# STONE WORKING IN ANTIQUITY
# GENERAL TECHNIQUES AND A FRAMEWORK OF CRITICAL FACTORS DERIVED FROM THE CONSTRUCTION OF SOLOMON'S TEMPLE IN JERUSALEM

by

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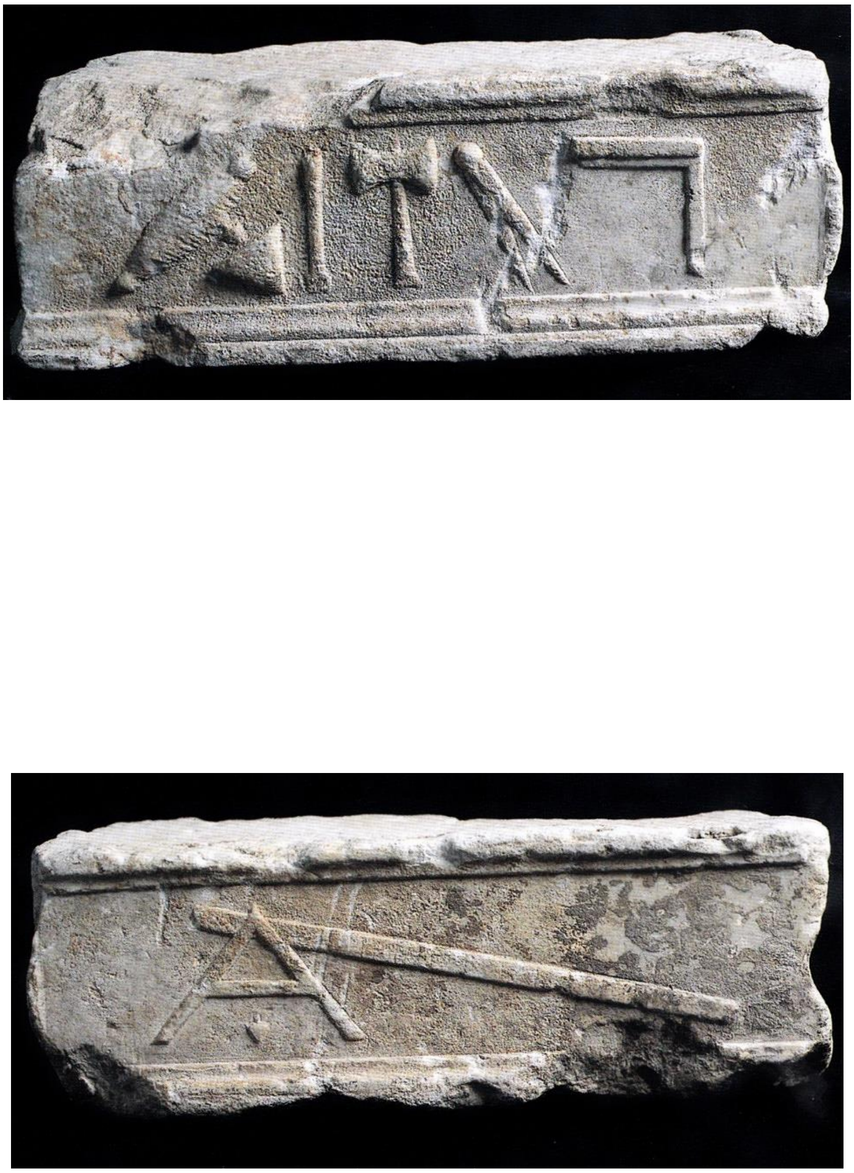

**Figure 1-1: Plinth in two parts, depicting stonemason tools, Rome, 1st century AD (De Nuccio & Ungaro 2002: 502-503).**

# Declaration

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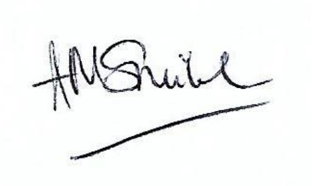
Exact wording of the title of the thesis as appearing on the electronic copy submitted for examination: Stone working in antiquity, general techniques and a framework of critical factors derived from the construction of Solomon's Temple in Jerusalem.

I declare that the above thesis is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

I further declare that I submitted the thesis to originality checking software and that it falls within the accepted requirements for originality.

I further declare that I have not previously submitted this work, or part of it, for examination at Unisa for another qualification or at any other higher education institution.



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# Abstract

The focus of this thesis is on the most commonly used types of stone, the methods of quarrying stone, stone working, the tools developed and used for that purpose, and the ways in which stone was transported and hoisted into place. This is starting from the earliest times in which large temples or buildings were constructed, namely the Neolithic, up till the time of the Roman Empire.

Besides being a kind of compendium of most aspects of stone working, which could be found, also attention is given to the ideal conditions under which the construction of a large temple or monument could take place. The framework, which is developed from the description of the construction of Solomon’s Temple in Jerusalem in I Kings 5 and I Chronicles 28, is used to analyse the construction of a number of other temples in different times, places and settings, and with the use of different materials, to test if the framework is applicable in all these situations.

Moreover, also other aspects of stone working, such as mosaics and the manufacturing of stone vessels in Jerusalem are described and analysed as to their origins and uses.

The intention is to give an overview of the many ways in which stone has been used, so that the reader can get an idea of how large temples and monuments were built and to gain an understanding of what kind of technical know-how and ingenuity existed in antiquity.

Key words: Stone working, stonemason, sandstone, limestone, marble, slate, basalt, granite, sanding, polishing, transport of stone, mosaics, restoring mosaics, stone vessels, Temple of Solomon, I Kings 5, I Chronicles 28, Göbekli Tepe, Orkney Islands, Temple of Karnak, Black Pharaohs, Parthenon, Herod’s Temple Mount, low chronology.

# Acknowledgements

This thesis is dedicated to the stonemasons in my family:

- to my great-grandfather, Johan Huibert Buddingh, who started his own business in 1879, now 140 years ago, in Wageningen, the Netherlands in the garden of his in-laws. This happened with encouragement from the customers of his former employer, as the latter had gone bankrupt

- to my grandfather, Dirk Buddingh for whom the business in Wageningen with his father and brother had become too small, so he started his own business in the nearby town of Veenendaal before WW I

- to my father, Johan Huibert Buddingh, who took over his father's business after the ravages of WW II, and who built it up from 3 employees and two rickety machines to 30 employees working in a well-equipped and robust company. Besides this he also re-united the two companies, when his uncle in Wageningen died without a successor

- to my brothers, Diederik and Gerard Buddingh, who joined the business in the late 1970's and have worked hard to keep it going, as well as managed to keep it afloat during the recession of 2009 and who have now brought it to new prosperity

my admiration is for you all.

My profound thanks are to the following persons:

- to my supervisor, Prof. Magdel Le Roux, for her advice and her patience with my slow progress and the long-term loan of the book by Kotsanas

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# CHAPTER ONE

# INTRODUCTION

## 1.1 BACKGROUND

This thesis would not have come about if it had not been for an Enrichment Seminar at the then Department of Old Testament and Ancient Near Eastern Studies at Unisa. There an older female student of Unisa, who was very interested in Hatshepsut, proclaimed out loud, that she did not know how the people in antiquity had managed to build the massive structures that they did construct. There was nobody in the audience who said anything in response, but I thought: ‘There must be an explanation for that, and I already know some of it’. I never saw her again and do not know her name or even if she is still alive. But indeed, I already knew some of the stone working techniques. That is because I grew up in the Netherlands with a stonemason company in the yard behind our house. It started out small, but my father managed to expand it, until it was one of the larger companies in the Netherlands.

Growing up, the stonemason yard was my playground, and after a while I knew all the types of stone then in use, off by heart. The workers were my friends and I would sit with them when they had a break at 9 am to have a bite to eat. In retrospect I realise that they also watched over me, that I would not come to any harm while I was wandering around the stacks of stone, and they were going about their tasks.

I already saw the first stone quarry in Belgium when I was eight and visited Carrara in Italy, where the quarries of the famous Carrara marble are found, when I was fourteen. Over the years I watched many loads of many different types of stone being delivered to our company and many different finished products getting loaded for delivery to customers. Already during my High school years, when I received a classical education at Gymnasium α, and learned about the classical world of Greece and Rome with their elaborate buildings, there were times that I used to wonder how these had been constructed. After graduating from the Hoger Rijksinstituut voor Vertalers en Tolken (Higher State Institute for Translators and Interpreters) in Brussels, Belgium, I worked for the family company for four years, and used my knowledge of languages to buy stone all over Europe, and in the process saw another fair number of quarries and stone working companies. Once you have been bitten by the ‘stone bug’, as my late father used to call it, it stays with you. Stone is a fascinating material, of many different colours and varieties, and in the past was an indispensable building material. The search was on to try and figure out how the ancients managed to build what they did, without all our modern tools, equipment, techniques, and without the use of cement or concrete.

## 1.2 PROBLEM STATEMENT AND RESEARCH QUESTIONS

The problem to be investigated in this thesis will be analysed from two angles. In the first place there does not seem to be a comprehensive overview of the development of tools, quarrying, transport and building techniques from the earliest times large monumental buildings or temples were built. Therefore, an attempt will be made to make a compilation of these techniques used in antiquity, starting from the construction of what is considered to be the oldest known temple complex in the ancient Near East, namely Göbekli Tepe in present day Turkey, dating to the Neolithic. After that an overview of the building techniques and tools of the later times, such as the Copper Age and Iron Age will follow, as they were developed in various times and places, and in as much as these can be found. The intention is to give answers to questions such as:

- How did people in antiquity manage to work stone before there were metal tools available?
- What kind of stone materials were they able to use?
- How did people manage to work stone with copper tools, which are relatively soft?
- How were materials quarried, shaped, transported to the building site and put or hoisted into place in the different eras under consideration?
- What other kinds of tools were used?
- What type of building techniques were used, for what purpose, and by whom?
- Was stone used for any other purpose in antiquity?

