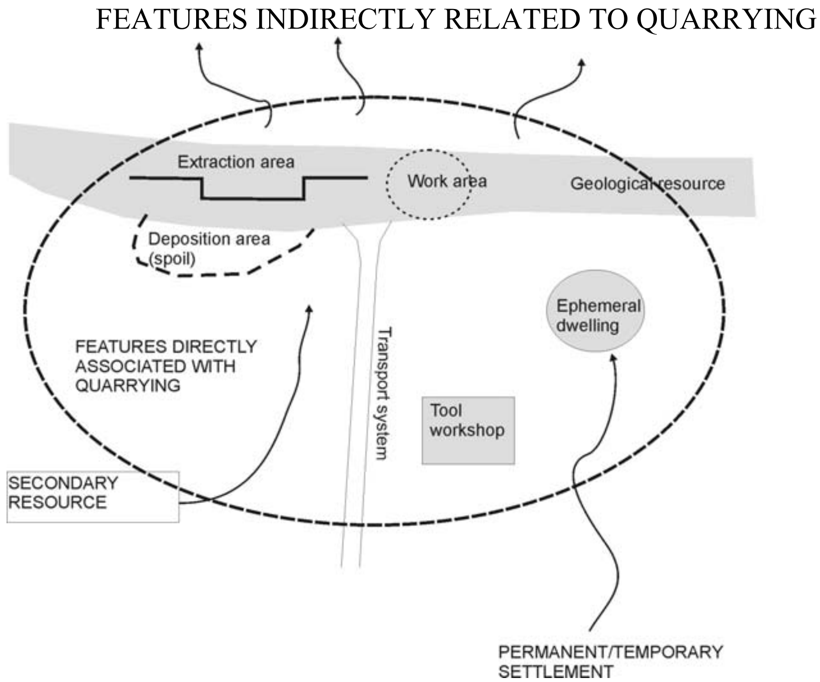

Figure 4. Ideal representation of a quarry unit.

In most cases, quarry landscapes are multilayered and multifunctional. Thus, following the definition of elements related to quarrying and the micro-level 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 elements 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.

In a general view, a quarry complex may be visualised as a system of interconnected quarries sharing social infrastructure and logistics, input of labour force and secondary resources and output of products (figure 5).

The criteria on which a complex is defined depend on many factors, and may be one or combinations of the following:

- Time/period ("Historical Complex")
- 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 (example sheet 6).

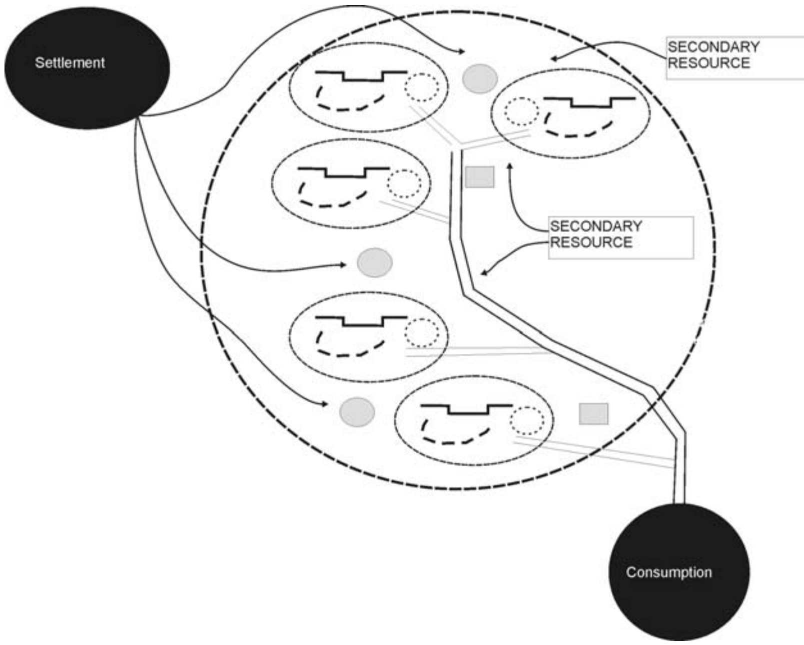

Figure 5. Simple model for visualising a quarry complex limited by the resource, as a number of connected quarries sharing common features of social infrastructure and logistics.

Surveying and mapping quarry landscapes

As quarry landscapes differ significantly in complexity, size and character, it is difficult to recommend a standard method of documentation and mapping of them. But given that such sites rarely are subject to highly detailed archaeological investigations, it is possible to suggest a procedure that can provide an overview of the features in a quarry landscape and their connections in time and space with relatively small efforts.

As particular archaeological landscapes, quarry landscapes often share the following characteristics, which are important to take into account before surveying:

- Quarry landscapes often display exploitation activities over long periods of time, perhaps thousands of years, and thus show significant evolution of technology and organisation of the quarrying through their lifetime
- Modern stone quarrying is often situated in the same deposits as the ancient one. In essence, stone resources that were attractive two thousand years ago will still be commercially interesting today. Thus, there are often special challenges in creating a balance between ancient and modern quarrying
- Quarry landscapes often cover large areas
- Quarry landscapes are closely connected to geological formations (stone resources) and their spatial distributions follow the bedrock geology

Pre-survey studies:

- Geological maps and other geological information from the area are important for predicting the spatial extent of quarry landscapes and for knowing the stone resources in question
- Satellite images and/or aerial photographs may be extremely useful for locating quarries and logistical features
- A pre-study of the consumption of the stone(s) in question is valuable for better recognition of products and production patterns in the field

When planning a survey, the level of accuracy has to be balanced with available time and funding. As many documented quarry landscapes cover an area of 100 square kilometres or more, it is obvious that a highly detailed survey with accuracy (or level of details to be documented) less than one metre will be extremely time consuming. For a general survey, it is recommended to work on 5-10 metres accuracy/detail level. This gives a good balance between speed, necessary accuracy and costs. Within that framework, it is possible to work with low-cost GPS equipment combined with the standard level of accuracy given on satellite images.

Surveying:

- A survey should include geological mapping and resource characterisation, since the exploited resources define the limit of potential, previously undiscovered quarry areas.
- It is convenient to divide recordings/observations into main classes (ex. quarry, road, man-made feature, etc.) which are further divided in subclasses.
- A pre-defined table structure/shapefile for GPS-based data-collection should contain enough fields to allow for spatial analyses of several datasets, to facilitate post-survey interpretation of inter-dependent features. Separate tables should be used for point registration (i.e. artefacts), polygon registration (i.e. quarry) and line registration (i.e. road). An example of shapefiles for GPS field surveying is given in example sheet 7.
- A survey should include the recording of the physical condition of the features (destruction, erosion/weathering) and an evaluation of immediate threats from modern activities.

National inventory of quarries and quarry landscapes

An inventory of quarry sites/landscapes within a region or nation is of great value for being able to view and manage this kind of heritage in a holistic way. A national survey will provide an overview of the number of sites/landscapes, their legal status, their condition for conservation and the distribution of typologies. Since quarry landscapes in a global context are poorly documented and rarely protected as cultural heritage, such an inventory is invaluable for shaping a national policy of conservation and being able to compare and evaluate the overall importance of the sites. A database designed to meet such demands should contain:

- Rock types (main groups and classifications)
- Main commodities (i.e. millstone or building-stone)
- Age (period(s) of quarrying)

- Legal status (registered or non-registered, protected, etc.)
- Protection (inside or outside protected area, ex. nature reserve)
- Condition (preservation, destruction)
- Main threats (i.e. urban development, etc.)
- Reference to research and other work at the site

Within the framework of QuarryScapes, a national inventory of quarry sites was completed in Egypt. Structure of the database and examples of data entries and use of the database is presented in Example sheet 8.

4. Statement of significance

Introduction

The final phase of expert documentation, characterisation and interpretation of a quarry landscape is the production of a formalised *statement of significance*. In the conservation process, this document provides decision-makers, heritage authorities and stakeholders with essential information concerning the significance and value of the cultural resource from an 'expert' perspective. This document has to be written in an accessible manner so that it is understandable across a range of interests and has to avoid complicated scientific discussions. As quarry landscapes are often the most difficult cultural landscapes to visualise and understand from a non-expert perspective, it is important to develop concepts and models through which their significance and value can be articulated *within much broader frameworks*; such as their connection with important historical events/places that are more generally known and recognised.

A methodology that contains the steps necessary to produce a statement of significance that has relevance across a broad range of interests has been developed during the QuarryScapes project (Figure 6). This chapter deals with the last two stages of this method from macro-level interpretation and historical value assessment, up to the statement of significance.

There are 3 steps in this process:

1. Identifying heritage values
2. Macro-level interpretation: four concepts of landscape
3. Historical value assessment and statement of significance

The following presents an outline of these 3 key stages.

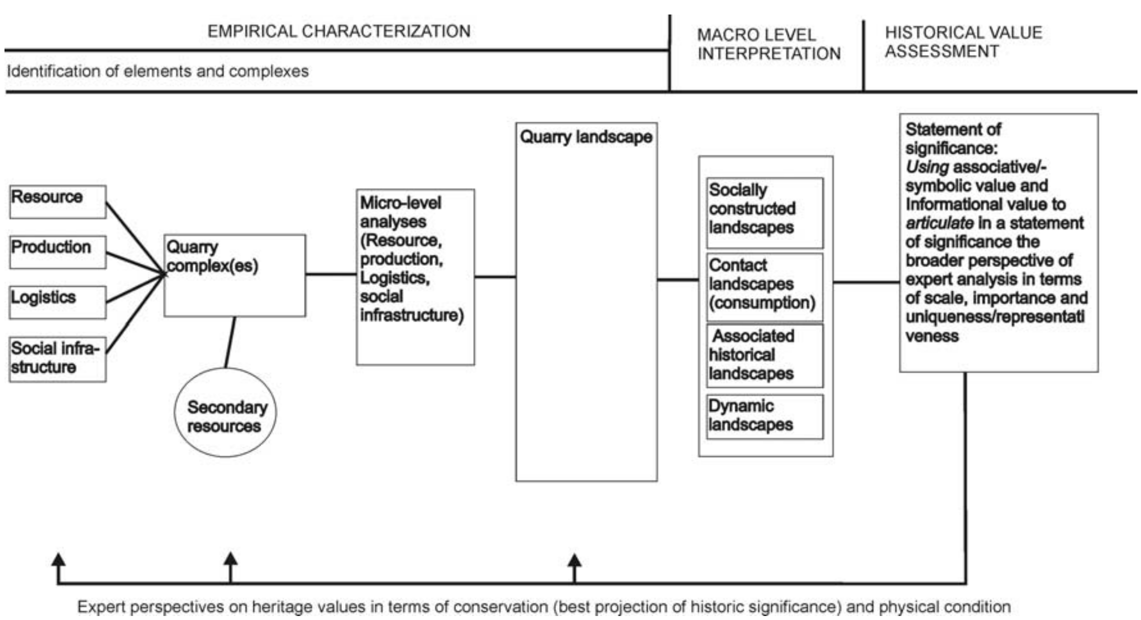

Figure 6. A procedure for "building a case of conservation" for quarry landscapes.

Identifying heritage values

Identifying heritage values to be assigned to a cultural resource would include those given by experts, decision-makers, heritage authorities, local communities and other stakeholders. All these value assessments would then be formalised in the statement of significance. From a Western perspective, the most widely used baseline criteria for assigning values to cultural resources come from those identified by Lipe (fact sheet 13). Given the range of perspectives from which all these values are being assigned to the cultural resource, it would be expected that the statement of significance would often be contradictory and so *cannot represent a universal view*. In addition, these value assessment types would also adhere to legal frameworks of the specific country and other statutory criteria in a given cultural context.

An *expert assessment of significance* of an ancient quarry landscape is generally based on two sets of values: *historical* and *informational* value as summarised below:

1. Historic value – or Associative/symbolic value – the essence of physical cultural remains and their authenticity, even if re-used, that can transmit cultural information about the past.
2. Informational value – made as 'best projections' by experts of what kind of resources/elements will be most useful for future study.

Although these definitions are made from a Western perspective, it would be expected that the essence of these value types is largely universal in an expert assessment of significance.

Macro-level interpretation: four concepts of landscape

Macro-level interpretation of ancient quarry landscapes, from an expert perspective, is key to how historical and informational values can be assigned to the ranges of material remains that constitute them. It is also the foundation for making *best projections* as to which places or 'sites' within a quarry landscape should be conserved over others. This step is necessary to balance the needs of modern development with conservation, given that quarry landscapes can often extend over large areas. With this in mind, the statement of significance needs to put across historical and informational values in a meaningful way that has relevance across a broad spectrum of interests. So, this next step in the production of a statement of significance has to place the ancient quarry landscape within a broader historical context. This can be done by using broadly-based concepts, or analytical frameworks, as a means to connect ancient quarry landscapes with other places and/or events of broader historical significance.

Four concepts of landscape have been developed with the specific aim of being adaptable to the diverse ranges of material remains, and archaeological contexts, in which a given quarry landscape may be situated. These concepts can only be applied after micro-level characterisation and interpretation of material remains has been undertaken. In summary, the four concepts of landscape are as follows (see fact sheet 14 for more detailed descriptions):

1. *Socially constructed landscapes*: this concept can be used to isolate values of multi-period quarry landscapes in terms of time depth of quarrying and also where re-use of the landscape for other activities over time has compromised authenticity of some material remains. The concept of a 'socially constructed landscape' also allows for the historical value context to be assessed across the totality of a landscape that may be related to ancestry, social embeddedness and tradition into the modern era.
2. *Contact landscapes (consumption)*: part of the historical significance of the ancient quarry landscape may be its connection to another more highly visible and significant place through consumption of its products.
3. *Associated historical landscapes*: ancient quarry landscapes may be implicated in and provide additional evidence about significant events and transformations in history and prehistory. Can be used to 'best project' specific areas within a landscape that hold key historical and informational values.
4. *Dynamic landscapes*: to assign values to quarry landscapes where re-use for other activities may have completely or partially destroyed them. For instance, when a quarry landscape has been totally integrated into a modern city as a means to assess historical and informational values through human agency as characterising the present-day landscape, rather than its past.

One or more of these concepts would be used on a quarry landscape depending on single, or combinations, of variables such as:

- the extent of the quarry landscape and need for making 'best projections' if under pressure from modern development
- range of material remains, their visibility and status of preservation
- extent of landscape re-use and how this has affected the authenticity of material remains, ie., is this multi-layering over time significant in terms of the historical value it adds to a landscape in its totality
- proximity to a larger more significant monument and/or city
- historical documents/written sources that can provide important contextual information
- products produced in a quarry landscape that can be securely provenanced to places of consumption

Historical value assessment and statement of significance

This is where we have to assign *associative/symbolic value (historical value)* and *informational value* to the physical remains, as interpreted at a micro-level and macro-level, in a formalised statement of significance that will inform decision-makers. Important to this stage is making a relative assessment of these values, as applied to a quarry landscape and its material remains, in terms of:

- Scale: something may be important to a local community, region, state, nation or globally
- Importance: how important is it at the appropriate scale and why
- Either uniqueness or representativeness: can be a unique case (such as “the last remaining”), or it is a representative example of a type (comparative analysis).

In cases where the relative assessment of values of a quarry landscape may conclude that it is of global significance, then the statement of significance should inform decision-makers that there would be a strong case for UNESCO World Heritage status. Decision-makers should be advised to look at UNESCO criteria for nomination of a quarry landscape as having ‘outstanding universal value’ (fact sheet 15).

Assessing relative scales of significance, from an expert perspective, of ancient quarry landscapes requires:

- comparative knowledge of other quarry landscapes in the country/region and also internationally (where applicable)
- identification of specific elements of a quarry landscape, these may be roads, objects, extraction technologies, epigraphic material, that may be ‘world firsts’, the last remaining example of its type, represents a key innovation of both historical and informational value
- defining by ‘best projections’ areas (quarry complex with its key elements) within a landscape that represent the highest scale of value – this should be in terms of both historical and informational value

Summary

A statement of significance, from an expert perspective, is the key outcome of both micro-level and macro-level interpretation of a quarry landscape, the assignment of historical and informational values to the material remains, articulated through a scheme of relative scale. This document has to be accessible and meaningful to decision-makers, stakeholders and heritage authorities and so enable them to visualise where historical and informational value has been applied to specific material remains. Using four concepts of landscape in the assessment of historical and informational value of ancient quarry landscapes allows for significance to be put across in two ways: first, across a landscape as whole, and second, to make ‘best projections’ onto specific areas of material remains, or quarry complexes, that hold key values.