There does not seem to exist a comprehensive overview of these techniques, which changed and developed over time as well. The information is spread over a number of specialised publications, and they deal with either Neolithic tools, or with Egyptian tools and construction methods, or they deal with combined Greek and Roman construction methods, or only Roman construction, hoisting and other methods, but there is not a broad overview of the developments over time, starting in the Neolithic, when construction of large temples began and following the developments over time all the way to the Roman era, about which quite a lot is known. Besides the practical aspects of materials, tools, extraction methods and building techniques, in the second place aspects of affordability, and societal factors, such as the availability of labour, food and organisation will be analysed to provide an answer in this thesis to the questions:

- What were the requisite and most ideal conditions under which construction of a large temple or monument could take place?
- How was it possible to afford the construction of a large building in antiquity, both from a financial perspective, as well as from the perspective of withdrawing workers from the production of food?
- What kind of factors played a role in the process?
- Where can we find an account of the construction of a large monument written in antiquity?
- What could be the implications for the understanding /dating of the construction of the temple as described in I Kings 5?

## 1.3 AIM AND OBJECTIVES

The aim of the thesis is to analyse how people started to build large monumental structures, with what kind of tools, and with what kind of transport and building techniques, as well as to try and provide an answer to the question of how the people in antiquity were able to afford what they built, against what would in our present day and age seem unsurmountable odds. With respect to Biblical Archaeology the aim is to find answers to the question of whether Solomon was instrumental in building the First Temple in Jerusalem.

## 1.4 METHODOLOGY AND STRUCTURE

### 1.4.1 Approach

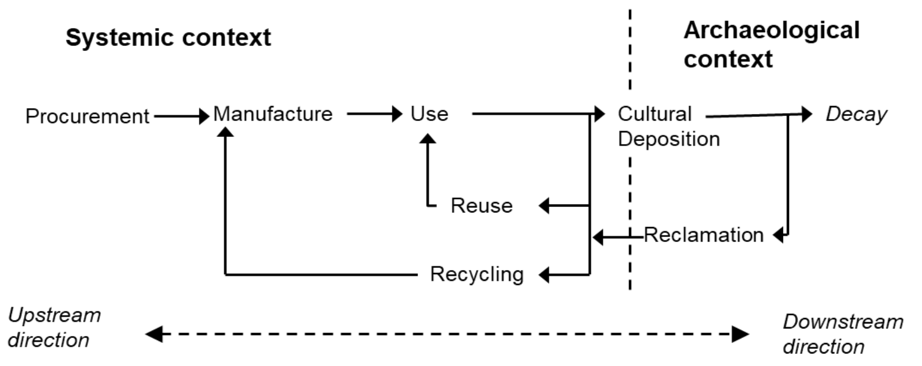
The methodology to be used in this study will be qualitative. Nieuwenhuis gives as a definition of qualitative research, that it is a form of research by means of which a wealth of descriptive data is collected about a particular topic or within a particular context for the purpose of developing a deeper understanding about that what is studied or observed (Nieuwenhuis in *First steps in research* by Maree [ed], 2010:50). In Welman, Kruger & Mitchell, qualitative research is called a descriptive form of research (2005:188), and that is essentially the methodological approach of this thesis. In the first part of the study the practical and technical aspects of stone working will be described as obtained from the available sources. So far, I have not been able to find a comprehensive description of stone working techniques ranging from the Neolithic to the Roman era. For the second part of the study, use will be made of the Old Testament for the analysis of the factors involved in the construction of Solomon's Temple in I Kings 5 and I Chronicles 28. It will play an important role in the understanding of what factors all came into play in the construction of buildings in antiquity. Following the analysis of the factors involved in the construction of Solomon's Temple, a number of case studies will follow, using the factors distilled from Solomon's description as a framework, to see if these factors also apply to the construction of other large temples or monuments in antiquity, in different times and places and with different materials. Historical backgrounds to the case studies will be used to 'set the scene' for the construction of a particular building of monument where possible and necessary. Information gained from archaeological excavations of these sites will be used to explain what was built and what kind of technology was used. The information obtained from the case studies in turn will be used to determine whether the factors which were derived from the description of the construction of Solomon's Temple, are valid. This can be used to determine whether Solomon's description is credible and whether the factors derived from I Kings 5 and I Chronicles 28 are genuine. In other words, is the account credible?

For this study use will be made of information obtained from both archaeological and biblical archaeological research, and an archaeological approach will be applied. This archaeological approach will be based more specifically on Behavioural Archaeology.

This is a branch of archaeology, which was developed in the 1970's, and which is the 'study of material objects regardless of time or space in order to describe and explain human behaviour' (Reid, Schiffer & Rathje 1975:864). Behavioural Archaeology starts from the premise that, 'The relationships between human behaviour and material objects can be approached from several directions, depending on the nature of the questions asked' (Reid, Schiffer & Rathje 1975:864), and makes use of four strategies. The first strategy is focussed on making use of material culture, which was produced in the past, to answer specific questions about human behaviour in the past (Reid, Schiffer & Rathje 1975:864). It is also involved with the drawing up of behavioural laws in order to document and explain past laws (Reid, Schiffer & Rathje 1975:864). The second strategy is the pursuit of general questions about present material culture to obtain laws useful for the study of the past (Reid, Schiffer & Rathje 1975:865). The third strategy consists of making use of general questions to study past material remains for the purpose of distilling laws which can be applied widely to illuminate past and present human behaviour (Reid, Schiffer & Rathje 1975:865). And the fourth strategy focusses on the study of present material objects in continuing cultural systems to describe present human behaviour (Reid, Schiffer & Rathje 1975:866).

La Motta provides a more updated version of Behavioural Archaeology by adding the notion of 'Life history models', which describe 'the behavioural lives of objects, from the procurement of their raw materials, through manufacture and use, to the time they finally enter the archaeological record and are no longer directly involved in human activities' (La Motta 2012:39). He illustrates this with the model which follows below (see Figure 1-2).

This model is very applicable to the research I intend to undertake namely: the procurement of materials, in this case stone. Then the manufacture of an object, in this study a large monumental building. After that, the use, which was made of this building, followed by the maintenance, which at times entails the periodic remodelling of the building. This is followed by the cultural deposition of the building, usually the abandonment, and thereafter the reclamation, the re-use of the building, or of part of it, and then as conclusion, the recycling of materials that were used. These various aspects are not always applicable, but are observed in some of the case studies. Besides this all, my approach will be to attempt to add knowledge from my own background and exposure to the stonemason industry over the years that I was involved in it.[1]




**General Life History Processes**

**Procurement:** acquisition of raw materials necessary to manufacture a particular object

**Manufacture:** production or assembly of an object from its constituent materials

**Use:** principal function of an object – the activity or activities for which it was specifically designed or obtained and in which it was actually used

**Maintenance:** periodic modification or repair of an object to allow continued use

**Reuse:** repurposing of an object, especially after it has become broken or worn

**Cultural deposition:** process through which objects leave systematic context and enter the archaeological record, including loss, discard and abandonment

- ***Loss***: accidental deposition of objects
- ***Discard:*** purposeful disposal of objects, for example trash midden
- ***Abandonment:*** leaving behind of objects and archaeological spaces, for example during a residence move

**Reclamation:** retrieval of objects from the archaeological record for purposes of using, reusing or recycling those objects

**Recycling:** returning of objects to the manufacturing stage, breaking them down into raw materials which maybe used to manufacture new objects

**Figure 1-2: Life history model developed by La Motta (La Motta 2012:40).**

### 1.4.2 Structure

The structure of the thesis will be as follows:

[1] Criticism has been expressed that Behavioural Archaeology is an older and outdated theory, but the fact that La Motta still saw fit to use it and create an updated version in 2012, has convinced me that it is the correct theoretical model, which provides an accurate framework for this study.

*Chapter One*: INTRODUCTION.

*Chapter Two*: PHYSICAL PROPERTIES, HARDNESS, COMPOSITION OF STONE, AND STONEWORKING TOOLS. In this chapter the physical properties of stone will be explained, such as the way it was formed, the differences in hardness between various stone materials and what type of tools were and are used to work stone.

*Chapter Three*: QUARRYING, TRANSPORT AND HOISTING; STONE VESSELS AND MOSAICS. This chapter will provide a description of various quarrying methods and different types of quarries, as well as methods of transport and hoisting. It will also contain information about the use of stone to produce mosaics and for the manufacturing of stone vessels.

*Chapter Four:* SANDING AND POLISHING STONE MATERIALS AS WELL AS APPLYING INSCRIPTIONS. This chapter will contain information about sanding and polishing, applying inscriptions and the possible use of diamonds, diamond dust and meteorite iron as tools to work granite in Egypt.

*Chapter Five*: CONDITIONS FAVOURABLE FOR THE CONSTRUCTION OF LARGE MONUMENTAL BUILDINGS IN ANTIQUITY. In this chapter an analysis will be given of the conditions under which Solomon's Temple was built, as described in I Kings 5 and I Chronicles 28. This will be used as a framework to determine whether these factors can be applied to other building sites in other times in antiquity.

*Chapter Six*: CASE STUDIES BASED ON THE FACTORS DERIVED FROM THE DESCRIPTION OF THE CONSTRUCTION OF SOLOMON'S TEMPLE IN JERUSALEM. This chapter will contain a number of Case Studies regarding the construction of several large monuments in antiquity in different times and places and with different materials. The Case Studies will be the following: Göbekli Tepe, the Orkney Islands, the Parthenon in Athens, the Black Pharaohs and the additions to the temple at Karnak in Egypt and King Herod's Extension of the Temple Mount in Jerusalem. These will be analysed according to the criteria which have been established in the study of the construction of Solomon's Temple to see if these criteria can be applied to all the cases under scrutiny.

*Chapter Seven*: CONCLUSION.

## 1.5 HYPOTHESIS

The hypothesis is that the account of the description of the construction of Solomon's Temple in Jerusalem, as described in I Kings 5 and I Chronicles 28 could possibly be used as a template to deduct what factors played a role in the construction of a large building or monument in antiquity. So often the Bible's verses are used for just a spiritual purpose, and are given a spiritual interpretation, but in this study I want to use the description of the construction of the Temple in Jerusalem in a very practical sense, and investigate whether the factors that can be distilled from it, can be applied to other times, and other places. This is to determine whether that what is attributed to Solomon in connection with the construction of the First Temple, is plausible or not. An archaeological approach could also add to the understanding of stone working techniques in antiquity.

## 1.6 MOTIVATION FOR THE STUDY

In this undertaking the motivation and personal rationale is, that coming from a stonemason background and having worked in the industry myself, it should be easier to assess the available material, to distinguish what are correct assumptions and which ones are not, more so than a person who has absolutely no experience of stone working. I also want to bring my own experience into the narrative at times, as some methods of stone working have not changed for millennia, or have only changed recently.

The potential contribution of this study is to give more insight into how buildings and monuments were constructed in antiquity, both from a practical aspect, the actual work that was done, as well as how could a society afford to construct a large building. It is also intended to show how a whole number of important factors needed to come together for a building or monument to be constructed in a certain era and place. These factors will be analysed in the Case Studies mentioned in 1.4.2, and will be used to determine whether most of these factors were present when the monuments or buildings were constructed. These factors in turn may be of assistance to archaeologists and biblical archaeologists in the analysis of a site they are investigating.

## 1.7 LITERATURE REVIEW

### 1.7.1 Introduction

In order to find material for this study, I requested a literature survey from the Unisa Library. When it eventually arrived, it contained absolutely nothing that could be used. Trying to obtain material in the Netherlands from an information center for stone located in Rijswijk, was equally impossible, as it no longer existed. A few books, which had belonged to my father, contained some information, but on the whole, it has been difficult throughout the entire time that it has taken to compile this study, to get hold of the information that I needed. What follows below is an overview of the most important sources that I have consulted.

### 1.7.2 Primary sources

For this study the *Hebrew Bible* will be used as a primary source, as it provides a description of the various aspects which play a role in a society, to make it possible for the process of constructing a large building or temple to take place. The account of the construction of the Jerusalem Temple under King Solomon in I Kings 5 and I Chronicles 28, provides interesting insights in this regard. It also provides some information about the construction methods.

Limited use will be made of ancient sources such as the *Jewish Antiquities by* Josephus, the *Jerusalem Talmud, Berachot,* the *Babylonian Talmud, Ta'anit* and *Vitruvius,* as well as some *inscriptions* and *images.*

Some information about the site of Göbekli Tepe will be sourced from the report by Klaus Schmidt, entitled: Göbekli Tepe, South-eastern Turkey: A preliminary report on the 1995-1999 excavations, which was published in *Paléorient* (2000).

### 1.7.3 Secondary sources

By far the most information for this study was found in books, which will be the secondary sources for this study. *Stone* by Asher Shadmon (1996), provides a starting point on the basic methods of the use of stone and stone working. *Archaeology from above* by Albanese et al (2010), was inspirational through the images they provide of large buildings, temples and monuments, built in antiquity.

For the construction techniques used by the Egyptians to build the pyramids, use will be made of the book, *The complete pyramids* by Mark Lehner (1997). What is interesting about the author, is that he has engaged in experimental archaeology. By trying out various techniques, which have been suggested to have been used, he has tried to find out in reality what would work. In his book he combines information about what has been found during excavations, with what he has learned from his experiments.

The older book *Ancient Egypt* by Lionel Casson (1966) will be consulted for general information about Egyptian society, and some of its illustrations of methods of constructing the pyramids will be used.

Henri Stierlin's book, *The Pharaohs, master builders* (1995) provided a number of useful images as well as some information about stone working techniques.

A very useful source: *Constructing the ancient world, architectural techniques of the Greeks and Romans,* by Carmelo G. Malacrino (2010), will be drawn upon for its excellent illustrations of stone working techniques in Greek and Roman times. A further source about Greek quarrying and transport methods, from which several drawings will be incorporated into this study is: *Architecture and city planning, rediscovering Greece series* by J. Phoca and P. Valavanis (1999). *Marble, the history of a culture* by Luciana and Tiziano Mannoni (1985) mostly focusses on marble quarrying in Carrara, Italy, but also provides some information about tools and stone working methods that were in use before the Roman era. The book *I marmi colorati della Roma imperiale* by Marilda De Nuccio and Lucrezia Ungaro (2002), will mostly be employed as a reference book on the location of quarries in various countries around the Mediterranean Sea as well as for some of the tools. Kostas Kotsanas, with his book *Ancient Greek technology, the inventions of the ancient Greeks* (2017), will provide technical information about hoisting techniques in the Greek era as well as lathes. *Africa through the mists of time* by Brenda Sullivan (2001), contains valuable information about pre-historic diamond mining in southern Africa, and her hypothesis that these were used to work stone in ancient Egypt. Older sources regarding pre-historic diamond mining which will be consulted are: *The geology and archaeology of the Vaal river basin (memoir 35),* by P.G Söhnge, DJL Visser and C Van Riet Lowe

(1937) and *Early man in the Vaal river basin* by H. Breuil, C. Van Riet Lowe and F.R.S. Du Toit (1948).

For the case study on Göbekli Tepe, use will be made of the chapter written by Klaus Schmidt, the director of the excavations at the site, in *The Oxford handbook of ancient Anatolia* (2011). Unfortunately, the handbook was so voluminous, and the images contained in the article so feint, that it was impossible to scan any of them.

Some source material for the case study on the Orkney Islands will be drawn from *The monument builders* by Wernick (1974), and from Oliver's, *A history of Scotland* (2009).

For the case study about the construction efforts of the Black Pharaoh's of Egypt, information will be obtained from the book, *The Nubian Pharaohs, Black kings on the Nile* by Charles Bonnet and Dominique Valbelle (2005). They were the main excavators at the site of Doukki Gel, where the broken statues of these Pharaohs were found. Further information will be drawn from the book *Karnak, evolution of a temple* by Elizabeth Blyth (2006).

The bulk of the information of the case study about the Parthenon will be provided by Rhys Carpenter's book, *The architects of the Parthenon* (1970).

The case study on the extension of the Temple Mount by King Herod will draw on information from *The Quest, revealing the Temple Mount in Jerusalem* by Leen Ritmeyer (2006), which is an extensive and detailed study of the excavations below the Temple Mount and an in-depth study of the various stages of the temple and the Temple Mount. Meir Ben-Dov's book, *Jerusalem, man and stone* (1990), also will be consulted on the building activities of Herod. This same book also will provide information for the section on the Stone vessels. Further use will be made of, *The complete guide to the Temple Mount excavations* by Eilat Mazar (2002), and *The final days of Jesus, the archaeological evidence* by Shimon Gibson (2009).

Regarding the debate about the so-called 'low-chronology' method of dating archaeological finds in Israel, as well as the find of a limestone temple model, found during archaeological excavations at Khirbet Qeiyafa in Israel, the book *Solomon's Temple and Palace: new archaeological discoveries* by Yosef Garfinkel and Madeleine Mumcuoglu (2016), will add an interesting contribution to this study.

Furthermore, a number of magazine and journal articles will be used as secondary sources. The magazine articles are from *National Geographic Magazine,* and the authors, titles and dates will follow below. These articles might be considered as questionable sources, as to my knowledge, they are not peer reviewed, but they provided the basis for the discovery that there are a number of similarities between various sites where large temples or monuments have been erected. These similarities are societal factors that surround the construction project, and these factors will be investigated and discussed in the case studies, which will form the second half of this thesis. The articles were all written by different authors, and still the various factors kept recurring in the different narratives. The authors of the magazine articles may not be academics, but they take their research for an article to be written very seriously. This also applies to the illustrators of the magazine, who work in teams to produce the artwork. This is stated very clearly in the introduction of the book *Inside/Out*, *the best of National Geographic diagrams and cutaways* (National Geographic Society 1998:6-11, 30-31), which comprises the best of the diagrams and cutaways which have been produced by the staff of the magazine including the image of what the Uluburun ship may have looked like. The various authors of the magazine articles also provided information about the practical aspects of stone working.