The information that decision-makers, managers and stakeholders take away from a statement of significance in relation to an ancient quarry landscape in terms of scale, importance, uniqueness and representativeness, would then be integrated into other frameworks of value assessment in their domain.

Sources used in the formulation in this methodology can be seen in the accompanying bibliography.

5. Definitions of terms

Blank: a worked piece of stone having the rough shape and size of a finished object.

“Blank” and “rough-out” are often used about similar objects, the latter maybe the less finished.

Block reduction: the process of reducing the size of a stone block, and in most cases also shaping it, into a core

Block: an angular stone block, irregular or regular in shape

Boulder: a rounded block of stone, in most cases shaped by geological processes

Building stone: stone used for construction of buildings, monumental or not.

Chips: in quarries meaning small fragments of rock leftovers from hewing, carving and dressing

Core: a reduced and often shaped stone block from which the final product can be made

Decorative stone: stone used for decoration (similar to ornamental stone)

Deposit: the known part of the usable (or rather desired) part of a rock unit

Dressing: the process of the final shaping of a stone block to desired size/measurements and evening the surfaces of it

Extraction: in quarries, meaning removing pices of rock from the bedrock

Finishing: the final work on an object before it is finished. Regarding stone objects, includes fine hammering, fine carving and honing/polishing

Grinding stone: stone used for grinding implements (primarily for grinding grain, but also for other purposes, such as grinding other vegetable matter, pigments and minerals). Some use "quernstone" and "millstone".

Hammerstone (stone hammer): piece of stone, often rounded, used for splitting rock. The division between pounder and hammerstone may be blurred, and the same stone tools can be used for both splitting and dressing.

Hard stone: rocks in which the majority of the minerals have hardness larger than steel, including most feltspathic and quartz-rich rocks.

Masonry stone: building stone used for masonry

Mine: a production site for specific minerals that need to be extracted from the rock, including metallic ore, industrial minerals, flint and gemstone.

Natural stone: term used for describing stone resources that are exploited for extracting and shaping blocks of stone.

Ornamental stone: stone predominantly aimed for use as statues, obelisks, decoration or other elite type products.

Pounder: piece of stone, often rounded, used for dressing of stone surfaces. The division between pounder and hammerstone may be blurred, and the same stone tools can be used for both splitting and dressing.

Quarry: 1) place where rocks are being or have been extracted. In most traditions, the term is used in the context of exploitation of whole rock (and not only components within it) such as stone blocks and aggregate production. 2) a stone production unit, limited and connected in space (but not necessarily in time), or a group of overlapping units which cannot be separated. A quarry consists of e.g. extraction sites (where the stone actually has been removed from an outcrop, bedrock or boulder), work areas (where secondary production took place), spoil heaps (left over debitage from quarrying) and other features directly related to the stone production.

Quarry area: a limited geographic area containing a group of quarries

Quarry complex: a collection of quarries related to each other in time, space and/or function, including associated infrastructure and material culture

Quarry landscape: 1) a 'cultural landscape' shaped by stone quarrying, consisting of groups of quarries/quarry areas but also associated infrastructure and other elements of material culture related to the exploitation of stone resources; may also be defined as a landscape containing one or several quarry complexes. 2) a perception (or perspective) of landscapes where stone quarrying activities were important

Resource (stone): the usable (or rather desired) part of a rock unit

Roughout: a worked piece of stone having the rough shape and size of a finished object. "Blank" and "rough-out" are often used about similar objects, the latter maybe the less finished.

Soft stone: rocks in which the majority of the minerals have hardness less than steel, including limestone, marble and soapstone. May also include rocks containing harder minerals that appear "soft" when worked, due to high porosity.

Spoil: leftover rock material from quarrying activities.

Stone (commodity): sometimes used in the same way as "natural stone".

Utilitarian stone: non-elite stone production for manufacturing of everyday products, such as tools.

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(can be downloaded from www.quarryscapes.no):

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7. Enclosures (fact sheets and example sheets)

Fact sheet 1

Rock characterisation

The scientific characterization of the rocks that have been the subject to quarrying 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. The first step is the simple, visual inspection of the rocks (macroscopic examination) and classification of it. In many cases, rocks employed have unique and recognisable features (minerals, structure and colour) visible to the eye that are sufficient to determine provenance. In other cases, combinations of more sophisticated methods are needed, depending on the rock type in question and the nature and size of available samples (see below). In addition to finding provenance, the investigation of mineral composition, texture and physical properties may provide important input to the interpretation of the quality of the stone for specific purposes, being tools or sculptures.

Simplified classification scheme for rocks

Main class	**Subclass**	**Examples**
Igneous rocks	Volcanic (Extrusive)	Basalt, Dacite, Andesite, Rhyolite, Trachyte, Latite, Obsidian
	Pyroclastic (Extrusive)	Tuff, Ignimbrite, Agglomerate, Lapilli, Pumice
	Plutonic (Intrusive)	Gabbro, Diorite, Anorthosite, Granite, Granodiorite, Syenite, Tonalite, Monzonite, Aplite, Pegmatite, Peridotite
	Dyke (Intrusive)	Diabase (UK), Dolerite (US)
Metamorphic rocks	Thermal	Hornfels
	Dynamothermal	Slate, Schist, Phyllite, Marble, Quartzite, Gneiss, Amphibolite, Serpentinite, Greenschist
Sedimentary rocks	Clastic	Claystone/mudstone, Siltstone, Sandstone, Conglomerate, breccia
	Carbonates	Limestone, Dolostone/dolomite, Travertine, Tufa
	Chemical and biochemical	Gypsum, Chert, Jasper, Phosphates
Fault rocks	Brittle	Fault breccias, Cataclastite
	Ductile	Mylonite, Phyllonite

Examples of methods for establishing rock provenance

METHOD	TYPE OF ANALYSIS	PARTICULARLY USEFUL FOR	COMMENTS
Mesoscopic examination	Structure (sedimentary, igneous, metamorphic	All rocks	Many rocks can be distinguished on mesoscopic features alone
	Colour, weathering		
	Minerals and grain size		
	Fossils	Limestone, mudstone, sandstone	Fossils can be diagnostic to certain beds/layers in rock units
Microscopic examination (thin section)	Mineral content	Igneous and metamorphic rocks	Quantitative mineralogy useful for certain groups of igneous rocks. Diagnostic minerals can be highly important for metamorphic rocks
	Mineral fabric	Igneous and metamorphic rocks	Microfabrics can In rare cases be unique
	Microstructures	Igneous and metamorphic rocks	
	Microfossils	Limestone, mudstone	Can allow very detailed identification of strata, also within deposits
Whole rock geochemistry	XRF main and trace elements	Igneous and metamorphic rocks	
	ICP-MS Rare earth elements	Igneous and metamorphic rocks	Particularly for igneous and metamorphic igneous rocks
Mineral geochemistry	SEM/Microprobe	Igneous and metamorphic rocks	For minerals which commonly display large variations in chemistry
Cathode luminescence		Limestone, marble, quartzite, sandstone	Can identify growth generations, recrystallisation patterns and source of quartz grains
Isotopes	d13C/d18O (Sr)	Limestone and marble	Can in some cases give unique signatures
	Sr-Nd	Mafic and ultramafic igneous rocks	Particularly useful for intermediate to mafic volcanic rocks
Radiometric dating	Zirkon U-Pb	Igneous rocks	Can give accurate dating of the rock
	Ar-Ar	Micaceous rocks (metamorphic)	Can give cooling age of mica in metamorphic rocks
Petrophysics	Magnetic susceptibility	Igneous rocks	In rare cases can be diagnostic
	Palaeomagnetism	Igneous rocks	Rocks can be linked to geological provinces by palaeomagnetism (indirect dating)
Physical properties	Various mechanical tests	Particular cases	

Fact sheet 2

Stone commodities

For what purpose was a specific rock quarried at a specific time? At present time, as in the past, the exploitation of stone resources can originate from different needs; of available building material, of particularly valuable stone for decoration, of high quality rocks suitable for specialised tools. The view of stone resources as commodities may be helpful in getting closer to why they were exploited and the past.

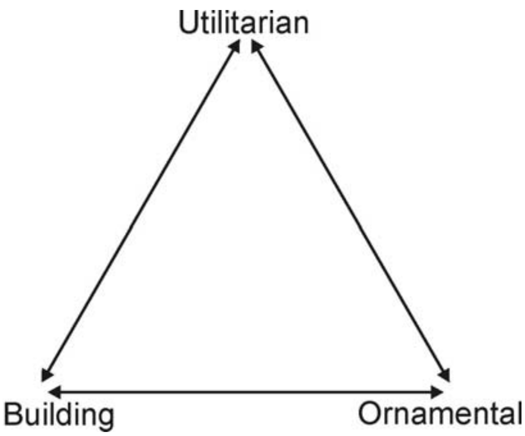
Building stone includes stone resources that were basically quarried to obtain construction materials for roads (paving) and buildings, i.e. the stone forms an integral part of the construction, and not primarily for decoration. "Masonry stone" is a term that is also used, but in a somewhat more narrow context (excluding for instance rubble for local housing) and "monumental building stone" even more restricted, to prestige buildings. 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.

Main commodity groups of stone resources

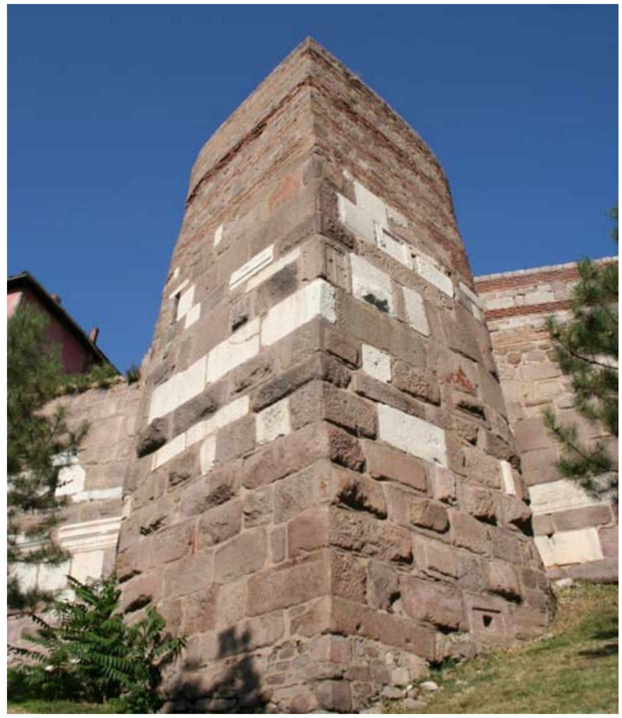
	Commodity	**Uses**	**Common rocks**	**Important aspects**
Stone resources	Building stone (masonry stone)	Rubble walls Ashlar walls Architectural elements Roof Floor Paving (funerary)	Sandstone Limestone Granite Gneiss Marble Schist Slate	Availability Workability
	Ornamental stone (decorative stone)	Sculpture Cladding Floor Columns Funerary	Marble Granite Div igneous rocks Porphyry Gneiss Quartzite	Aesthetic appearance Symbolic value Rarity Carving properties
	Utilitarian stone	Tools Weapons Grinding stone Millstone Whetstone Cooking vessels (funerary)	Chert Volcanic rocks Quartzite Sandstone Schist Soapstone	Physical properties



Stone commodity groups as three overlapping perspectives.

Ornamental stones in the St. Marc's Cathedral, Venice, chosen for their aesthetic appearance.

Utilitarian stone – exemplified by a millstone, Norway



Building stones, Ankara, Turkey. Ashlars of volcanic rocks and marble.

Stone for funerary monuments – Roman sarcophagi in travertine, Hierapolis, Turkey

Fact sheet 3

Physical properties of rocks

The scientific characterization of the rocks is useful for many reasons, but ancient as well as modern quarrymen were not particularly concerned about the geochemistry or origin of the rocks employed. Rather, what did concern them, was the workability and technical properties of the rocks. Hard or soft, brittle or less brittle, etc. Such properties are important to identify in order to understand how the resource itself impacts on the quarrying technology employed. As shown below, we can divide rocks into rather simple groups according to their working/quarrying properties.

Massive stone includes rocks that do not have closely spaced planar planes of weakness along which the rocks easily split into slabs. Thus, they are extracted as blocks of more or less uniform shape. We may subdivide them into *hard rocks* and *soft rocks*; basically, “hard rocks” are composed of minerals that are harder than steel, such as granite, quartzite and gabbro. “Soft rocks” are consequently composed of minerals softer than steel and/or poorly cemented rocks and include marble, limestone, porous sandstone, soapstone etc. But regarding quarrying and processing, the contrast between hard and soft rocks appears large, and will be displayed by completely different quarrying techniques and/or applications.

Cleavable stone includes a variety of rocks that display closely spaced planar structures along which the rocks split easily. Thus, they are extracted as slabs, not blocks. Examples are roofing slate and flagstones for paving. *Rubble* basically includes any stone that is collected and used for any purpose without being further worked.

Division of rocks according to their physical properties (hardness, brittleness and cleavability)

NATURAL STONE	MASSIVE STONE (quarried as blocks)	“Hard” rocks	Granite, gabbro and most other igneous rocks Quartzite Chert Silica-cemented sandstone
		“Soft” rocks	Limestone Travertine Marble Calcite-cemented sandstone Gypsum (alabaster) Serpentinite Soapstone (steatite)
	CLEAVABLE STONE (quarried as slabs)	Slate	True slate or any other thin-layered low grade metamorphic rock
		Schist	Phyllite, schist, green schist or any other layered metamorphic rock displaying a spaced cleavage
		Flagstone	Thin bedded sedimentary rock or thick-layered metamorphic
	RUBBLE (collected)		Any available

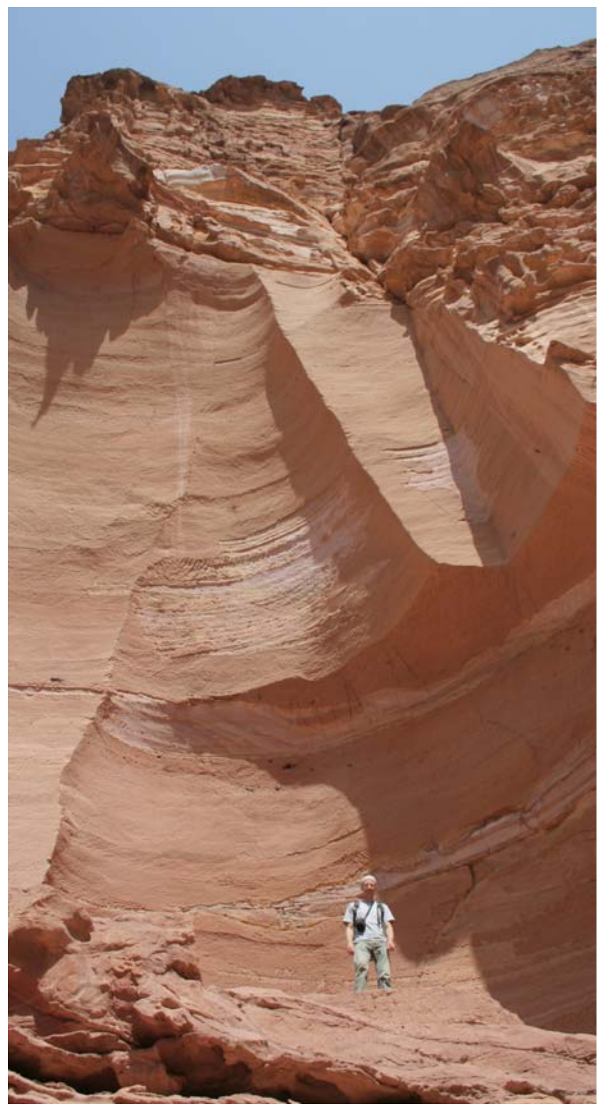
Fact sheet 4

Stone resource geometry, occurrence and the resulting layout of quarrying

The exposure of stone resources in the landscape is the result of multiple geological processes; from the formation of the rocks, through transformations of them through weathering and landscape forming processes. The geometry and outcropping pattern of the resource establishes the physical conditions of quarrying, to which quarrying 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 visually appears. 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.