The articles that will be used are: '*The birth of religion'*, by Charles Mann (2011), about Göbekli Tepe and '*Before Stonehenge'*, by Roff Smith (2014), about the cluster of monuments on the Orkney Islands. Furthermore, '*The Black Pharaohs, conquerors of ancient Egypt',* by Robert Draper (2008), about the additions to the temple of Amun at Karnak. Somewhat limited use will be made of the article: '*The She-King of Egypt'*, by Chip Brown (2009), for information about Queen Hatshepsut, as well as of*: 'Herod, the Holy land's visionary builder'*, by Tom Mueller (2008), for the case study on the extension of the Temple Mount in Jerusalem. Most of the information about this latter topic will be drawn from the journal article by Meir Ben-Dov: '*Herod's Mighty Temple Mount*' (1986), which was published in *Biblical Archaeology Review.*

Further information will be taken from the *National Geographic* Magazine articles: '*The pyramid build*ers', by Virginia Morell (2001) about conditions at the building site of the pyramids, and from '*Kings of controversy'*, by Robert Draper (2010) about the Kings David and Solomon.

The article *'Cabul: a royal gift foun*d', by Zvi Gal (1993), will be used as well as '*Free clinic for ancient Egyptians'*, by Anne Austin (2015), both from *Biblical Archaeology Review*. The latter article deals with the fact that there was medical care for the stone workers in Egypt. The article: '*Pharaoh's workers: How the Israelites lived in Egypt'*, by Leonard and Barbara Lesko (1999), published in *Biblical Archaeology Review* provides interesting information about the lives of stone workers in Egypt, who were living in the village of Deir El-Medina.

About the excavations in the Orkney Islands, a number of articles have been published by the director of the excavations, Nick Card. These are the following: '*Neolithic temples of the Northern Isles, stunning new discoveries in Orkney*' (2010), and '*The Ness of Brodgar, uncovering Orkney's Neolithic Heart*' (2018b) published in *Current Archaeology*. Furthermore '*A place of celebration and pilgrimage'* (2018a), and '*The Ness of Brodgar, more than a stone circle'* (2013), both published in *British Archaeology.* Considerable additional information has also been obtained from the official website of the dig, https://www.nessofbrodgar.co.uk.

### 1.7.4 Tertiary sources

For information about the development of tools, the lengthy article '*Hand tool'*, in the digital *Encyclopaedia Britannica* by Richard S. Hartenberg and Joseph A. McGeough (2019), will be drawn on as a useful source.

Regarding the find of the hauling track at Hatnub, no journal article has been published yet, due to the fact that research on this discovery is still ongoing and no final conclusions have been reached yet. Therefore, the magazine articles published in the popular press and sent to me by Doctor Roland Enmarch of the University of Liverpool, who discovered the track, will be quoted as source material. These are: '*This 4,500-year-old ramp contraption may have been used to build Egypt's Great Pyramid*' by Owen Jarus (2018), published online by *Livescience.com,* and *'New discovery throws light on mystery of pyramids'* construction' by K. Rawlinson (2018), which appeared in *The Guardian.* Also, information from the article by Roland Enmarch, '*New tests from an old site: discoveries from the September 2018 season at the Hatnub alabaster quarries*' (2018), published on the University of Liverpool's website will be used.

A number of websites mentioned in the bibliography were consulted for small amounts of information, such as geographical locations, verification of scientific facts about flint and obsidian, volcanic origins of stone and hardness.

## 1.8 LIMITATIONS

### 1.8.1 Scope of the thesis

The scope of this thesis will be very broad. It was initially the intention that it would only cover the period of the Old Testament biblical era, and would not extend beyond the Greek era, but as the Romans took over the stone working techniques of the Greeks, which they encountered in Sicily and in Magna Grecia, and expanded these, it is very hard to cut off the study before the Roman era. The one flowed organically over into the other. Moreover, the Roman era still falls within the scope of Biblical Archaeology, be it in New Testament times. For me the Old Testament and New Testament, as well as the stone working activities of the Greeks and the Romans are inextricably linked. Therefore, the Roman era is the end point of this study. However, as stone was already used much earlier to build monumental structures, and with different tools, the beginning point of this study will be much further back, starting from the Neolithic. This is in order to show the development of tools and technology over time, and to have a clearer starting point. It will therefore be necessary to draw upon information from the field of Archaeology, as Biblical Archaeology does not go that far back in time.

### 1.8.2 Assumptions

The assumptions when writing this thesis are that it will be written on an academic level, but that it will also be accessible to the reader who does not have much knowledge of stone or stone working and would like to know more about the techniques and how a building or monument came about, as well as how a society could afford to put so much energy into the construction of a large building or monument.

### 1.8.3 Constraints

As for constraints, it needs to be stated that it is impossible to cover each and every aspect of stone working in the era under consideration. It is also impossible to explain exactly how every structure was built, but an attempt is made to give as close an explanation as possible for the structures under consideration. The study is intended to an extent as a generic approach, that is to say, that if the use and working of limestone is discussed, this can be applied to all areas where limestone has been used as a construction material in antiquity. The material has more or less the same hardness, whether it was used in Jerusalem or in Turkey or Egypt, so would present more or less the same difficulties or ease of extraction. The only aspect that could differ would be the kind of tools that were at the disposal of the workers depending on the time in history when the material was worked.

Some of the case studies fall outside the scope of the Old and New Testament period. They were chosen in order to show how stone was worked before metal tools were available, and before the construction of Solomon’s Temple in Jerusalem. This is the case with the case studies on Göbekli Tepe and the Orkney Islands. These were also chosen because they represented different types of societies (hunter-gatherer and agrarian respectively). The Orkney Islands were also selected because of the use of a layered material for its construction as opposed to solid blocks, which were used elsewhere.

The other three case studies have a link with the Old and New Testament period, with the era of the Black Pharaohs coinciding with the attacks by the Assyrians in the time of King Hezekiah of Judah, whereby one of the Black Pharaohs came to his rescue, as regaled in II Kings 19:9. This example was chosen to highlight the contribution of Black Africans in the construction of large monumental buildings in antiquity. As for the Parthenon in Athens, the apostle Paul visited close-by, when he spoke on the Areopagus, as described in Acts 17:16-34. The fact that an urban society built this temple and the use of marble as the construction material, were deciding factors in the choice of this example. The case study on Herod’s reconstruction of the Temple Mount was chosen for the sheer size of the project and is the case study falling within the ambit of Biblical Archaeology, be it in the New Testament era.

This thesis, though written in the context of the field of Biblical Archaeology, has a much broader scope, because it makes use of information gathered by non-biblical Archaeology. It is not meant to be an exegetical or redactional study of I Kings 5 and I Chronicles 28, or an investigation into the existence of the historical Solomon, but the texts will be analysed from a practical perspective to distil the aspects that will make up the framework for the analysis of other large buildings in antiquity. These will be described in the Case Studies, which will be presented in Chapter Six.

A further limitation will be, that this thesis will not be focussing on pottery, because pottery or pottery remains did not emerge much at all alongside stone in my research.

# CHAPTER TWO

## PHYSICAL PROPERTIES, HARDNESS, COMPOSITION OF STONE, AND STONEWORKING TOOLS

## 2.1 INTRODUCTION

In this chapter the physical properties, composition, and the hardness of various types of stone materials will be dealt with. This implies the type of stone, whether a material is layered or solid in its composition, and how hard it is, which has an influence on the way it is quarried and worked. Moreover, stone working tools will be discussed, as there were different types of tools available in different eras, and these also had an impact on the way stone was quarried and worked.

## 2.2 PHYSICAL PROPERTIES OF STONE

The physical properties of the various stone materials, which have been used in antiquity for the construction of monuments and buildings, are of importance, as they determine how these materials were worked. As a point of departure, it is important to first make a distinction between the words: ‘rock’ and ‘stone’. ‘Rock’ is used to indicate an appreciable part of the earth’s crust, as well as a firm and consolidated substance, which cannot normally be excavated by manual activity alone (Shadmon 1996:10). It becomes ‘stone’ after extraction and breaking[2] up into smaller sizes to be used for construction purposes (Shadmon 1996:10).

Rock can generally be classified into three main types: igneous, metamorphic and sedimentary (Shadmon 1996:12). These terms will be explained below.

### 2.2.1 Igneous rock

Igneous rock originates from the molten mixtures of minerals, which are known as magma, and this is found deep below the earth’s surface (Shadmon 1996:12). Magma can harden in two different ways, namely beneath the earth’s surface, or above it. If it hardens beneath the surface, it is called intrusive rock, and granite is the result of this

[2]The general term ’breaking’ here does not imply that the material is thrown down to shatter it into pieces, but to imply that it can be reduced to smaller pieces by means of splitting, cutting, sawing etc. Compare the term ‘breakers yard’ for the place where old ships are taken apart.

process (Shadmon 1996:12). Intrusive rock also includes gabbros (coarse-grained, dark plutonic rock), norites (a variety of gabbro) and diorites (coarse-grained igneous rock) which are all encompassed by the term granite (Shadmon 1996:12, 169-170).

When the magma cools above the surface, because it has burst through the earth's crust, it is called extrusive. An example of this is basalt (Shadmon 1996:12).

Extrusive igneous rock occurs as the following types of materials: basalt, basalt-lava, tuff and pumice. These materials will be further elaborated on below.