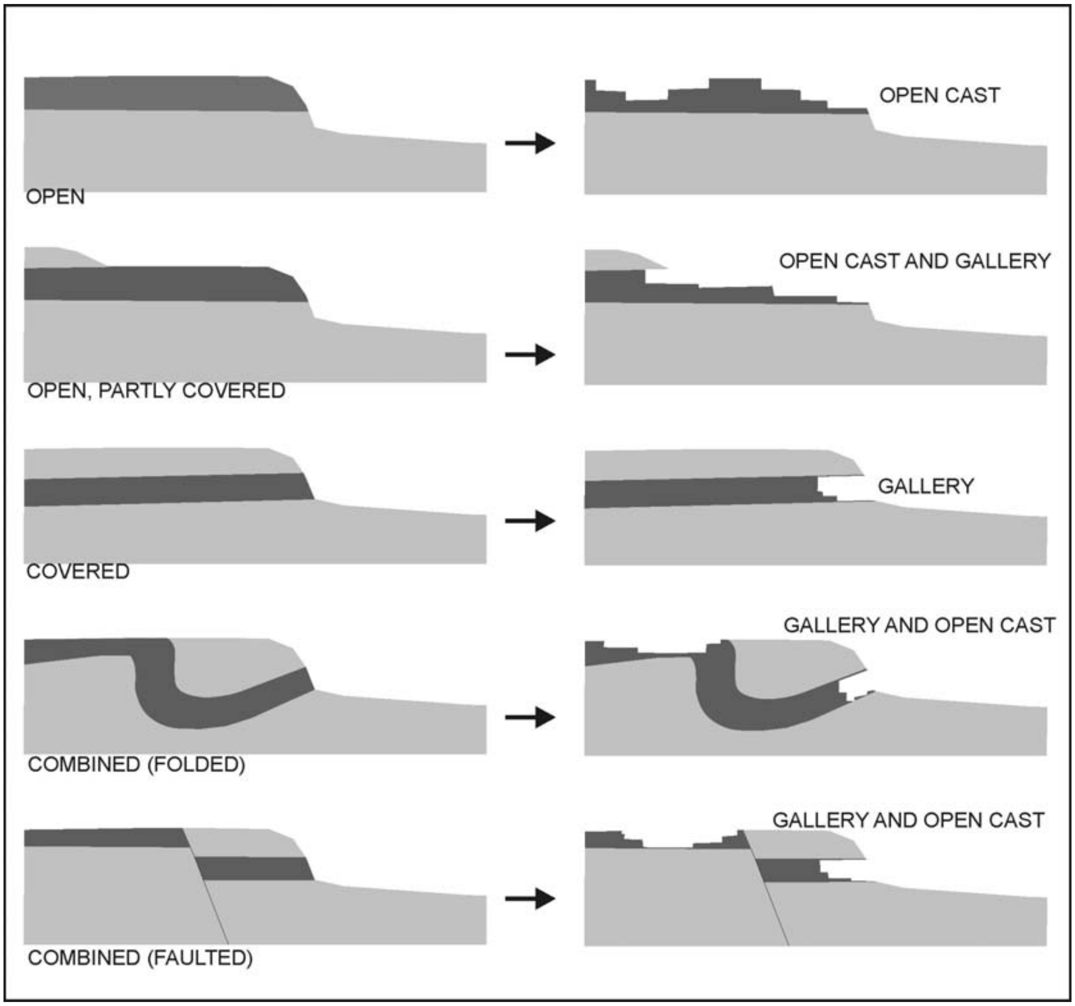
Since quarrying is about removing pieces of rock from the landscape, being able to reconstruct the situation before quarrying is an important part of characterizing quarry landscapes. In the case of an underground quarry (gallery quarry) leaving a distinctive cavity in the resource, such interpretations 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 the resulting quarry landscape may be visualize as small, scattered heaps of debitage 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 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 shown in the examples below.



Steep and tall sandstone quarries at Petra, Jordan, carved with picks and chisels.

Examples of layered deposit geometries and the resulting quarry layout

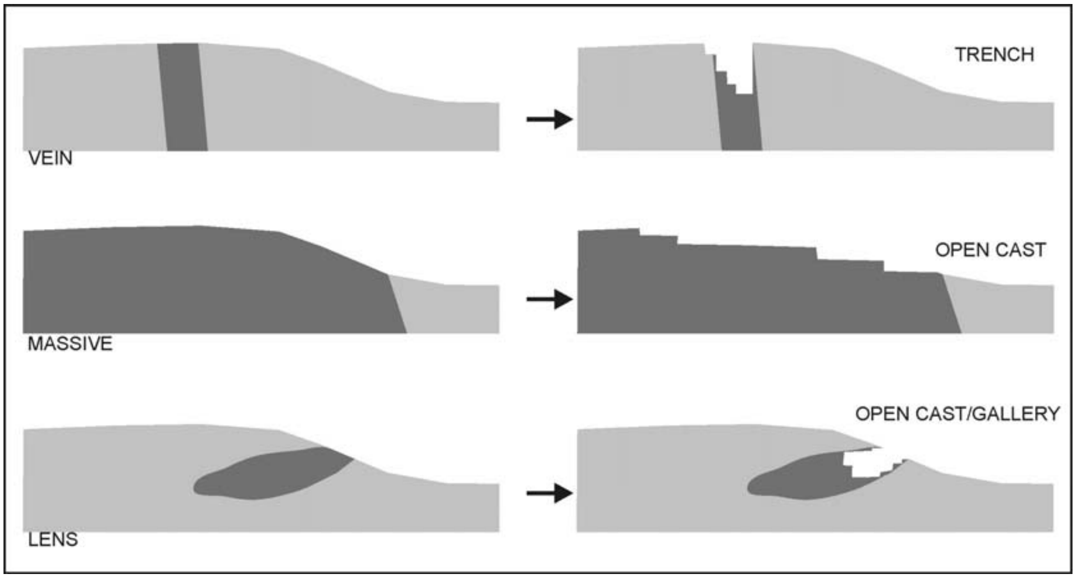


Open cast sandstone quarries situated in a horisontal layer of good quality sandstone (upper limit marked with the dotted line). Gebel el Silsila, Egypt.

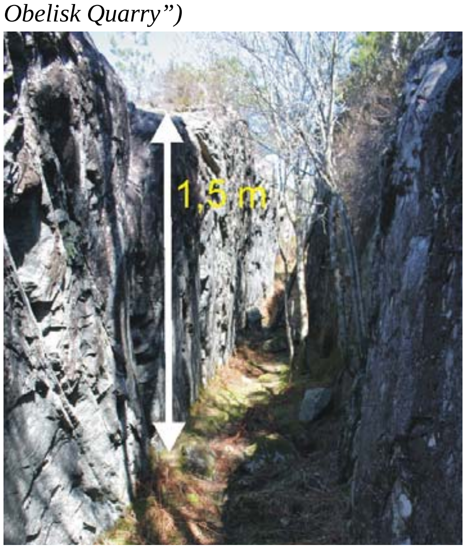
Horisontal layer of basalt (above dotted line) exploited during the Old Kingdom. Faiyum, Egypt.

Gallery quarry following a high quality sandstone layer. Gebel el Silsila, Egypt

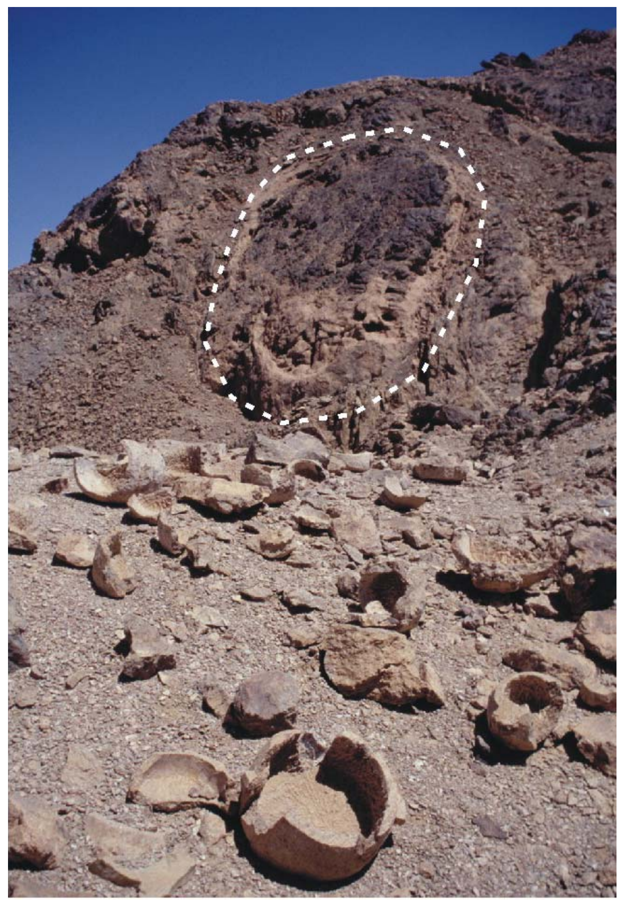
Examples of non-layered deposit geometries and the resulting quarry layout



Massive deposit of granite, Aswan, Egypt ("Unfinished Obelisk Quarry")

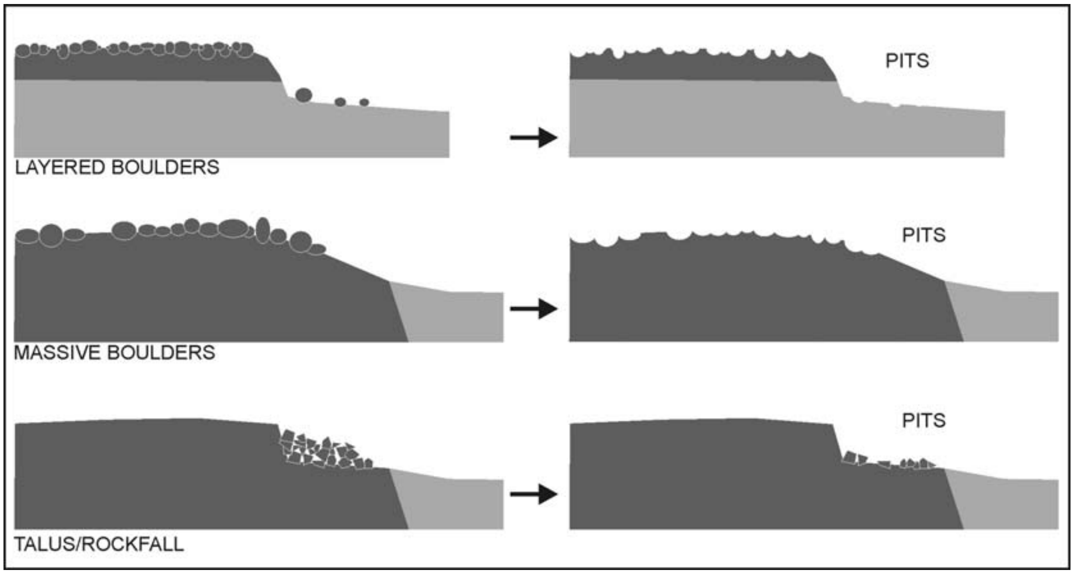


Trench quarry caused by extraction of a dyke rock, Norway.



Lens-shaped soapstone deposit, Egypt. All the quarries are situated along the margin of the deposit where the quality is best (close to the dotted line).

Examples of surface deposit geometries and resulting quarry layout



Boulder weathering in granite. Aswan, Egypt

Spoil heaps around cluster of worked boulders of gneiss, Chephren's Quarry, Egypt.

Quarry pits with circular spoil heaps formed after quarrying of scattered boulders, Aswan, Egypt.

Fact Sheet 5

Principles of stone extraction

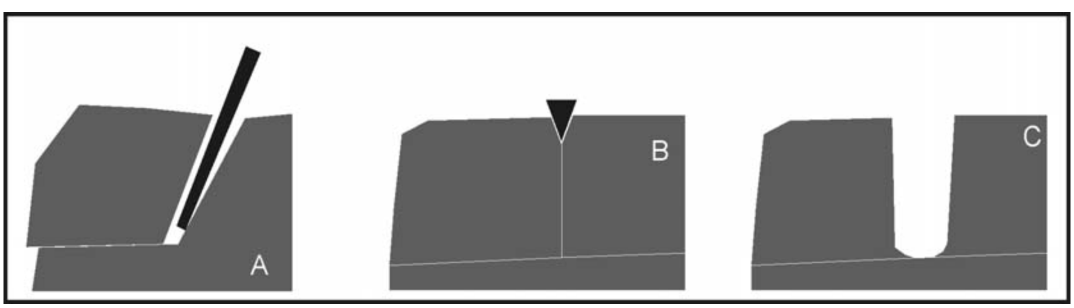
In all stone quarry situations the extraction phase is based on one or combinations of three fundamental principles:

1. Levering; expanding open fractures by inserting levers, crowbars or stones
2. Splitting; creating fractures, preferable planar, by strokes (i.e. sledge hammer), wedging; heating or blasting with explosives
3. Channelling (carving); making channels in the rock by carving with hammer and chisel, pickaxe or stone tools, heating with fire, sawing or drilling

Levering may be described as the "simplest" way of extraction, involving the expansion of natural cracks or other planes of weakness (such as bedding planes) using various tools.

Splitting may be defined as the act of generating new fractures for extracting rock. This may be done by percussion (stroke), inserting wedges of some kind in prefabricated holes or by heat. In a modern context, splitting is mainly done by detonating explosives in drillholes. Although splitting techniques may be applied on most rock types, it is working best on hard siliceous (quartz-rich) ones. Partly because they in general display the most brittle behaviour, but also because it is a well documented fact (and experience among quarrymen) that siliceous rocks (granite in particular) have well defined preferred splitting directions defined by microfractures in quartz. Splitting by heating is caused by a combination of thermal expansion properties and brittle behaviour. It works best on quartz-rich rocks due to the well known but poorly understood change of mechanical properties of quartz when heated.

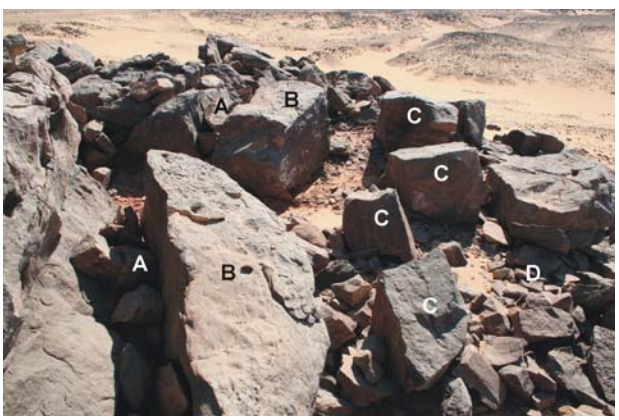
Channelling is the third fundamental principle. Channels in the rock are made by removing the rock mass by chiselling, picking, sawing or heating. In most soft stone quarries from the Bronze Age onwards, channelling is the most important extraction method. In most cases, channelling is combined with other methods. For instance, channels are made perpendicular to the natural layering of the rocks, and when the block is free on four sides, it is split with wedges ("trench and wedge" method) or levers/crowbars inserted in chiselled grooves ("Minoan technique") or by inserting wooden wedges in the channels themselves, creating shear stress along the block's bases.



Three basic principles of extraction from bedrock. A) levering, B) splitting and C) channelling.