*Basalt* is the wall of the core (or chimney) of the volcano, and it occurs in hexagonal 'pipes' (Morgan 2015:4-5). This material is extremely hard and is used in hexagonally shaped blocks to reinforce the sea-facing side of dikes along sea-coasts and as such has been used extensively as cladding for dikes in the Netherlands. I have seen countless examples of this use when sailing on the waterways of the Netherlands. I have tried to access the website of Rijkswaterstaat in the Netherlands as a source to confirm this, but it is inaccessible for an outsider due to safeguards. The only confirmation I have been able to find is in a photo book about the Netherlands (Tomei 2006:242), and in Morgan (2015:4).

*Basalt-lava* is the material which was formed when lava flowed out of the volcano and hardened into a solid deposit. It normally is dark grey and has small holes in it, which were caused by escaping gasses. This can be quarried in blocks and used in slab form. For example, the houses in Capernaum were built of this material (Crossan and Reed 2001:121).

*Tuff* is rock formed from consolidated volcanic ash, with pebble-sized fragments in it and can be used for construction purposes, even though it is not very hard (Shadmon 1996:172). The *moai*, the giant statues for which Easter Island is famous, were carved out of volcanic tuff (Bloch 2012:40; Shadmon 1996:1).

*Pumice* is a light grey-coloured material full of holes and is so light that it can float (Zangger 2001:45-46). It was formed when the volcano threw out rocks saturated with hot gasses which jetted out of the material as it cooled, and occurs as round balls. (http://www.livescience.com/31774-amazing-volcano-facts.html). In our stonemason company pumice used to be used as an abrasive, as a hand-polishing stone to polish marble. Gibson (1983:186) also refers to the use of pumice for polishing purposes. All these materials mentioned are found near volcanos in various parts of the world.

### 2.2.2 Metamorphic rock

Metamorphic rock is rock formed by the re-crystallisation of pre-existing rock under the influence of heat, pressure and chemical fluids (Shadmon 1996:12). As a result of this process, limestone becomes highly crystalline marble, sandstone becomes quartzite, and clays and shales become slate (Shadmon 1996:12). Quartzite, slate and some types of sandstone are found in a layered state, which makes it easier to quarry them with simple tools, as it is possible to split the material along thin layer lines. These materials are not quarried in blocks, but in slabs. An example of this is the layered sandstone that was used in slab form to build the houses of Skara Brae in the Orkney Islands (see Figure 2-1), dating to the Neolithic period (Wernick 1974:99-103).

**Figure 2-1: Detail of a layered stone wall of a house and flagstone walkway from Skara Brae, Orkney Islands (Wernick 1974:99).**

Another example is slate, which has been used in Norway and Great Britain for centuries as building material for various purposes such a roof shingles (Smith 2014:37) and to insulate fireplaces[3].

[3] Personal observation in Norway.

**Figure 2-2: Slate quarry in Otta, Norway. Note how this material occurs in layers (Photograph A.M. Smith, circa 1980).**

**Figure 2-3: Workers splitting slate into thin layers in a slate quarry in Otta, Norway (Photograph A.M. Smith, circa 1980).**

Slate is metamorphic rock with a fine grain, and can be split quite easily in smooth, flat slabs (Shadmon 1996:171). A slate quarry is shown in Figure 2-2, and the splitting process into thin layers in Figure 2-3.

### 2.2.3 Sedimentary rock

The third main type of rock is Sedimentary rock, which consists of ancient sediments, which have been compacted and naturally cemented (Shadmon 1996:12). This originates mainly from the disintegration of igneous rock, but can also come from organic origin or chemical precipitation. This process mostly occurs on the sea floor, and to a lesser extent on land (Shadmon 1996:12). When material is deposited in this manner, it is consolidated by its own weight, or by the weight of other material lying on top. The cementation into a consolidated material comes about by minerals that are carried by percolating waters. The resulting materials are limestone, dolomite and sandstone (Shadmon 1996:12). An example of limestone would be the travertine found at Bagni di Tivoli near Rome, which has been widely used for construction purposes in Rome (Malacrino 2010:13). I have personally observed the percolating waters there, which carry the minerals from which the material eventually is formed. This process has been going on for millennia. Another example of sedimentary rock can be found in Pamukkale, the ancient town of Hierapolis in Turkey (see Figure 2-4).

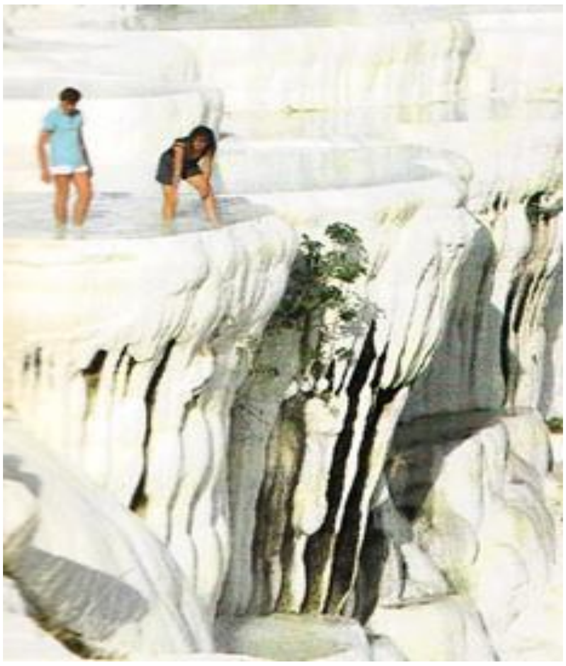


**Figure 2-4: Percolating waters have deposited white calcium, which forms travertine in Pamukkale, Turkey (Kekeç 1997:21).**

There the hillside outside the town is covered with white calcium deposits, brought by percolating waters, which have hardened into travertine over time (Kekeç 1997:19).

**Figure 2-5: White travertine from Pamukkale, has changed colour due to exposure to air (Kekeç 1997:41).**

When the material is quarried and used for construction purposes, it gets darker over time due to exposure to air, such as is the case with the exterior arches of the Northern Grand Bath at Hierapolis (Kekeç 1997:15; see Figure 2-5).

## 2.3 HARDNESS

Natural stone can be a deceptive commodity, because when one touches it, most types of stone will feel equally hard. This is however not the case, as different types of materials can differ greatly in hardness. That there were differences in the hardness of stone materials was already known in the time of the Roman architect and author Vitruvius, as he makes mention of harder and softer types of stone (Malacrino 2010:10). He even warned against using materials that were too soft, as these were not weather proof when exposed to frost, or could dissolve under influence of salt laden sea air (Malacrino 2010:10). Despite this fact being known, it is only in more recent times in history that a first attempt to determine those differences has been made, and a scale to indicate the hardness of different minerals was developed by Frederick Mohs in Austria in 1822. He based his scale on tests by means of which he determined which mineral could be scratched with the use of a harder mineral (Morgan 2015:26). In this way he came to establish the information provided in Table 2-1.

Unfortunately, his table is not linear, so the difference from one category to the next is not equal. There is not so much difference in hardness between 3 and 5, but the difference in hardness from 5 to 6 is noticeable. From 7 to 8 the difference is small, but from 8 to 9 it is very clearly noticeable and from 9 to 10 is the most considerable. (http://art4all.woelmuis.nl/beeldhouwerswiki/Beeldhouwkunst/3-3-Hardheid.html).

**Table 2-1: Hardness of minerals determined by Mohs**

| **Material** | **Hardness (Mohs)** |
|---|---|
| Talc, which is the softest mineral | **1** |
| Gypsum | **2** |
| Calcite | **3** |
| Fluorite | **4** |
| Apatite | **5** |
| Orthoclase | **6** |
| Quartz | **7** |
| Topaz | **8** |
| Corundum | **9** |
| Diamond, which is the hardest | **10** |

(Morgan 2015:26)

Based on this table as established by Mohs, a comparable table was developed for natural stone varieties.

This list in Table 2-2 (below) also presents the problem of lack of linearity, just like the original list compiled by Mohs in Table 2-1. It does however indicate that different types of stone have a different level of hardness. Soapstone occurs in levels of hardness between 1 and 2; limestone can vary in hardness from level 3 to 5. Serpentine varies between levels 2 to 4. The methods to work them are based on modern day workmanship, but in antiquity, limestone was worked with hand-held tools, as were marble, and even granite.

**Table 2-2: Natural stone varieties and working methods**

| Natural Stone Types | Method of Working |
|---|---|
| 1. Soapstone of the softer varieties | These can be cut, grated and some can be chiselled very carefully |
| 2. Soapstone of the harder varieties, in the darker colours; red sandstone; softer varieties of serpentine; alabaster | These varieties can be chiselled or grated and some can be cut<br>As an example of soapstone, the carvings from Zimbabwe can be mentioned which have been sold in South Africa in many shapes and sizes[4] |
| 3. Limestone; somewhat harder serpentine; red sandstone up to a hardness of 3.5; marble | These materials can be chiselled |
| 4. Limestone; the hardest varieties of serpentine till hardness of 4.5; marble | These materials can be chiselled or worked with a file, but preferably should be worked with a machine |
| 5. Limestone; Belgian 'Petit Granit' | These materials should be worked with machines |
| 6. Black serpentine; jade (hardness 6.5), granite with hardness 6.5 (not containing quartz) | These materials should be worked with machines |
| 7. Jade, granite containing quartz | These materials are to be worked with machines or pneumatic equipment |
| 8. Verdite | Of similar hardness as an emery board |
| 9. Corundum | Used as an abrasive on saw-blades |
| 10. Diamond | The hardest material known with no equivalent |

(http://art4all.woelmuis.nl/beeldhouwerswiki/Beeldhouwkunst/3-3-Hardheid.html).

Because the Mohs scale is not accurate, and technology has advanced, these days the absolute hardness of materials can be determined with a Sclerometer. This has provided a much more accurate measurement of the hardness of materials. When a

[4] A puppy in our household cut its teeth on some hippo carvings in a low windowsill and chewed the ears off them. This would have been impossible with a harder material, such as marble or granite.

Sclerometer is applied to the materials of the original list of Mohs the results are as follows:

**Table 2-3: Absolute hardness of minerals**

| Material | Hardness |
|---|---|
| Talc: | 1 |
| Gypsum: | 2 |
| Calcite: | 9 |
| Fluorite: | 21 |
| Apatite: | 48 |
| Orthoclase: | 72 |
| Quartz: | 100 |
| Topaz: | 200 |
| Corundum: | 400 |
| Diamond: | 1500 |

(http://art4all.woelmuis.nl/beeldhouwerswiki/Beeldhouwkunst/3-3-Hardheid.html)

When we apply these numbers obtained by means of the sclerometer test to the natural stone materials from the list in Table 2-2, this would mean the following:

- Sandstone has a hardness of about 2 to 9 (depending on the type of material)
- Limestone would have a hardness of about 9 to about 48.
- Marble's hardness ranges from 9 to 21.
- Granite without quartz has a hardness of 72, and granite with quartz would have a hardness of 100, and Diamond is the hardest material known.

The materials mentioned here are the ones most frequently used in antiquity for the purpose of constructing monuments, buildings and statuary[5]. Shadmon is of the opinion that limestone is relatively easy to work and states that it has been used widely.

[5] This is the art of making statues; the word is used in the singular (Merriam Webster 1977:1137).

An interesting aspect of the use of the softer varieties of limestone is that they form a harder skin after prolonged exposure to air (Shadmon 1996:24).

To give a few examples: the cultic center at Göbekli Tepe in Turkey was built of limestone (Mann 2011:44). The pyramids at Giza were built of limestone and certain parts of granite (Morell 2001:82). Solomon's temple in Jerusalem was built of limestone (Ritmeyer 1989:46). The statues of the Black Pharaohs of Nubia were made of black granite (gabbro), as well as their pyramids (Draper 2008:42-43). The obelisk erected in the time of Hatshepsut was made of pink granite, containing quartz, which is the hardest variety of granite (Stierlin 1995:88). These latter materials were not so easy to work and most of the various examples mentioned will be discussed further in the case studies, which are to follow in Chapter Six.

## 2.4 COMPOSITION OF STONE

Materials such as limestone, marble and granite occur in solid deposits, which can be quarried as blocks. Besides the materials that have a solid composition, there are also stone materials that occur in layers, as already mentioned in section 2.2.2. These are not quarried as blocks, but by splitting the layers. This is done by hammering sharpened tools, or wedges a few centimetres under the top of the layered material and splitting a layer off. If this is done by a few workers at the same time, also making use of levers, a fair size slab can be dislodged (Shadmon 1996:96). This process is easier than quarrying a large block. Examples of this type of material are slate, quartzite and certain types of sandstone, which have undergone metamorphosis during their formation which has resulted in them being layered (Shadmon 1996:86). Slate has been formed by the compression of clay due to high pressure and can contain bits of quartz, mica, hematite, pyrite or feldspar. It has a hardness of about 3-4 on Mohs's scale (see Table 2-1; http://www.mineralszone.com/stones/slate.html).

Quartzite as the name already indicates, contains a large amount of quartz and has a hardness of about 7 (http://www.mineralszone.com/stones/quartzite.html).

The degree of hardness of a particular type of stone influences how easily or less easily the particular material is worked when it is used for the construction of a building or monument. This will be discussed further below in 2.6, when the use of tools is analysed.

Another interesting aspect is that fine-grained stone materials are usually stronger than coarse-grained ones (Shadmon 1996:19). Besides this there is still another aspect to be analysed however, which is the weight of stone.

## 2.5 WEIGHT OF STONE

It is probably useful to give an indication of how much stone weighs. This differs for different materials, as for instance the specific gravity[6] of soft limestone varies between 1.64 to 2.15. For sandstone the specific gravity can vary between 1.75 to 1.95 and hard limestone varies from 2.36 to 2.75 (Shadmon 1996:20). According to Ritmeyer, the limestone used to build the Jerusalem Temple has an average weight of 2.5 tons per cubic meter (Ritmeyer 2006:61). Ben Dov (1990:80) states that the specific gravity of stone is 2.7. This latter figure is more or less in keeping with what we used as a yardstick for calculating the weight of a load of stone in our stonemason company in the Netherlands. We used to calculate that one square meter of stone, of one centimeter thickness weighs about 25 to 28 kilograms depending on the type of material, because we dealt in the heavier materials of which the specific gravity of stone is between 2.5 and 2.8. The specific gravity of granite is slightly higher than 2.7. This means that every centimeter additional thickness of a square meter of stone, adds another 25 to 28 kilograms to the weight of the piece of material, depending on the type of material. This in turn means that a block of a heavy type of stone measuring one meter by one meter, and one meter high, that is one cubic meter, weighs about 2,500 to 2,800 kilograms. This may help us to understand what enormous effort is involved in transporting large blocks of stone.

## 2.6 TOOLS

### 2.6.1 Development of tools

In this section a very brief overview will be given of the general development of tools, before a more focussed account will be given of the kind of tools that have been used in ancient times to work stone for construction purposes.

[6] Specific gravity is the ratio of the density of a substance to the density of a substance (as pure water of hydrogen) taken as a standard when both densities are obtained by weighing in air (Merriam Webster 1977:1116). So the specific density of a stone material is the ratio measured against the density of water. It is a ratio and not a unit of weight and therefore is not expressed in kilograms.

The development of tools has been a process that has been going on for millennia, basically for as long as humans have been in existence. Until the first use of metal, which started about 5,000 years ago, stone was the main material of which tools were made. Initially broken pieces of rock with sharp edges were used, but over time skills were developed to chip stone intentionally to produce tools (Hartenberg & McGeough 2019:1).

The Stone Age started about 2.6 million years ago and lasted till 11,700 years ago, when the last glaciers receded, and it can be divided into two periods. The Old Stone Age, or Palaeolithic, was of long duration and was characterised by stagnation. This was followed by the New Stone Age, or Neolithic, which was a short period, characterised by rapid progress (Hartenberg & McGeough 2019:2).

Characteristic for the Palaeolithic period were tools of chipped stone, cutting tools with rough surfaces and serrated cutting edges. During the later stage of the Palaeolithic period also other materials such as wood, antler and bone came into use as tools. The tools made of bone were shaped with the use of sharpened stone tools such as serrated blades and scrapers with narrow chisel-like ends. Barbed fishhooks, needles with eyes and small awls for leatherworking can be mentioned as examples of some of these bone tools (Hartenberg & McGeough 2019:2).

The Neolithic period was characterised by the development of ground and polished rock tools, mostly axes, which was a new method of working stone to make tools, which coincided with the retreat of the last glaciers. The Neolithic period also saw the development of agriculture and with it the beginning of food crops, as well as the domestication of animals (Hartenberg & McGeough 2019:3).

In the process of developing all the above-mentioned tools, different kinds of stone materials were tried out, such as granite and quartzite, which have a coarse grain, as well as flint and obsidian, which are dense and grain-less. These latter two materials were found to be the best for making tools (Hartenberg & McGeough 2019:3). They will be discussed more in detail in section 2.6.2.

By the time the Neolithic began, about eleven to ten thousand years ago, people started to settle down, and the climate changed, becoming warmer and wetter (Sykes 2001:170). The change in climate came about by the retreat of the ice cap, covering a large part of northern Europe during the last Ice Age (Spinney 2012:137). This change in climate in turn brought about that more food was produced than was necessary for the immediate needs, which meant that instead of being involved full time in food production, some people could turn to other activities, and become craftsmen, artists, mystics etcetera (Sykes 2001:170-171).

The first nucleus of domestication that anything is known about occurred about eleven thousand years ago in what is known as the Fertile Crescent. This region encompasses parts of what is now Syria, Iraq, Turkey, Iran and Israel (Sykes 2001: 171). And it is here that remains have been found of the world's first stone temple as well as flint tools. At Göbekli Tepe in present day southern Turkey, remains are being excavated of what was once a vast temple complex (see Figure 2-6).