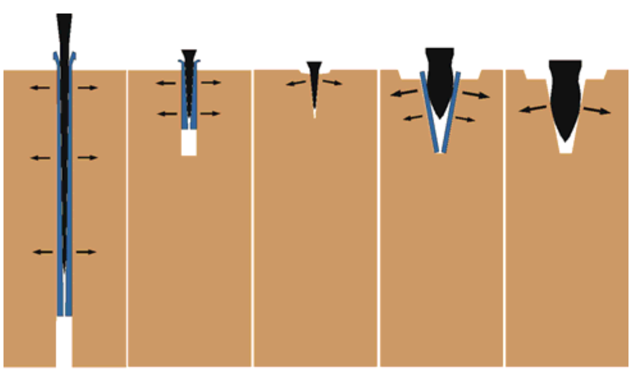
Principles of extraction and associated process/features

Principle	Process	Tools	Toolmarks
Levering/extraction on fractures	Crack expansion	Logs Crowbars Stones	Hardly any
Splitting	Percussion	Stone hammers/pounders Chisel Pick Sledge hammer	Percussion marks, plumose marks on cracks
	Wedging	Simple iron wedges Plugs and feather wedges Wooden wedges	Wedge marks of various shapes
	Heating	Fire	Surface parallel flaking
	Blasting (M)	Explosives	---
Channelling	Carving	Chisel Pick Stone tools	Straight parallel Curved parallel Pointed grooves
	Sawing	Blade Wire	Sawn surface, straight grooves Sawn surface, curved grooves
	Drilling (mainly modern		----
	Heating (mainly modern)	Fire	----



Opening natural fractures and isolating blocks by inserting stones (A). The blocks are then further split in several steps (B and C). Aswan, Egypt.

Splitting granite with small iron wedges (Vigo, Spain).



Wedging techniques. The two on the left side ("plug and feather") are put in premade drillholes (modern).

Roman wedge-marks from splitting, Aswan, Egypt.

Wedge-line in a Roman granite quarry, Egypt.

Percussion marks made by chisel for splitting a sandstone block. Roman Period, Egypt.

Percussion marks made by stone hammers for splitting a sandstone block (Dynastic Egypt).

Channel in granite quarry, Egypt, made by stone hammers, possibly combined with heating.


Channel made by Roman pick in limestone quarry. Sagalassos, Turkey.


Channels around limestone block made by bronze chisel, and premade holes for inserting wooden levers or wedges along the base. Old Kingdom, Giza, Egypt.


Channel in sandstone made by Roman iron pick and premade holes for inserting levers or wedges to split the block along its base. Roman Period, Gebel el Silsila, Egypt.


Extraction of marble slabs by chiseling channels around the blocks and splitting along their bedding plane by pointillé-method (repeated strokes with a pointed chisel along the splitting plane). Byzantine marble quarry, Thassos, Greece.

Fact sheet 6

Tools and tool marks

Different tools applied in the quarrying process leave marks on the stone surface that can be interpreted and even used for dating the quarries if the preservation is good. There are three main types of tools applied in quarrying:

1. Stone tools (stone hammers and pounders)
2. Chisels (and mallets)
3. Picks

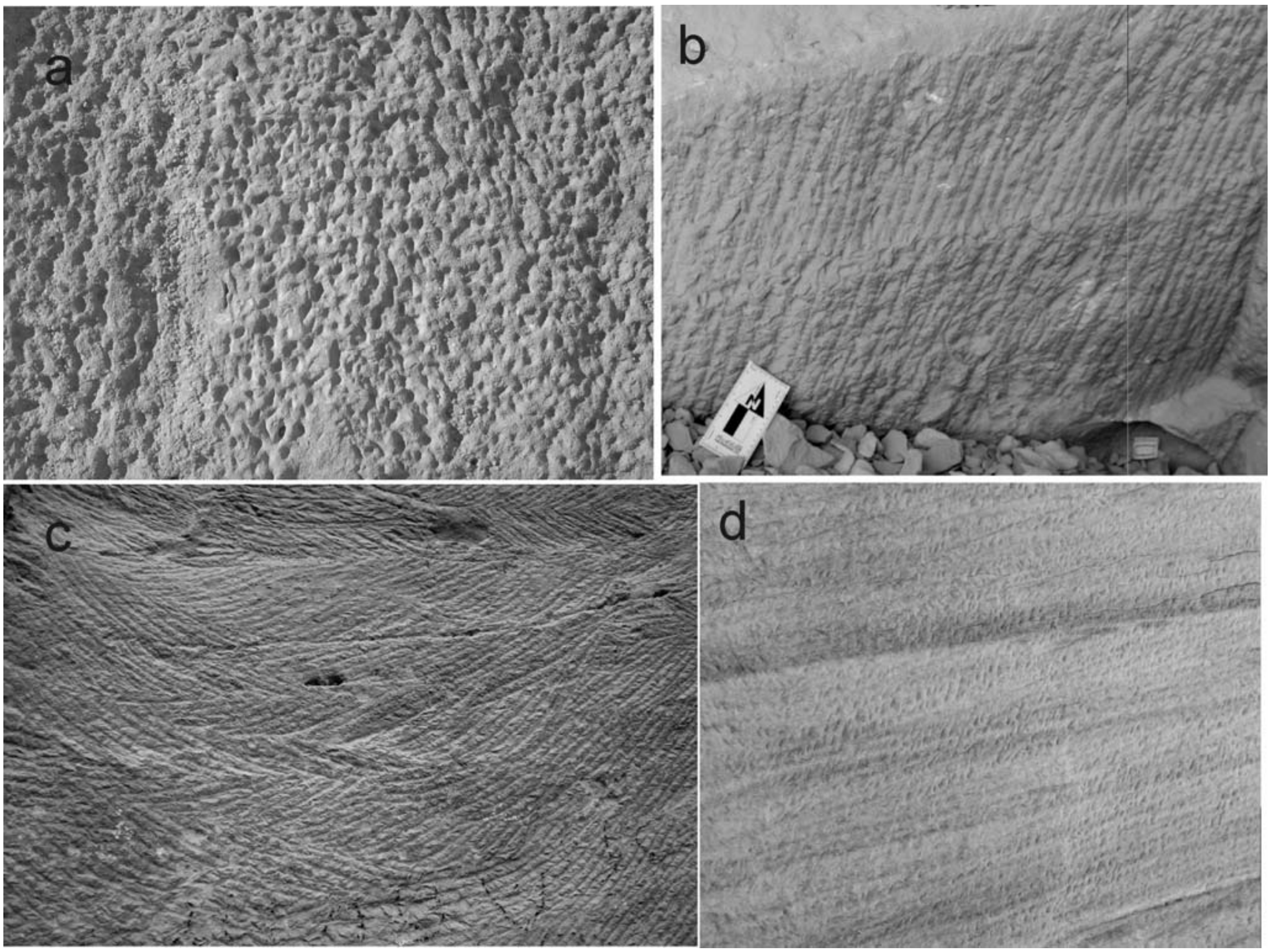
The use of stone pounders leaves a smooth surface displaying a dense pattern of percussion marks from the blunt tool. Corners tend to be rounded.

Channelling with metal tools leaves parallel grooves on the quarry face that may differ in appearance depending on the rock type, tool and method of channelling. Parallel, curved grooves are often interpreted as pick marks. The curving is a result of working from one position at the time, and the marks thus define a circle in which the quarryman's arm and the pick define the radius. Parallel, straight grooves are interpreted as marks from chisels. The inclination of the grooves tells us something about how the channels progressed; steeply inclined grooves are worked from one side, horizontal ones are worked from the top, and "herringbone-pattern" reflects frequent change of position.

Marks from stone tools on a silicified sandstone block, Aswan, Egypt.

Outcrop in silicified sandstone worked by stone tools, Aswan, Egypt.

Examples of pounders. Left: granite cobble stone from the river bed, Aswan West Bank, Egypt. Middle: manufactured granite pounder, Chephren's Quarry, Egypt. Right: hafted stone hammer made of imported rock found in Widan el Faras Basalt quarries, Egypt.



Tool marks on quarry faces. a) stone hammer marks on quarry face, silicified sandstone, Aswan West Bank, Egypt (New Kingdom), b) inclined chisel marks on inclined shifts, sidewall of a channel in sandstone, Aswan West Bank, Egypt (Greco-Roman), c) assumed pick marks (curved shifts and changing directions) on a sandstone quarry face, Petra, Jordan (Nabatean), d) inclined chisel marks and horizontal shifts, marble quarry, Thassos, Greece (probably Byzantine)

Fact sheet 7

Spoil characterization

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 often is necessary during quarrying for getting access to rock outcrops, care must be taken in the interpretation.

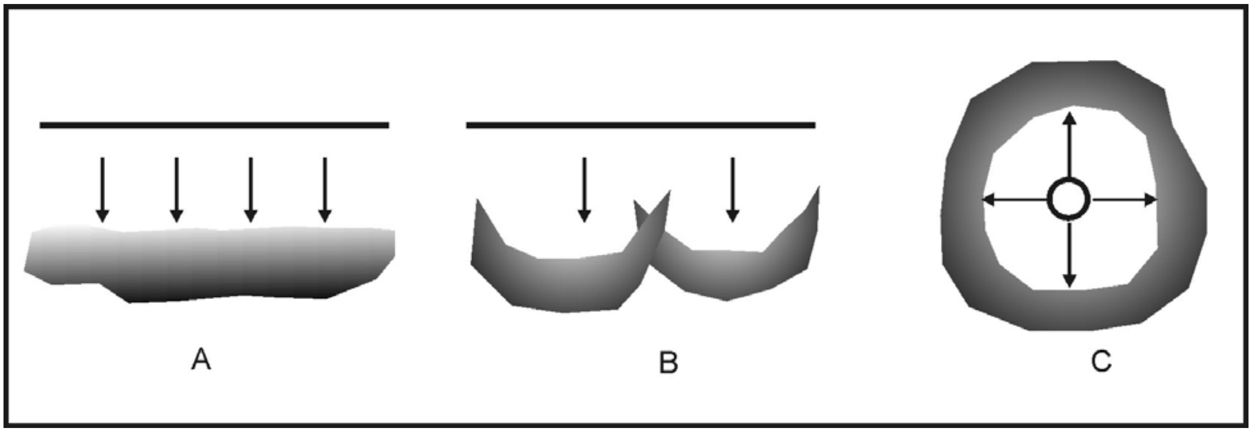
Huge spoil heaps in fron of sandstone quarries at Gebel el Silsila, Egypt.

Uniform distribution of spoil fragment size indicate mass production of small product, in this case grinding stones. Aswan, Egypt.

Fine sand mixed with tool fragments, deposited from grinding of obelisks in a Dynastic silicified sandstone quarry, Aswan, Egypt.

Roman work area in silicified sandstone, Aswan, displaying a variegated composition of the spoil material, from blocks (waste from splitting) to fine chips (from carving).

Spoil heaps in limestone quarry, Sagalassos, Turkey. Quarry face in the foreground, transport exit in between the heaps.



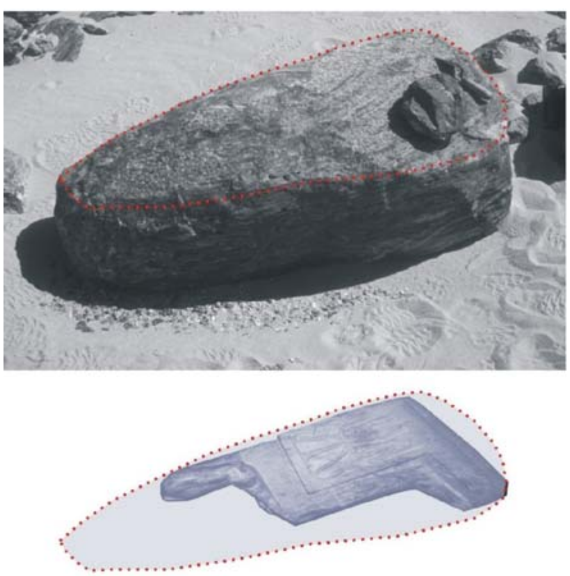
Three situations of spoil heap development. a) simultaneous extraction along the full length of a quarry face, b) progressive extraction from a quarry face (first right side then the left), c) spoil heap around a central point of extraction.

Fact sheet 8

Blanks, roughouts and finished products in quarries

In most cases, the “products” being made in a quarry are not ready to use. They are “blanks”, “roughouts” or “dressed blocks” which were brought to a workshop or a building site where the completion of them took place. An ashlar may have been finished to the point of its dimensions and rough shape in the quarry, but the final working for fitting it with others and making a smooth surface was 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.

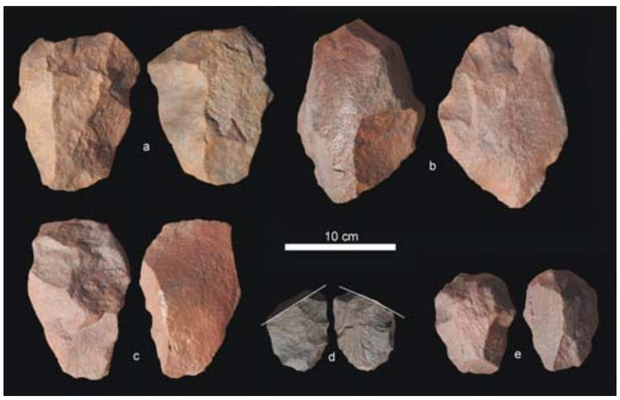
The question of finishing or not in the quarries thus depends on several factors that usually fall into the realm of economic and functional explanations: on the one hand it is important to avoid costly transport of excess stone and stone with failures that may break at a later stage of finishing. So, 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.



Dressed block of stone shaped as a “statue blank” fit for making life sized statues of King Khafra, Old Kingdom, Egypt.

Oval grinding stone blank as found in the quarries made from silicified sandstone, Aswan, Egypt

Stockpile of roughly shaped vessel blanks in Chephren's Quarry, Egypt.



Roughout of Palaeolithic tools (axes and scrapers) as found in the quarry sites, Aswan, Egypt

Semi-finished statues, Aswan, Egypt

Close to finished, Roman column at the Mons Claudianus granite quarry, Egypt

Obelisk tip, finished to inscriptions, at Aswan West Bank, Egypt

Trimmed blank of statuette, Aswan, Egypt

Fact sheet 9

Quarry logistics

The transport of stone blocks and products is an important element of all quarrying activities. Clearly, the production of small objects that can be carried by a man or a donkey does require less constructed infrastructure than huge obelisks. However, whatever the output of the quarrying was, the remains of elements related to transport are important to characterise. These remains can be divided into groups:

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

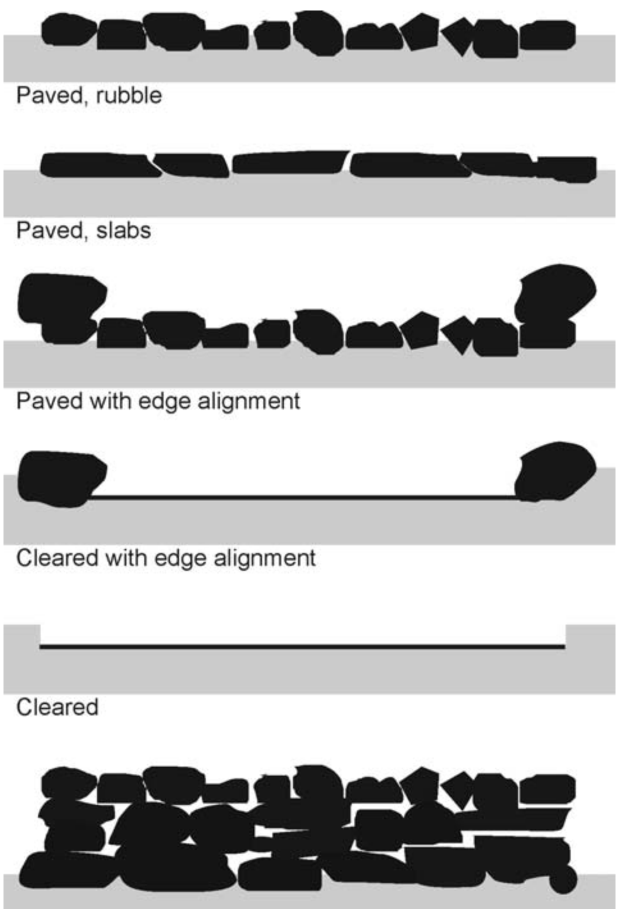
The internal logistics in a quarry may be defined as all transport between the production steps, and from the final step to a place of stockpiling or specific loading area if that exists. Depending on the pattern of production and the outcome of it, the internal logistics between the production steps may include constructed features or not.