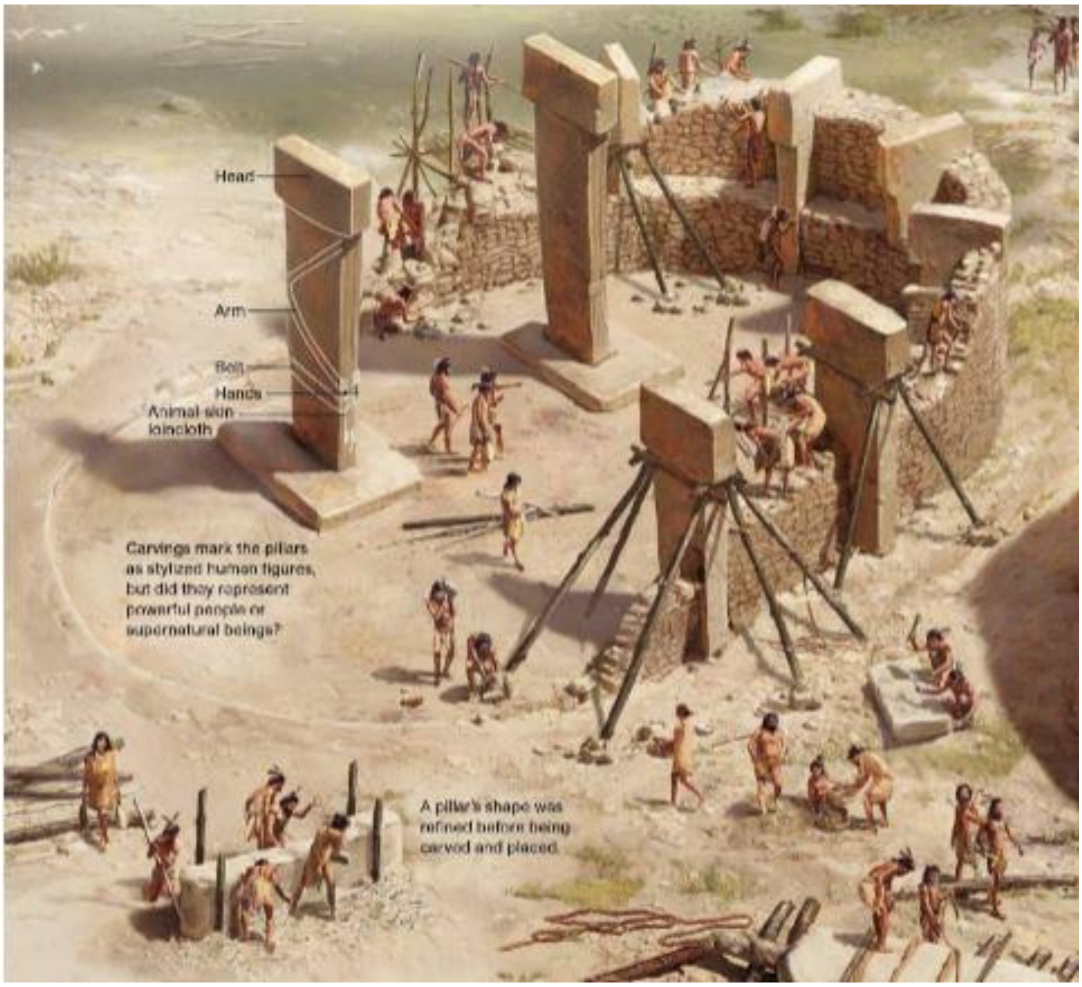



**Figure 2-6: Reconstruction of one of the temples at Göbekli Tepe, Turkey, which was built with the use of flint tools (Mann 2011:45).**

Limestone pillars were hewn there with flint tools and were decorated with carved animal images about 11,600 years ago (Mann 2011:34-39). Those involved in its construction, are believed to still have been hunter-gatherers and were not quite settled in villages yet. This fact in turn has brought about further debate about the above-mentioned settlement pattern of hunter-gatherers becoming agriculturalists. Right now, two theories co-exist, as apparently at Göbekli Tepe hunter gatherers started to build a place of worship (see Figure 2-6), before they had settled down to an agricultural existence (Mann 2011:41). What is significant for this study though is that they had tools made of flint, available to work the stone used for the construction of the temple complex, even though they may have lacked a strong central authority to organise a labour force for such an undertaking.

So, my understanding is that instead of using their tools to meet their daily needs of food, clothing and shelter, the builders of Göbekli Tepe started to use their flint tools to build a stone temple, and carried on building more stone temples on that site as time went on (Mann 2011:48). With the warmer weather, and the increased quantities of food that became available as a result, they no longer had to spend most of their time meeting their immediate needs, but were able to set aside time and effort to create a center to meet their spiritual needs. This site will be discussed more in detail in 6.2.1.

### 2.6.2 Use of flint and obsidian to make tools

As already referred to in section 2.6.1, flint and obsidian were two materials, which were found to be extremely suited to make tools and these became tools for working stone. Even though these materials are similar, and were used for similar purposes, they are not the same, which will be explained in what follows.

#### *2.6.2.1 Flint*

Flint is a form of hard, tough *sedimentary* rock, which occurs as nodules in softer materials such as chalk and limestone, often in distinct layers (https://geology.com/rocks/flint.shtml.). It is an impure quartz, a type of silica, and it usually occurs in a grey or smoky-brown colour. Flint is not so glass-like, but is more kind of opaque in comparison with obsidian. It is fairly well distributed all over the world and reportedly is harder than most steels (Hartenberg & McGeough 2019:3). Because it has a hardness of 5 (Hall 1993:68), it can be used to work limestone up to a hardness of 4.5. It can also be fashioned into a sharp tool, by chipping off flakes along the edge of the tool to be fashioned. This process is called flint-knapping (Rudgley 1999:168; see Figure 2-7).

**Figure 2-7: Flint occurs in nodules, which can be knapped into tools with sharp edges. This image shows the remains of the knapping process (Edmonds 1995:11).**

### *2.6.2.2 Obsidian*

Obsidian is a natural form of glass, which has come about by *volcanic* activity (Hall 1993:68). It is formed when volcanic lava cools rapidly, which prevents the formation of a crystalline structure. As a result of that, it is an amorphous material, with a smooth uniform texture, and it breaks with a conchoidal (shell-like) fracture (https://geology.com/rocks/obsidian.shtml), forming a sharp edge after flakes have been removed. It occurs mostly in black or grey, and is fairly limited in its distribution (Hartenberg & McGeough 2019:3). It is found throughout the world in places where volcanic activity occurs, or has occurred, such as Hawaii, Japan, Iceland and the Lipari islands off Italy (Hall 1993:68), as well as Mexico (Stuart 1995:32; see Figure 2-8), to mention just a few,[7] and it can also be knapped into a sharp blade.

[7] From my studies at the University of Arizona (1971-1972), I remember that obsidian was used in the form of sharp tools by the Indian tribes of the Southwestern United States. It was also the preferred material for the manufacture of tools, both for domestic use as well as construction purposes in Mexico (Stuart 1995:33).

**Figure 2-8: Archaeologists investigating the remains of obsidian workings in de Cerro de las Navajas in Mexico (Stuart 1995:32-33).**

For instance, at the site of Göbekli Tepe, which was just mentioned in 2.6.1, there was an enormous amount of flint tools, knives, choppers, and projectile points, all lying scattered on the ground. The material had been brought from neighbouring valleys (Mann 2011:41) and had been shaped for use at the site (Mann 2011:40). Without flint tools, it would have been impossible for the builders of Göbekli Tepe to construct their circular temples with the large pillars, as there were no metal tools available yet at this period in time.

Flint continued to be used for a long time. Whereas at Göbekli Tepe the flint was used for the construction of the temples, the flint quarried at Grimes Graves in the county of Norfolk in the United Kingdom (this is about 130 kilometers northeast of London), which operated for about 600 years from about 2,300 BC over an area of 14 hectares (Hartenberg & McGeough 2019:13), was part of a large-scale industrial operation. At present the landscape there looks like the surface of a golf ball, and is dotted with more than 360 saucer-like depressions (see Figure 2-9). These are the remains of more than 360 shafts where flint was extracted at a depth of 2.5 meters, as this was where the best quality flint seams occurred (Rudgley 1999:168-169). The quantity that was excavated there was most likely traded elsewhere. To extract the flint from the pits, red deer antlers were used as picks and an estimated 40,000 antlers were found at the site (Rudgley 1999:175).

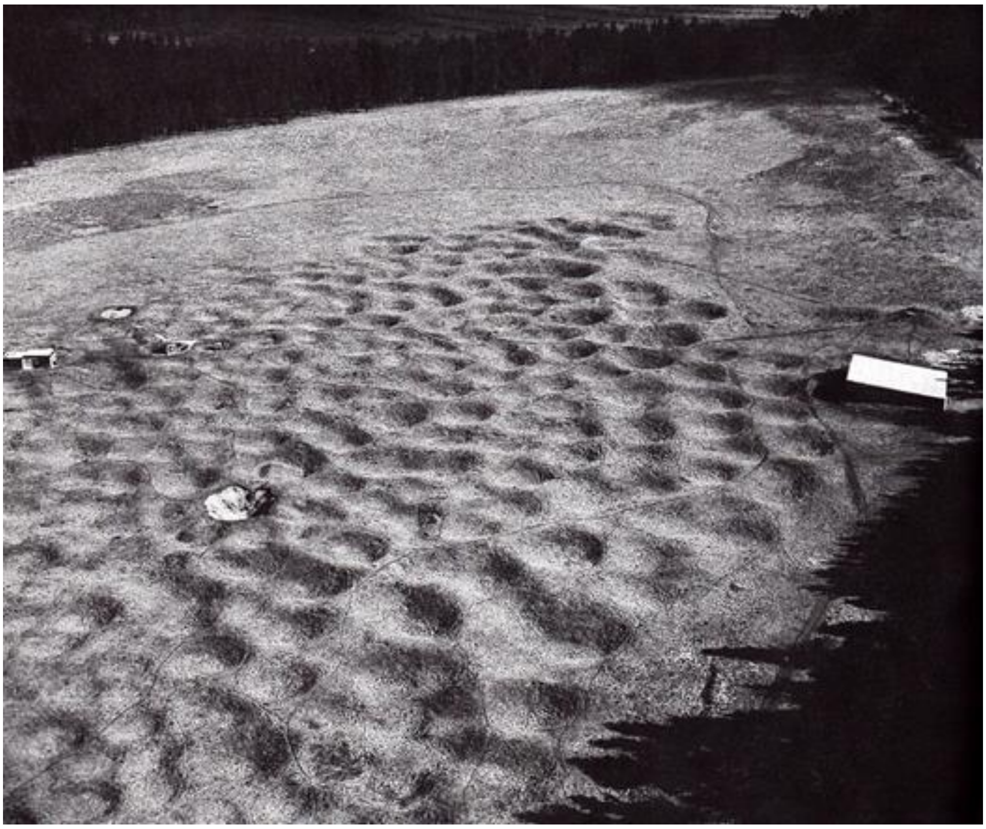


**Figure 2-9: The flint mines at Grimes Graves in the UK as seen from the air (Edmonds 1995:116).**

Fortunately, the red deer did not have to be killed for their antlers, as these animals shed their antlers annually and grow a new set (Cranfield 1991:20-21). The importance of flint should not be underestimated, even in later times when metals had already made their appearance (Hartenberg & McGeough 2019:14). It continued to be used side by side with metal tools, as will become clear when we discuss the next material.