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 less heavy stone products, they are not necessarily less important, and may contribute with important information about the exploitation in general.

Types of roads and ramps commonly found in quarries

Feature	**Classes**	**Definitions**
Road	Paved road	Road with a surface of (stone) pavement
	Non-paved road/earth road	Road with a cleared and/or smoothened surface on the natural soil
	Hollow road	Road defined by a semicircular depression made by repeated use for transport of goods
	Rock cut road	Road that is carved in the bedrock
Causeway		Built-up structure made for evening out topography
Slipway		A worn path made from sliding stone blocks down from one level to another
Ramp	Loading ramp	Built-up structure made for loading stones onto a vehicle of transport
	Terrain ramp	Built-up structure that connects one level of topography with another
Path	Footpath	Single path resulting from repetitive use by people and/or animals
Track		Multiple paths resulting from repetitive use by people and/or animals along a route

Tall loading ramp at Chephren's Quarry, Egypt (Old Kingdom); the parallel tracks in the foreground were artificially dug so that the top of the transport vehicle was level with the top of the ramp.



Types of road constructions seen on the Aswan West Bank, Egypt, from the New Kingdom Period.

New Kingdom quarry roads at the Aswan West Bank, Egypt

Built-up ramp for leveling out the terrain features. New Kingdom, Aswan West Bank, Egypt.

Quarry road paved with rubble. New Kingdom, Aswan West Bank, Egypt.

Paved quarry road made for transporting basalt blocks to the pyramid sites, Egypt, Old Kingdom.

Paved quarry road in Hellenistic marble quarry, Mount Pentelikon, Greece.

Roman quarry road carved out in the rock, displaying deep wear marks from wheels. Nea Skyra, Evia, Greece

Foot path for people and animals in a grinding stone quarry, Aswan, Egypt.

Cairn along stone transport route, Egypt

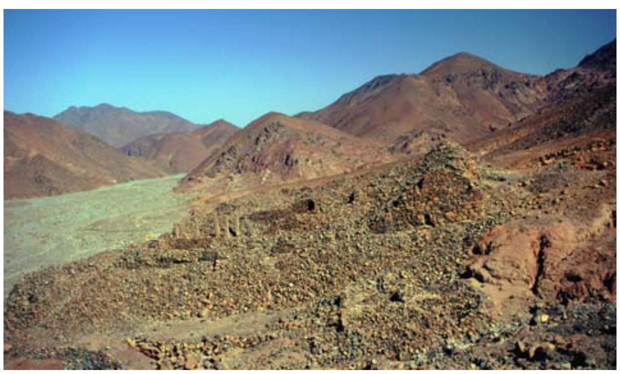
Mooring sockets for transport boats in a harbor at the Gebel el Silsila sandstone quarries, Egypt.

Fact sheet 10

Stone-built features

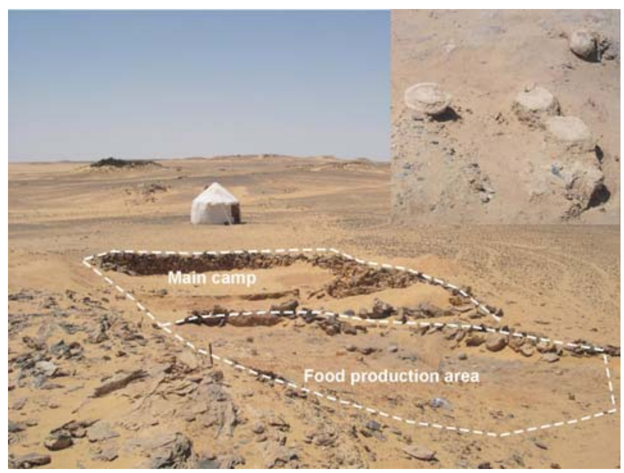
Identifying and characterising the ‘social infrastructure’ within a quarry complex as a means to interpret the social organisation of quarrying can be problematic, given that such remains are usually fragmentary and difficult to visualise. The problem in visual terms is that easily recognisable large purpose-built settlements associated with ancient quarries, the key remains to make inferences into the social context, are the exception rather than the rule. Hence, in the search for dwellings for quarry labour forces, much emphasis has been placed on the ubiquitous ‘stone circles’ or ‘stone enclosures’ and other mundane structures that occur in a number of ancient quarries, as being places of habitation.

Occurring either as scatters of one to several levels of dry-stone walls, or as clusters built around natural rock outcrops, recent excavation of such features in a range of ancient quarries has led to a greater understanding of the variety of functions that can be attributed to these structures. In essence, functions that can be applied to these features can range from temporary dwellings and shelters to ritual features, storage areas, smithy’s, wells and defense structures. By characterizing such features by their construction, location and material culture, it is possible to add significant layers of information, as crucial to understanding the social context and construction of an ancient quarry.



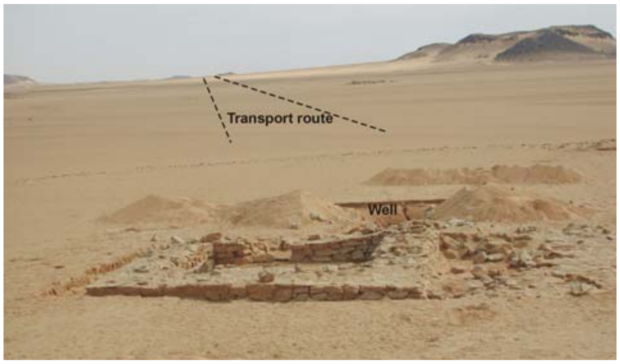
Roman quarries in the Eastern Desert of Egypt are exceptional in having large permanent settlements for the work force. Here from Mons Porphyrites.

Temporary settlement/shelter in Roman quarry, Aswan, Egypt



Temporary settlement/camp along the transport route at Chephren’s Quarry, Egypt (Old Kingdom)

A well (excavated on the right side) in Chephren’s Quarry, Egypt



Large well for animals along transport route, Chephren's Quarry, Egypt


Elaborated house by Roman marble quarries, Evia, Greece, probably for housing troops.


Stone-built feature near a quarry road (in the background) on Aswan West Bank, may be a lookout.


"New" (after 1850) and older (foreground right side) house ruins in a Norwegian millstone quarry (photo: T. Grenne)


Shelter made around natural outcrop, Aswan, Egypt (New Kingdom)

Fact sheet 11

Domestic artifacts

Whether or not the workmen in a quarry where there on a permanent or temporary basis, they left artifacts which can provide important information about the size and organization of the labour force. *Pottery* can be located in association with the social infrastructure, such as stone-built features and also in places of stone extraction. Such evidence is key in terms of indirectly determining periods when quarrying occurred and when found associated with stone-built features in secure contexts, is important to dating such structures. Typologies of ceramics can indicate not only chronology, but can aid in characterising subsistence patterns of a labour force, particularly when associated with organic remains. In addition, studies of ceramic fabrics can indicate whether pottery was locally made or imported to a quarry, this can have implications in determining the extent to which outside 'agencies' or a centralised bureaucracy were involved in the provisioning of a labour force. Other artifacts that may be found in quarries include grinding stones, whetstones and other kinds of domestic tools.

Old Kingdom ceramics found in Chephren's Quarry, Egypt. a) pouring vessel (found in well), b) bread mould, c) beer/wine jar

New Kingdom and Roman pottery as found in a shelter in a sandstone quarry, Aswan, Egypt.

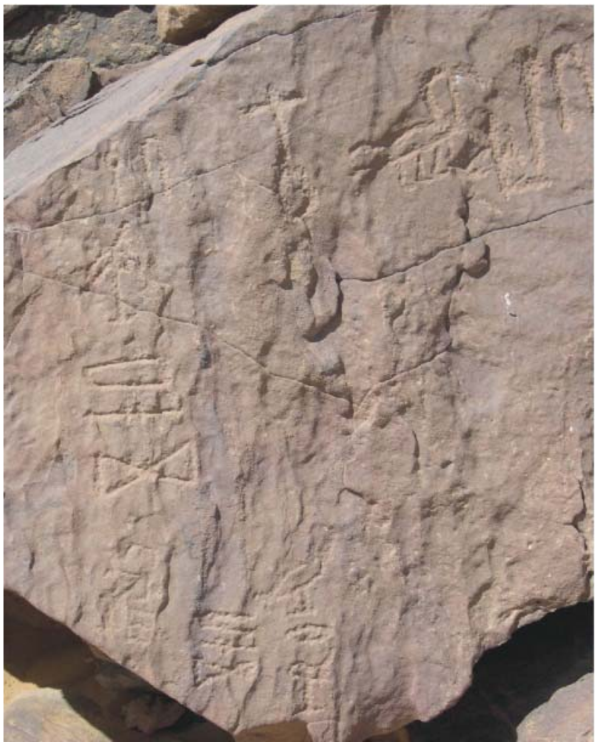
Used grinding stone found in temporary settlement, Chephren's Quarry, Egypt

Fact sheet 12

Epigraphic data

Characterising and visualising epigraphic data across an ancient quarry landscape and assessing meaning, in terms of understanding the social context of quarrying, can be problematic to unravel. ‘Epigraphic data’ is a collective term we have used to define any type of man-made inscribing of an ancient quarry landscape. Such inscribing can be as inscriptions, graffiti (this can include usually single characters and/or geometric of unrecognisable symbols, masons marks), rock art/petroglyphs (carvings on rocks of animals, humans, boats and symbols of often a religious nature and other pictorial, stylised and abstract art forms).

This range of epigraphic data and how it occurs across an ancient quarry landscape is extremely variable. In most instances, epigraphic data is usually inscribed onto a natural rock face. These may be cut into a worked quarry face, so placed there after quarrying. Or, epigraphic data may occur on unworked rock faces close to an extraction site in a quarry complex. Sometimes epigraphic data may be located in places across a quarry landscape distant from the extraction sites, this can often be along transport routes or at key places of embarkation from the quarries. Whether the epigraphic data are directly linked to the quarrying (made by the work force) or not (other use of the landscape) is a matter of interpretation in each case.



Hieroglyphic inscription by the transport route leading from Chephren’s Quarry to the Nile, naming the “overseer” of the craftsmen.

New Kingdom marks on sandstone outcrops naming mr-Ra (beloved of Ra), Aswan West Bank, Egypt. This probably relates to the solar cult linked to the use of silicified sandstone.

Grafitti and greek inscription on a quarry face at Gebel el Silsila sandstone quarry, Egypt. The graffiti reminds the shape of the Ptolemaic temples made by that stone.

Petroglyphs in a sandstone quarry, Aswan West Bank; connected to quarrying or not?

The famous Khufu Stela, as found by Rex Engelbach in 1933, Chephren's Quarry, Egypt.

Painted lines displaying progress of quarrying in sandstone quarry, Gebel el Silsila, Egypt

Fact sheet 13

Identifying heritage values

Lipe developed what are still key terms of reference through which types of resource value, can give meaning and importance to cultural materials of the past across a range of interests as summarised below:

Associative/symbolic value; the essence of physical cultural remains and their authenticity, that can transmit cultural information about the past. Powerful as symbols of the past that can also be bound up in 'Communal value' in terms of collective memory for those who relate to it by proximity but also in terms of society's needs in general for continuity through time.

Informational value; emerges from formal 'expert' research, in particular from multidisciplinary approaches and having to make 'best projections' of what kind of resources/elements will be most useful for future study.

Aesthetic value; complex and culturally specific, there is power in aesthetics to symbolise and commemorate a past culture. These values can also relate to actions from nature and man on a resource in how it looks today, its evolution through time that can also enhance its symbolic value.

Economic value; cultural resources have to compete with alternative uses of space and are not exempt from being reduced to costs and benefits in monetary terms. Hence, decisions re cultural resources to study, preserve, display, neglect and destroy all have an economic dimension. There are several pathways that resources enter the 'market' as: utilitarian value as a means to serve a present day need, modern quarrying, but also includes adaptive re-use but can these values can conflict with symbolic/associative and aesthetic values that led to it becoming a cultural resource in the first place. Informational value may still be inherent in a cultural resource even if elements have been incorporated into another function, such as a park or farm. Destruction of the resource for more pressing economic uses, as long as detailed recording has been undertaken, means that some informational value can still be accessible. Associative and aesthetic value in economic terms can be in conflict with associative/symbolic value if present day use means a severing of its power to evoke a remembrance of a past culture. Although any contemporary use of a resource will be different from its use in the past, there is need to assess the extent to which alternative uses will enhance or detract from associative and aesthetic values and degrees to which these are economically feasible.

Mason has added further to assessing values of cultural resources, such as 'social value' that may not capitalise directly on the historical value of the cultural resource, but rather on use of the place for social gatherings and cohesion that may be related to special interest groups, community identities or on other feelings of affiliation to the place. Cultural resources may also have spiritual and religious value in terms of evoking wonder and awe. In addition, economic values may also be perceived in terms of 'use' and 'non-use' value. The former refers to goods and services that can flow from the cultural resource (market value) such as admission fees, cost of land, goods and services that flow from it. In the latter, non-use value refers to the way in which individuals are willing to allocate economic resources to acquire or protect cultural resources. This may be broken down into three sets of values that relate to the type of heritage consumption: (1) Existence value (individuals value the heritage for its mere existence); (2) Option value (that it might be consumed in the future); (3) Bequest value (bequeathed as an asset for future generations).

Fact sheet 14

Four concepts of quarry landscapes

<u>I. Socially constructed landscapes</u>: this concept can be used to isolate values of multi-period quarry landscapes in terms of time depth of quarrying and also use and re-use of the landscape for other activities. Authenticity of cultural remains are key to assessing historical values, although often ancient quarry landscapes can lose 'authentic' remains of earlier quarrying from later quarrying and re-use. To get at the significance of these multiple traces of quarrying over time, and its connection to other activities occurring across the landscape, the concept of a 'socially constructed landscape' allows for the historical value context to be assessed in its totality. Stone working traditions, aspects of ancestry, and connection to a landscape, are key concepts to get at. Contributions from landscape archaeologies, ethnography and social archaeology are key theoretical sources that can aid in re-constructing the social landscape and from which historical values may be linked to specific material resources.

<u>II. Contact landscapes (consumption)</u>: ancient quarry landscapes do not exist in a vacuum but have connections with other places, sometimes over thousands of kilometres away, related to consumption of the material that came from the resource. In some instances these contacts may be extremely close to a quarry landscape and may be related to providing stone to a major city or monument of enormous historical importance. Hence, part of the historical significance of the ancient quarry, although this may be hard to visualise and attach to actual physical remains, is its connection to another more highly visible place. Consumption of stone from a particular resource over a wide geographical range can also be historically significant, in terms of identifying ancient trade patterns and values placed on particularly sought after resources over time. These contacts may also be significant in terms of identifying cross-cultural social relations between people, centred on the trade and consumption of a stone resource, that places the ancient quarry landscape at the epicentre of these connections.

<u>III. Associated historical significance</u>: at a macro-level, some ancient quarry landscapes may be implicated in and provide additional evidence about significant events and transformations in history and prehistory. For instance, political and ideological change at key periods in history may provoke intensive production of a specific resource due to its symbolic association with an emerging religious cult. Quarries can be key places to identify changing social relations in the transformation of early states, particularly where monumentality and large-raw material procure-ment were key indicators of an emerging political elite. Explosions in quarrying for utilitarian objects from a specific resource, such as grinding stones, may tell us about major changes in diet and methods of food processing at key transformative stages in prehistory. Important insights into past environment may also be directly and indirectly evident at ancient quarries. Technological changes in society over time can be reflected in quarries, for instance, the introduction of iron technology into quarrying.

<u>IV. Dynamic landscapes</u>: quarry landscapes, as with any type of landscape, are dynamic places that are not static in time. Although the concept of a 'socially constructed landscape' allows us to view multi-period transformations as adding new layers of historical significance, directly or indirectly related to quarrying, how do we articulate values of quarry landscapes where re-use for other activities may have completely or partially destroyed them? The aim is to view the landscape holistically from a perspective of how human agency into the present may have totally changed an earlier landscape and what threads of these past elements have been inherited and still survive. This is a particularly useful concept to use when a quarry landscape has been totally integrated into a modern city and where we need to assess historical and informational values through human agency as characterising the present-day landscape, rather than its past.

Fact sheet 15

'Outstanding universal value': global significance, authenticity and UNESCO criteria for establishing World Heritage Status

Three of the key criteria important in the establishment of significance, such as scale, importance, uniqueness or representativeness can also be articulated within the concept of 'outstanding universal value' - UNESCO's criteria for assessing values of a cultural resource in terms of World Heritage Status. Based on the concept of authenticity, it has taken some time and much debate into how these key criteria could be applied to cultural landscapes which are dynamic and comprise material culture that can represent several historical periods. After the Nara Conference on authenticity (UNESCO 1994) a more open and flexible approach to the concept of authenticity and cultural landscapes as representing 'the combined works of nature and man' allowed for the distinctive character and components of a landscape across multiple periods to be recognised. Such modification of this key criteria allowed for the inclusion of 'industrial landscapes', that may have evolved over several millennia, to be considered as World Heritage Sites.

The concept of 'outstanding universal value' has thus become an important method in terms of how we can articulate global values in a statement of significance. Such a method has recently been used in the assessment of significance of two ancient quarry landscapes: the Northern Faiyum and the Aswan West Bank. Key to this methodology was how we conceptualize the significance of the transformed landscape across time and its social construction. Theoretical approaches from social archaeology and landscape archaeologies allows us to get at aspects of the 'human experience' of quarrying in the past and its significance in terms of time-depth . Practical and theoretical methods to get at time-depth and to characterise the historical significance of dynamic landscapes have also recently arisen from ratification of the European Landscape Convention in 2004.

Example sheet 1

Secondary resources in some Old Kingdom quarries, Egypt

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 constructions 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, 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.

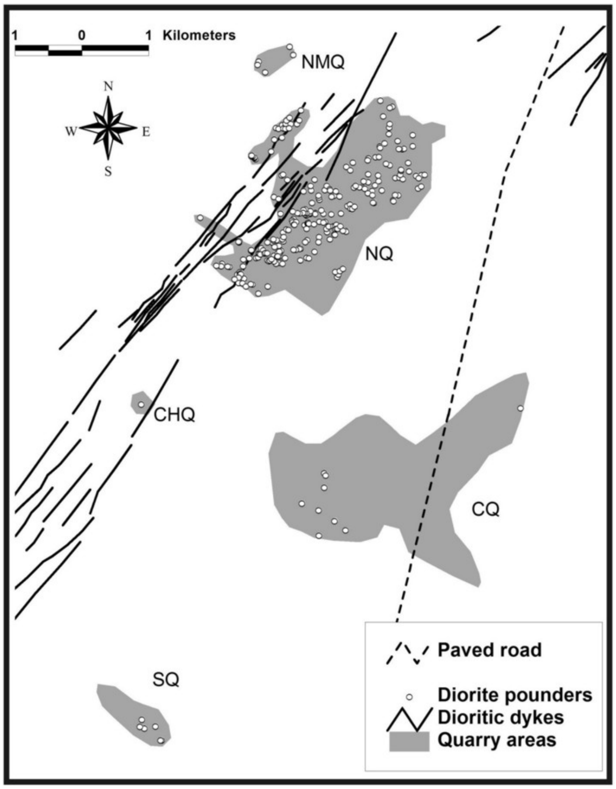
Examples of secondary resources

SECONDARY RESOURCE	Stone tools	Pounders/stone hammers Stone chisels
	Building stone	Houses Shelters Roads
	Domestic artifacts	Grinding stone/millstone Mortars Whetstone
	Clay	Ceramics Bricks
	Wood/charcoal	Smithy Fire setting Houses Lifting and transporting devices Wedges

In **Chephren's Quarry**, Egypt. the tools for working the gneiss are made from local resources; pounders are made from diorite (a series of dykes occurring in the western part of the area), granite (occurrences all over the area) and the Chephren Gneiss itself. In addition, rod-shaped hand-hammers, made from diorite and basalt, were applied. When viewing the distribution of tools from these different sources, we see a clear pattern of use; the diorite was predominantly used near the source. Further away, granite and/or Chephren Gneiss were preferred. Thus, we may conclude that proximity was a more important aspect in the selection of tool materials than differences in quality. Other secondary resources, also obtained locally, include silicified sandstone for grinding implements and clay for ceramics.

Secondary resources at Chephren's Quarry, Egypt

SECONDARY RESOURCE	PURPOSE/USE	LOCATION
Diorite (dykes)	Stone tools (pounder, hammers) Stela	Local
Granite	Stone tools (pounders)	Local
Basalt	Stone tools (hammers)	Local
Silicified sandstone	Grinding stone	Local
Sandstone	Shelters	Local
Clay	Ceramics (bread moulds)	Local

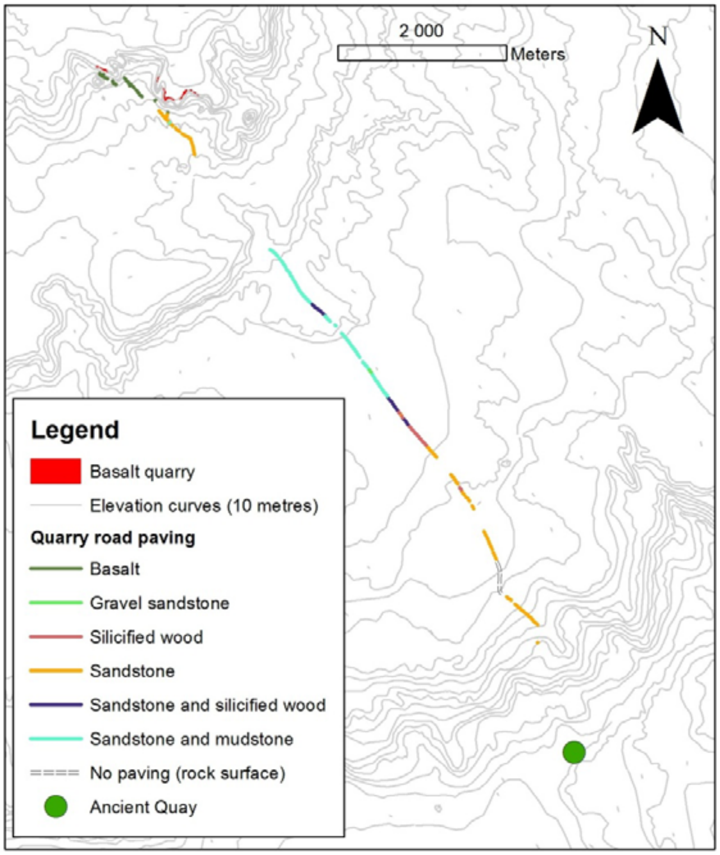


Observation of stone tools (small circles), Chephren's Quarry, made of diorite (dyke occurrences, black lines on the map). The use of this secondary resource for tools is decreasing the further away from the source one gets.

Moving north to the more or less contemporary basalt quarrying at Widan el Faras, we see a completely different pattern of stone tool use; the main type of tool found in the quarries are rather well fabricated pounders – most of them having contracted necks for the attachment of a haft. Interestingly, they all originate from the Precambrian rocks in the Eastern Desert and/or the Aswan area, far away from the quarries. Whether the reluctance of using local hard stone was related to quality, quarrying methods or social aspects is difficult to know, but certainly this contrast in the production and use of stone tools at two contemporary sites raises important questions about connections between quarry sites in the Old Kingdom. At Widan el Faras, local resources are, however, used to a large extent in the construction of the quarry road. The construction material varies along the road, reflecting the most available resources near it. Notable, basalt rubble from scree deposits is used only in the uppermost part of the road.

Secondary resources at Widan el-Faras, Egypt

SECONDARY RESOURCE	PURPOSE/USE	LOCATION
Gabbro, diorite	Stone tools (shafted hammers)	Imported
Sandstone	Road construction	Local
Silicified wood	Road construction	Local



Rock types used as paving on the quarry road from Widan el Faras.

Example sheet 2

Analysing production features

Interpretation of the production processes and the elements related to it forms a basic platform of knowledge for “building” the larger concept of a quarry landscape and its significance. The production process can be broken up in several steps, and each of them, or how they group together, may be the key factor that makes a quarry unique or representative for a specific historical context, given that there are distinguishing features in all cultural-historical contexts that are more or less diagnostic. When combining the datasets into a schematic illustration of the production process, similarities and differences are illuminated. This can later form the basis for defining complexes of quarrying within a quarry landscapes. Below are some examples from the QuarryScapes case studies in Egypt.

Widan el Faras, Egypt, is a rather simple case of basalt production, particularly when dealing with the Old Kingdom part of it. Here, the rough blocks of basalt, quarried with rather simple means by levering and exploiting natural fractures, were the “products” brought away from the quarries. This interpretation is partly made from studies of the actual basalt floor in front of the pyramids, being composed of well fitted irregular blocks. The final shaping and fitting must have taken place there. Due to the immense weathering in the quarries (all the blocks and quarry waste have disintegrated to small cobbles) we do not see tool marks or have any chance of performing studies of the spoil. In the table below, the simplicity of basalt production is visualised in that the whole production may be put in the “extraction” column.

Old Kingdom basalt quarrying	**Extraction**	**Block reduction**	**Semi-finishing**	**Finishing**	**Product (output from quarry)**
Work Process	Levering, using natural fractures	No evidence			Irregular basalt blocks
Spoil	No evidence				
Tools	Shafted hammer stones				
Output from process	Irregular blocks				

Aswan West Bank, Egypt, is a multi-layered, complex quarry landscape, comprising numerous sandstone and silicified sandstone quarries of different ages for different purposes. The oldest quarrying activity in the area is Early to Middle Palaeolithic exploitation of silicified sandstone for tools, using scattered, rounded cobbles. Grinding stones (querns) were quarried from the Late Palaeolithic up to at least the Roman Period. These quarries display a gradual evolution of quarry techniques, particularly in the first steps of production. In the New Kingdom, silicified sandstone was quarried for ornamental use, particularly for statues and obelisks. Such quarrying also took place in the Roman Period. In several periods, less silicified (“softer”) sandstone was quarried for building stone, particularly in the Greco-Roman Period. When analyzing the features related to production in the quarries, it is possible to make a clearer separation of one type of quarrying from the other, and to see evolutionary patterns over time for one type of quarrying acitivity. The tables below display some examples from this specific quarry landscape. Of particular interest is the evolution of extraction techniques within the grinding stone production.

Palaeolithic tools	**Extraction**	**Block reduction**	**Semi-finishing**	**Finishing**	**Product (output from quarry)**
Work Process		Splitting, trimming	Flaking, retouching		Flake (tool roughout)
Spoil		Small flakes	Small flakes		
Tools		Quartz pebbles	Quartz pebbles		
Output from process		Core	Flake (tool roughout)		

Palaeolithic grinding stone	**Extraction**	**Block reduction**	**Semi-finishing**	**Finishing**	**Product (output from quarry)**
Work Process		Splitting by percussion	Trimming Retouching along edges		Grinding stone blank
Spoil		Blocky	Flakes		
Tools		Cobble hammer stones	Cobble hammer stones		
Output from process		Core	Grinding stone blank		

Early(?) Dynastic grinding stone	**Extraction**	**Block reduction**	**Semi-finishing**	**Finishing**	**Product (output from quarry)**
Work Process	Levering, expanding natural fractures	Splitting by percussion	Trimming Retouching along edges		Grinding stone blank
Spoil	Blocky	Blocky	Flakes		
Tools	Stones	Cobble hammer stones	Cobble hammer stones		
Output from process	Block	Core	Grinding stone blank		

New Kingdom grinding stone	**Extraction**	**Block reduction**	**Semi-finishing**	**Finishing**	**Product (output from quarry)**
Work Process	Splitting of large flakes by percussion and heating		Trimming Retouching along edges		Grinding stone blank
Spoil	Blocky		Flakes		
Tools	Stone hammers, fire		Cobble hammer stones		
Output from process	Core		Grinding stone blank		

Aswan sandstone (building stone)	**Extraction**	**Block reduction**	**Semi-finishing**	**Finishing**	**Product (output from quarry)**
Work Process	Channelling and wedging		Dressing		Ashlar blanks
Spoil	Chips, flakes and some blocky		No evidence		
Tools	Hammer/chisel wedges		No evidence		
Output from process	Ashlar blocks		Ashlar blanks		

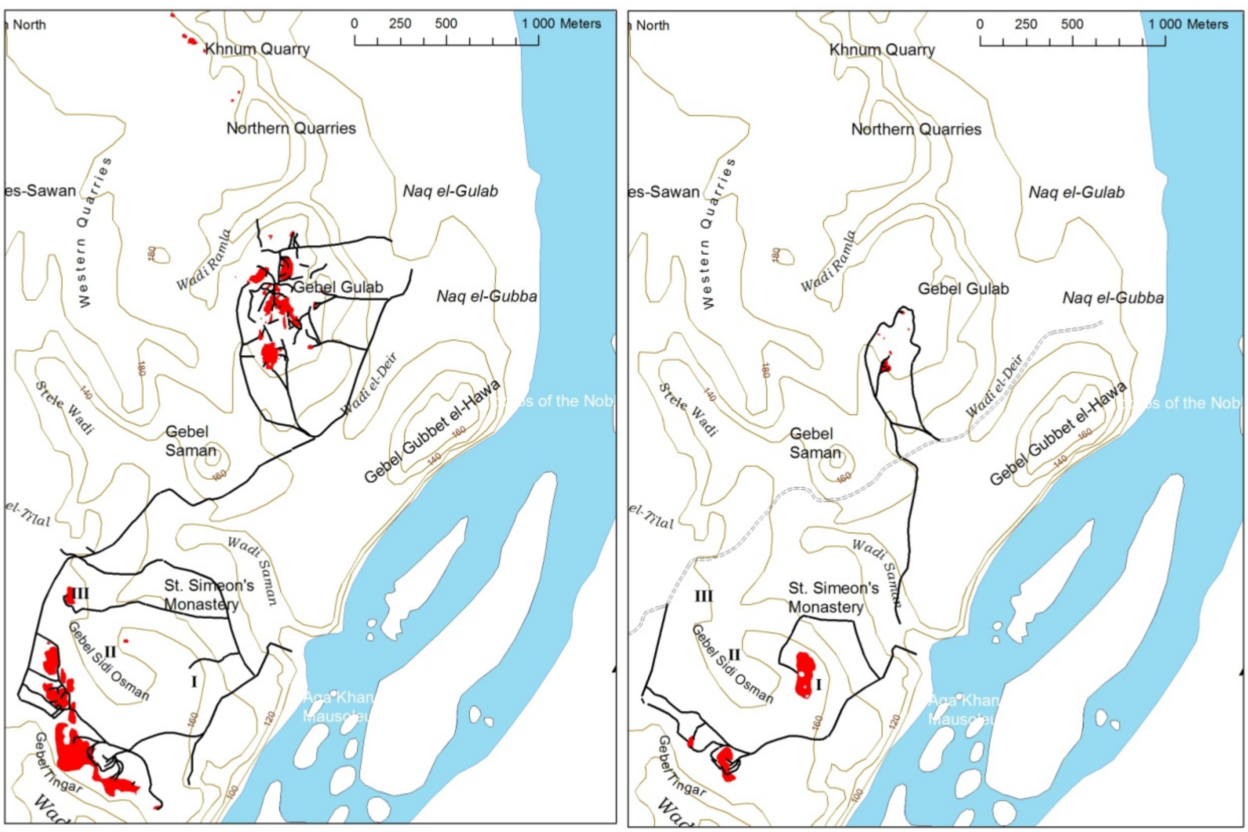
New Kingdom obelisk	**Extraction**	**Block reduction**	**Semi-finishing**	**Finishing**	**Product (output from quarry)**
Work Process	Splitting, Channelling		Dressing	Grinding, inscriptions	Ground and inscribed obelisk
Spoil	Blocky from splitting, powder from channelling		Sandy Powder	Fine powder	
Tools	Stone pounders, fire		Stone pounders	Grinding stones, stone chisels	
Output from process	Obelisk blocks		Dressed obelisk block	Ground and inscribed obelisk	

Example sheet 3

Analysing logistics

A key question is where the stone was transported. At the Aswan West Bank, quarries from different periods and for different purposes are overlapping each other, and so the overall picture is complex. But when putting together the logistical elements that, through the detailed characterization, have been connected to each other, we see systems of logistics from different quarrying operations. Here, we have separated the Pharaonic quarrying of ornamental stone (obelisks, statues) from that of the Roman Period. In the former case, we see a "draining" system of roads leading down to two harbours along the Nile. In the northern part of the area ("Khnum Quarry") there are several quarries containing unfinished obelisk bases and statues. However, there is a complete lack of roads in this area, indicating that no large stone objects were taken away from the quarries. This halt of production (particularly obelisks) may coincide with the death of the king Seti 1.

The Roman quarrying was far less extensive and partly the old logistic system was re-used. However, it seems that the Roman road system all points towards the southern harbour. A wide desert road (El-Deir road) from the Roman Period passes through the area, and part of this may also have been used for transport of stone.



New Kingdom logistics (left) showing ornamental stone quarries in red and interpretations of ramps and roads in black. To the right is the same visualization of the Roman Period ornamental stone quarrying; the New Kingdom roads were partly re-used, but also, new roads were constructed.

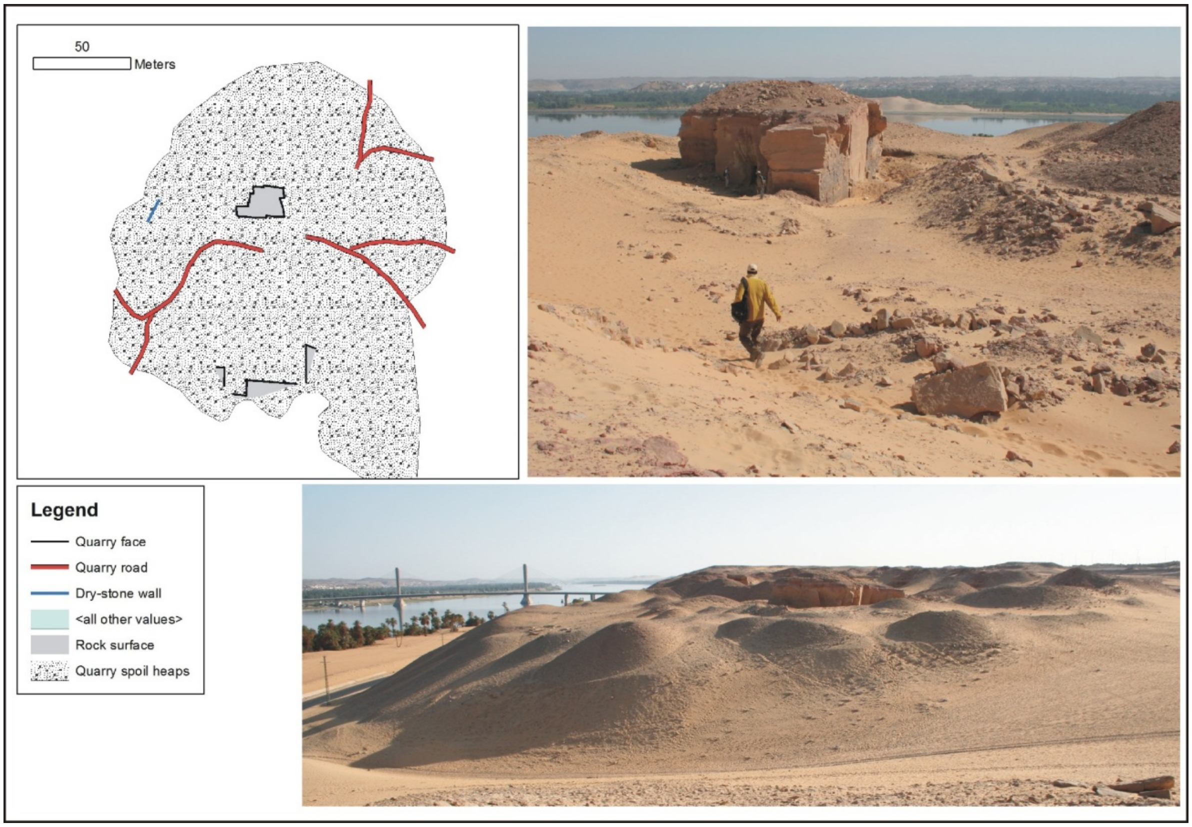
Example sheet 4

Micro-level analysis of the Widan el Faras basalt quarries (Old Kingdom)

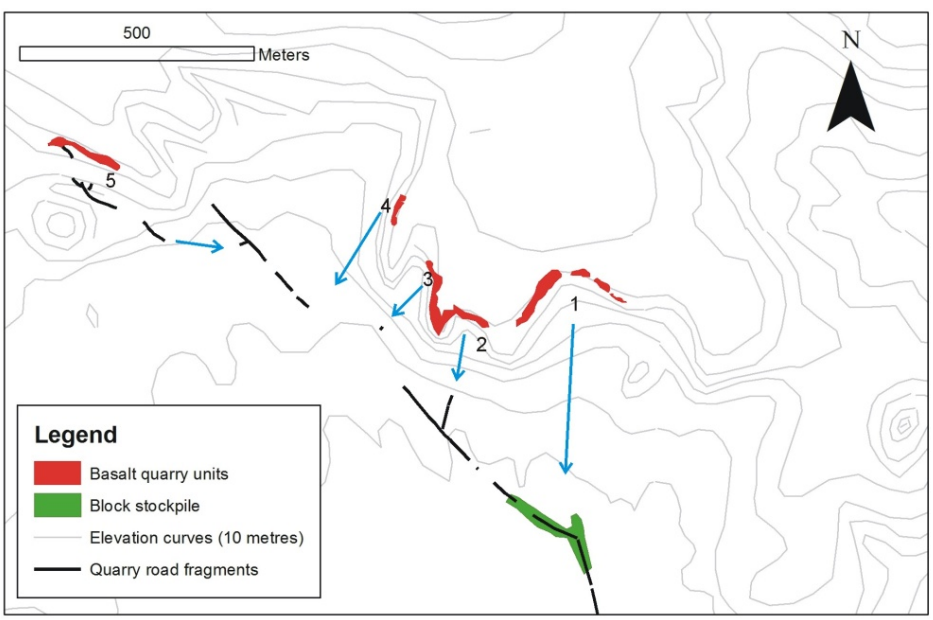
Widan el Faras basalt quarries (Old Kingdom production)		**FEATURES/DATA**	**INTERPRETATION**
Resource	**Rock**	Basalt	Used exclusively for construction of the temple floors, importance of black stone for this purpose.
	Consumption	Pyramid fields (mortuary temple floors)	
	Commodity	Ornamental stone	
	Landscape	Layered deposit	The basalt caps the hilltops in the area as one single layer. The basalt is severely weathered since the Old Kingdom .
	Secondary resources	Dolerite and metagabbro tools (imported); local sandstone and mudstone for road construction	Stone tools were imported from upper Egypt
Production	**Quarry morphology**	Open cast along escarpment	Open cast quarrying along the escarpment, mainly extracting irregular blocks of varying size which were not further treated. Such blocks were the end product from the quarries.
	Extraction	Levering along natural fractures	
	Block reduction	Minor	
	Semi-finishing	None	
	Finishing	None	
Logistics	**Internal**	Slipways, paved road, stockpile of blocks	Irregular blocks were stockpiled and transported on a paved road to an ancient harbor. From there the blocks were taken on the waterway to the pyramid fields, where they were further worked.
	Overland	11 km paved road down to the ancient Lake Moeris	
	Waterways	Quay features by the ancient shore of Lake Moeris. Water transport from there to the pyramid fields	
Social infrastructure	**Stone built features**	Camp with 6 stone structures and hearths	Small temporary settlement that could have sustained approximately 20-25 people.
	Domestic artifacts	Scatters of ceramics	
	Epigraphic	Not observed	
Time depth	**Direct dating**	Ceramics early 4th and 5th Dynasties	Correspondence between evidence from consumption and ceramics in the encampment indicate exclusive quarrying for four temple floors (Khufu, Userkaf, Sahura and Niyusera) in the 4th and 5th Dynasties (2590 – 2420 BCE)
	Consumption	Pyramid temple floors 4th and 5th Dynasties	
	Technology	No evidence except stone tool production (pre-iron)	
	Relative timing	Assumed younging of quarries from east to west	
Summary	The basalt quarries were sporadically exploited within a period of 170 years exclusively for making the temple floors at four pyramid complexes. The quarrying took place in parts of the basalt layer where the block size was sufficiently large, and involved predominantly extraction of blocks of irregular shape using natural fractures in the deposit. The blocks were brought from the quarries to a stockpile, from where they were transported overland 11 km to a harbour area, where they were loaded onto ships for the final transport to the place of use. The material culture in the quarry area indicates a small number of people involved in the quarrying and transport. Stone tools were imported from upper Egypt, and may indicate a connection between Old Kingdom quarry landscapes.		

Example sheet 5

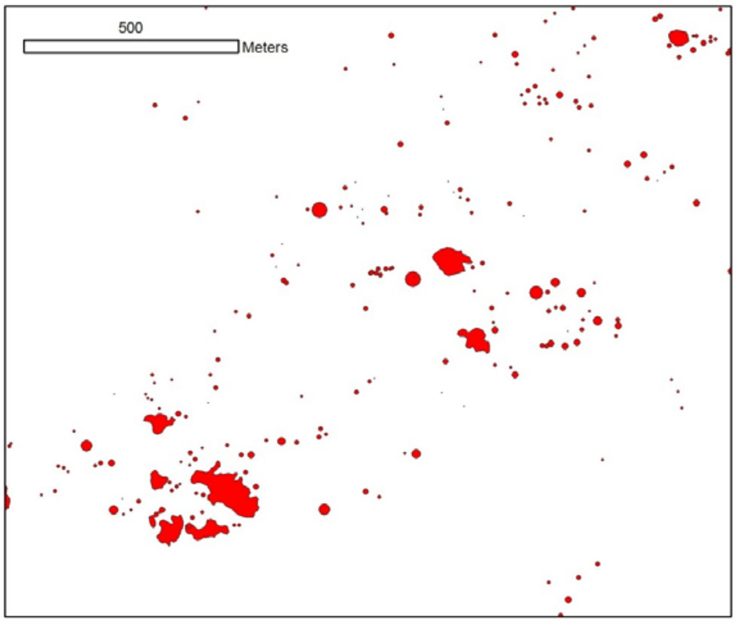
Examples of quarries/quarry units



A quarry unit (building stone, Aswan West Bank) comprising quarry faces, spoil heaps, roads and stone built features.



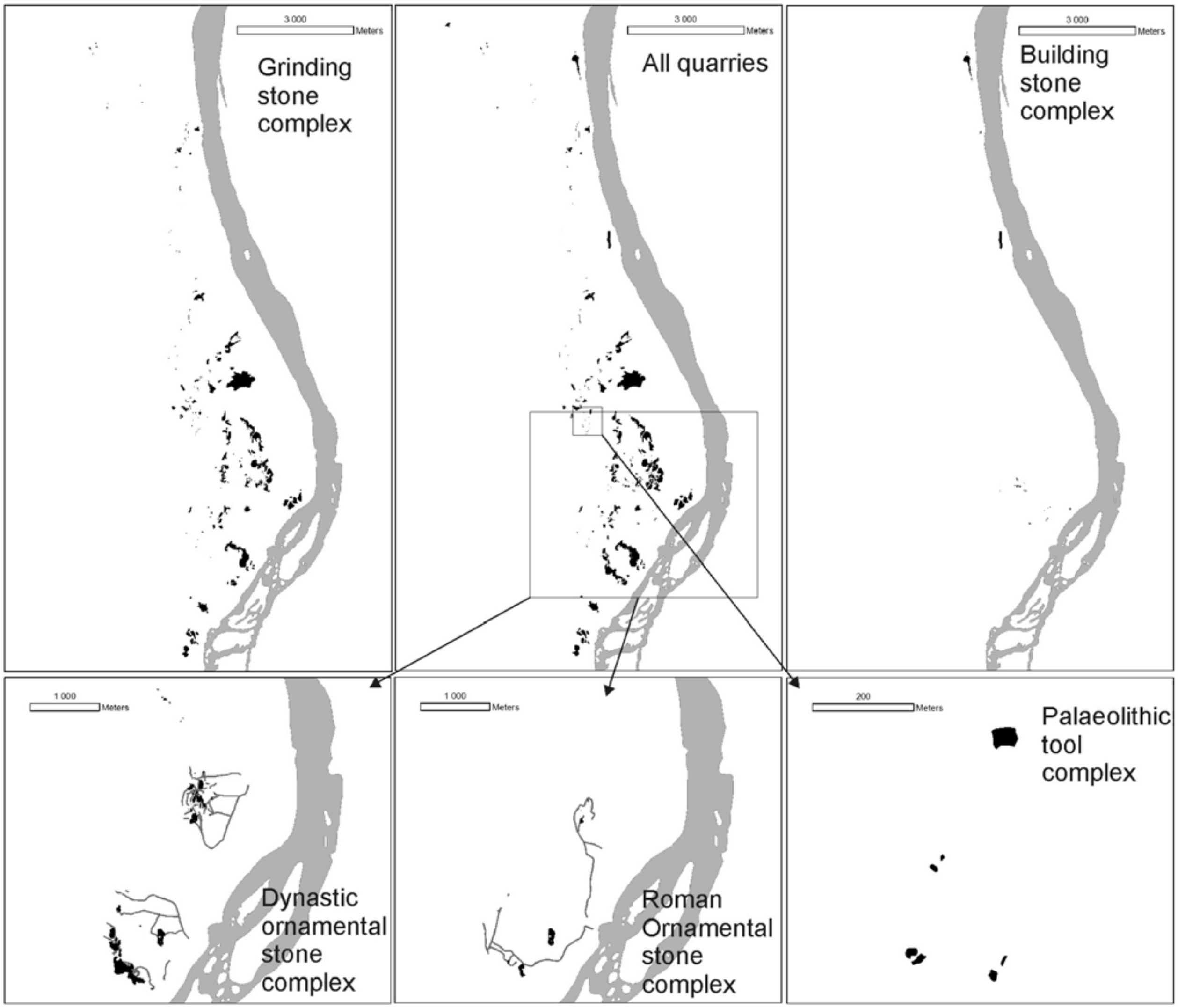
Quarry units and their internal logistics as defined in the Widan el Faras basalt quarry. Each unit may correspond with one pyramid complex.



Small (left photo) and large (right photo) quarry units in Chephren's Quarry, Egypt, and visualisation of them on a map.

Example sheet 6

Example of definition of quarry complexes at the Aswan West Bank, Egypt



Quarry complexes at the Aswan West Bank and their spatial distribution. All quarries in the upper centre.

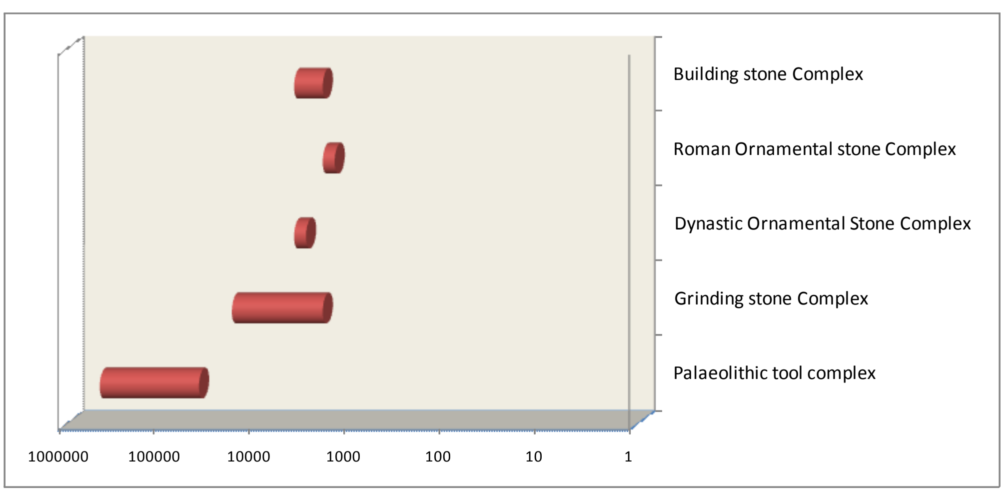


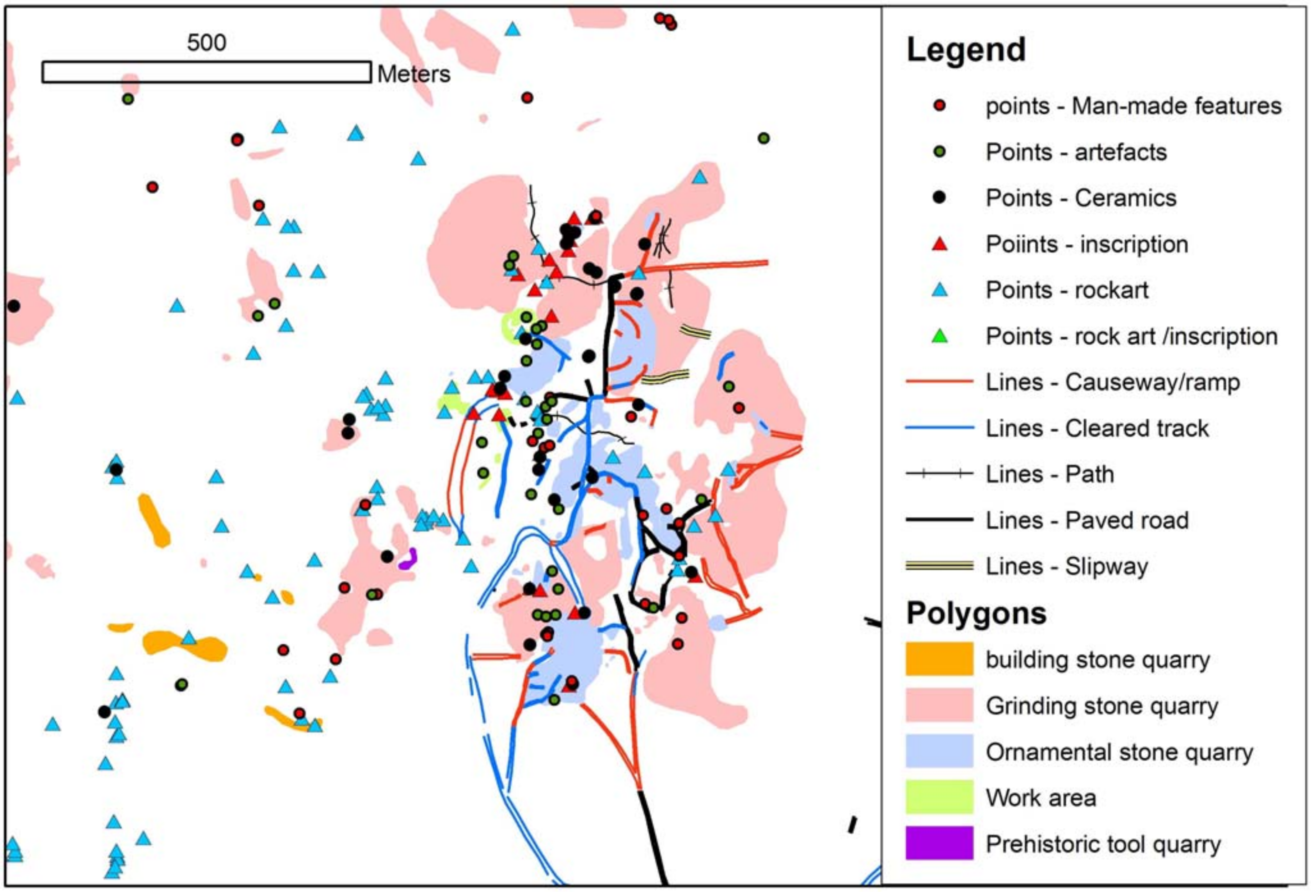
Illustration of time depth of quarry complexes at the Aswan West Bank (logarithmic scale, BP).

Example sheet 7

Example of GIS table structures

Example of table structure for polygons, lines and points

	Area (polygon)	**Line**	**Point**
ID	Unique ID	Unique ID	Unique ID
RECORDING DATE	Date	Date	Date
CLASS	Main area recording class: such as quarry, social infrastructure	Main line recording class, such as road (edge), path, stone alignment, etc.	Main point recording class, such as stone-built feature, artifact, epigraphic, etc.
SUBCLASS	Subtype of recording such as extraction area, spoil heap, work area (quarry); stone-built structures, settlement (social infrastructure)	Subtype of recording such as paved road, hollow road, ramp (road), dry-stone wall, stone circle (stone alignment)	Subtype of recording such as well, stone enclosure (stone-built feature); stone tool, ceramics (artifact); rock art, inscription (epigraphic)
TECHNOLOGY	For quarries: techniques applied in quarrying, such as stone hammering, chiseling, wedging		
MATERIAL	Rock type/subtype		Rock type/subtype, ceramic
PRODUCT	Output product from quarrying such as ashlar, grinding stone etc.		
ESTIMATED PERIOD	known or assumed time period	known or assumed time period	known or assumed time period
DATING	Method of dating	Method of dating	Method of dating
INTERPRETATION	Interpretation of function (ex. Grinding stone quarry, building stone quarry, etc.)	Interpretation of function (ex. Stone block transport, fence, etc.)	Interpretation of function
COMPLEX	Quarry complex if defined	Quarry complex if defined	Quarry complex if defined
CONDITION	Grade of preservation from weathering/erosion and human influence	Grade of preservation from weathering/erosion and human influence	Grade of preservation from weathering/erosion and human influence
PHOTO REFERENCE	Ref. to photos	Ref. to photos	Ref. to photos
DRAWING REFERENCE	Ref. to drawings	Ref. to drawings	Ref. to drawings
PUBLICATION REFERENCE	Ref. to reports and publications	Ref. to reports and publications	Ref. to reports and publications
DESCRIPTION	Free text description	Free text description	Free text description

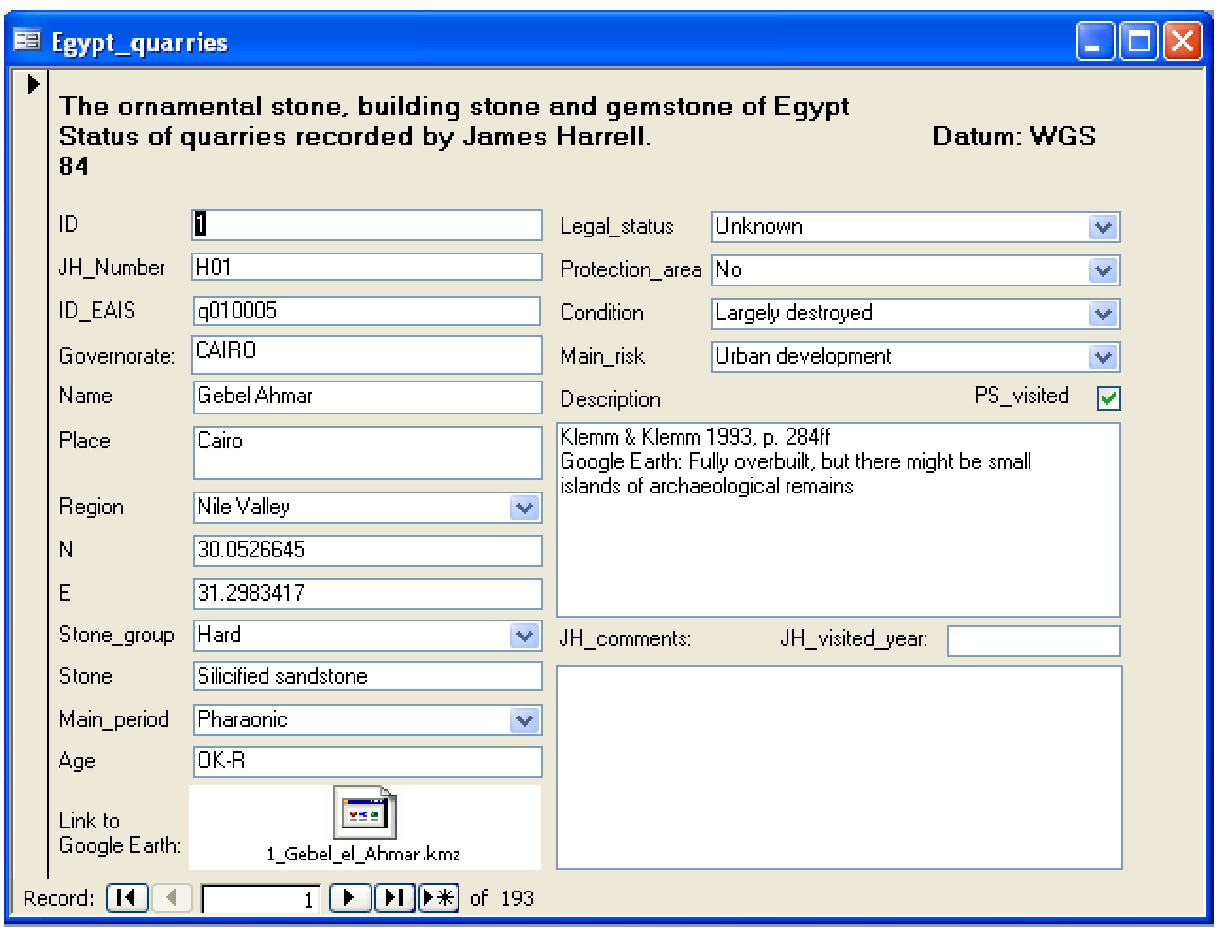


Subclass recordings from the Aswan West Bank quarry landscape plotted on a map.

Example sheet 8

National inventory of ancient quarries in Egypt

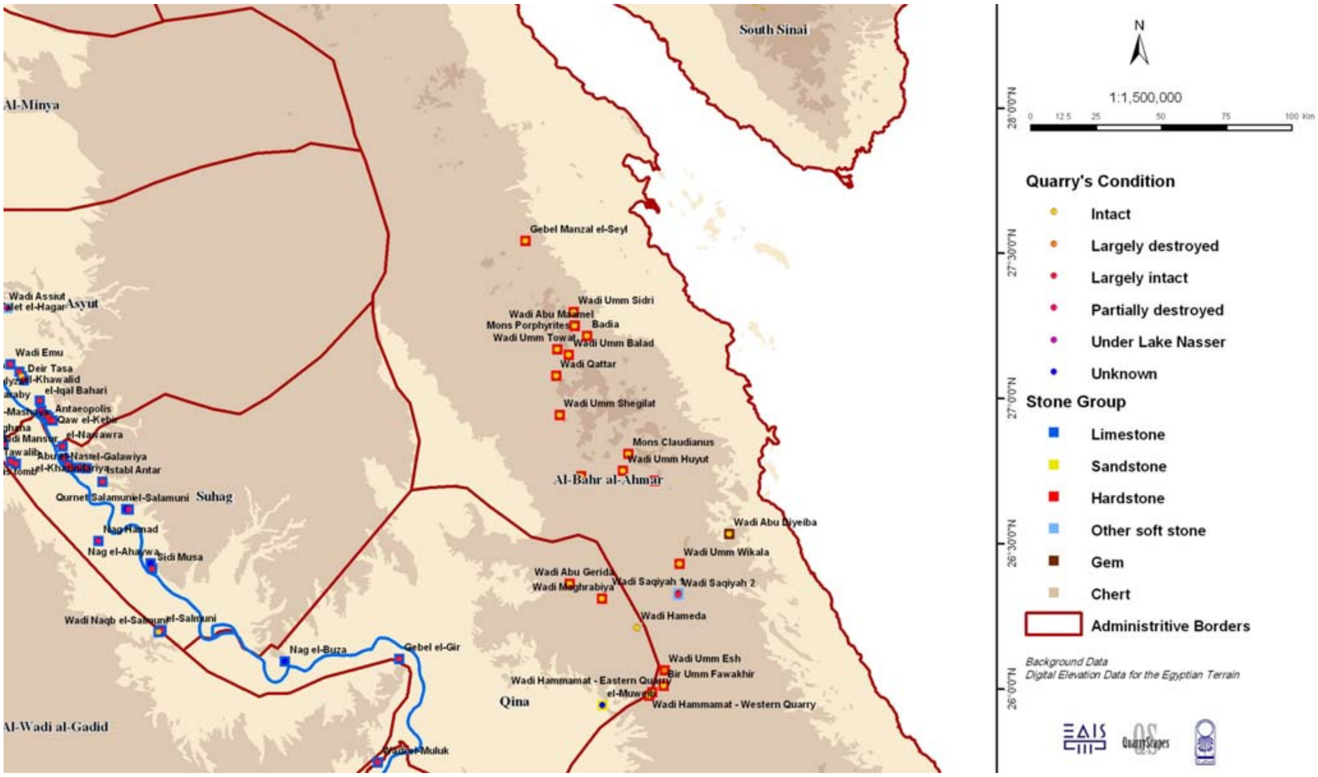
Based on information from the project and other researchers, the Egyptian Antiquities Information System (EAIS) at the Supreme Council of Antiquity has compiled a national database as an instrument for protection, monitoring and management of ancient Egyptian stone quarry landscapes, considering that the design and construction of a national map of ancient stone quarry landscapes in Egypt would not ONLY imply creating digital layers, but would deeply investigate the actual status of these quarries inside the Egyptian governmental administration. Hence, discovering the malfunction in the current documentation system and consequently recommend possible protective measures. The primary output is the creation of a shapefile, which includes193+ records. Each record represents a single ancient quarry landscape and is composed of several fields covering most of the essential information needed to recognize an ancient quarry. The practical aim is to have the output be used as an efficient tool to having the sites' physically protected and coherently managed by inspectors who are well aware of their values and significance.



Single entry in the Egyptian database

Structure and explanation of the fields used in the Egypt National Map shapefile

Field Name	Sample Data	Description	Field Originator
ID			
JH_Number	H03	A serial no. based on the categorization in J.Harrell's tables	WP5
ID_EAIS	q240044	ID code created based on the geographic location of the quarry site and its relation with the enclosing governorate.	WP7
Governorat	Al-Minya	Enclosing governorate	WP5
Name	Tilal Sawda	The quarry name as described in J. Harrell's tables	WP5
Place	By Behenasa	A description for the quarry's location as described in J. Harrell's tables	WP5
Region	Western Desert	The general region where the quarry is located	WP5
N	28.52016	North Latitude	WP7
E	30.5499761	Eastern Longitude	WP7
Stone_grou	Hard	The group to which the quarry stone belongs	WP7
Stone	Basalt	Stone type	WP7
Main_perio	Greco-Roman	The main period to which the quarry dates	WP7
Age	R	Other period(s) to which the quarry dates	WP5
Legal_stat	Unregistered	How the SCA regards the quarry	WP5
Protection	No	Whether the quarry undergoes and type of protection (e.g. World Heritage Site)	WP5
Condition	Partially destroyed	Current Condition	WP5
Main_threa	Mining and quarrying	Main threats endangering the quarry	WP5
Descript	No Google Earth high resolution coverage Eastern part of the site completely destroyed	Any additional relevant information	WP5
PS_visited	1	Whether the quarry was visited by Per Storemyr (1 = Yes, 0=No)	WP5
JH_visited	0	Whether the quarry was visited by J. Harrell (0=No, A year is specified in case the quarry as visited)	WP5
Field Name	**Sample Data**	**Description**	**Field Originator**
JH_comme nt		Other comments by J. Harrell	WP5
Hyp_Links	\\server-gis\Quarry Scapes\GIS_Data\Nati o nal Map\pix_samples\HAR DSTONE QUARRIES\NILE VALLEY AND WESTERN DESERT\Ornamental Stones\q240044\q2400 44.jpg	A field essential to create the link to the sample photo (if exists)	WP7
Ident_Taft	unknown	Whether the quarry is identified by local inspectorates	WP7



Example of map section showing types of stone resources and condition of the ancient quarries