### 2.6.3 Copper and bronze

In the process of making tools from various types of rock, the toolmakers discovered that some pieces did not flake or fracture, but were soft and changed in shape as a result of hammering. Besides the metals such as gold and silver, which were discovered in this way, but were too soft for making tools, copper was found to be a useful material for making tools (Hartenberg & McGeough 2019:14). Initially use was probably made of nuggets, which could be hammered into shape while cold, and the hammering process also hardened the material. It was possible to produce a sharp edge, and if too much hammering had made the copper brittle, it could be heated, then dunked into cold water to be made fit for re-use again. This process is called quenching (Hartenberg & McGeough 2019:14).

Subsequently it was discovered that copper could be melted and cast into a mould, which would produce a shaped item once it had cooled and congealed. Then only hammering would be needed to produce a sharp edge, on for instance an axe or knife (Hartenberg & McGeough 2019:15).

The development of pottery and how to control very hot fire played a role in the development of smelting, whereby teal-blue rocks (which we now know to be copper ore), when heated to a high temperature of 1083˚C, could yield copper (see Figure 2-10; Ozment 1999:78-79; Hartenberg & McGeough 2019:15-16). There is a difference between melting and smelting, the latter being the process by which metal is separated from its ore base, the former the use of nuggets of pure material reduced to liquid by means of heating, before casting into a mould takes place (Hartenberg & McGeough 2019:16).

This is how the Copper Age, also called the Chalcolithic Period began, which lasted about a thousand years (Ozment 1999:71). Not all authors seem to agree on when exactly the Copper Age began, as Ozment (1999:79) as well as Bahn ([ed] 2000:41) mention 6,500 years ago, and Hartenberg & McGeough (2019:1) state over 5,000 years ago.

**Figure 2-10: Chunks of copper ore obtained in western Jordan for a smelting experiment using ancient techniques (Ozment 1999:70).**

Subsequently bronze was invented, which is an amalgam of 90% copper and 10% tin (Hartenberg & McGeough 2019:17). Bronze was harder than copper, easier to melt than copper by itself, and could be hammered to a sharper edge than just plain copper (Hartenberg & McGeough 2019:17). It is believed that the Egyptians still used copper tools to shape the blocks with which the pyramids were built in circa 2,500 BC (Morell 2001:83), as there were no bronze tools available in Egypt at that time yet. Mark Lehner is of the opinion that bronze was probably not used in Egypt before the Middle Kingdom (Lehner 1997:210), which period lasted from about 1975 BC till about 1539 BC (Brown 2009:96-97). The copper tools, even though they were relatively soft, could either be reshaped, or were re-sharpened on a regular basis, to make them fit for use again (Morell 2001:82-83) and were hardened by hammering them (Shadmon 1996:74). Besides by means of hammering, the Egyptians also made the copper tools harder, by adding 6% arsenic to the copper (Odler 2017:5-6). The life-span of copper tools was definitely longer than those made of flint.

### 2.6.4 Iron

After the discovery that copper could be extracted from copper ore, a similar discovery was made about iron ore. In fact, lumps of meteoric iron had been known from early on and could be hammered into simple tools (Bahn [ed] 2000:41), but only from about the 2$^{nd}$ millennium BC techniques for smelting iron began to be developed in Anatolia. From about 1,200 BC onwards iron appeared more widely in the Near East

(Scheepers & Scheffler 2000:353). Due to the fact that iron was scarce in its initial stages of use, it must have taken a while for iron tools to become available for the quarrying and working of stone. To illustrate the scarcity of iron, one can look at the biblical account of the slaying of the giant Goliath, in which he is dressed in bronze armour, with only the tip of his spear made of iron (I Sam 17:7). In the account of the construction of the temple iron is available in a larger quantity, as David provided 'a large amount of iron to make nails for the doors of the gateways and the fittings' (I Chron 22:3; I Chron 29:2). In connection with this latter verse Schoneveld states that iron has only been in use since the 12th century BC and that it initially was just for purposes of war (Schoneveld 1977:243).

Once iron became more plentiful, it made life considerably easier for the stonemasons, as iron tools did not get blunt as quickly as copper tools because they were harder, and consequently did not need to be re-sharpened or reshaped as often as the copper tools. In fact, iron tools have remained in use until the present, even though they have become much more sophisticated by manufacturing them from alloys such as Wydia (this according to sculptor Henk van der Vis, in a discussion about working stone in Rhenen, the Netherlands on 30 July 2014).

### 2.6.5 Hammers

Where hammer stones were initially used simply held by hand, a major development took place about 35,000 years ago, when hafting was invented. This is the fitting of a handle to a stone implement with a sharp cutting edge (Hartenberg & McGeough 2019:10).

So, flint tools were not used as one would use a combination of a wooden hammer and metal chisel, but a sharpened flint blade would be attached to a deer antler with animal sinews or mounted in a wooden handle (Edmonds 1995:54) and then used like a hatchet or axe (see Figure 2-11).

Once copper chisels appeared on the scene, these were used with wooden hammers to dress stone. The chisels were no broader than about 8 mm, as wider blades of soft copper do not work on stone. This implies that the work could only progress by means of 'small increments repeated innumerable times' meaning: many small repeated hammer blows (Lehner 1997:211).

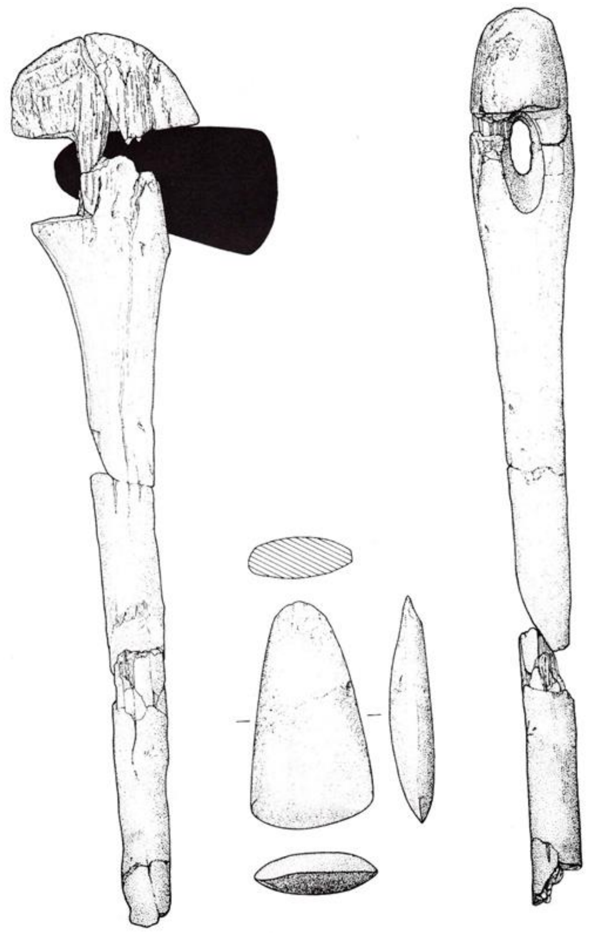


**Figure 2-11: Example of how a flint blade could be mounted into a wooden or bone shaft. (Edmonds 1995:54).**

The hammers already then consisted of a big solid wooden head, pared down to a thinner stem to hold (Lehner 1997:211). That shape endured for millennia, as the stonemasons in my father's employ during my youth, still used similarly shaped hammers (see Figures 2-12 and 2-13). The copper chisels in Egypt had to be re-sharpened very regularly and it is estimated that a full-time tool sharpener was needed for every 100 stonemasons working with the copper chisels to produce the fine Turah limestone facing, with which the pyramids were clad (Lehner 1997:211). In fact, all the pyramids of the Old and Middle Kingdom periods were clad with Turah limestone and depended on this material for their stability. When in later eras the Turah limestone was removed by builders for secondary use, many pyramids were reduced to heaps of rubble over time as a result of this practice, and only the best built pyramids retained some of their form (Dodson 2003:22).

**Figure 2-12: Mural image of an Egyptian stonemason using a big wooden hammer and chisel (Lehner 1997:211).**

**Figure 2-13: A worn wooden mallet and bronze chisel from an Egyptian tomb of the 15th century BC, collection of the Archaeological Museum of Turin (Mannoni 1985:142).**

In the quarries at Gebel el Silsila in Upper Egypt, the archaeologists Doctor Maria Nilsson and John Ward, have found that chisels of different sizes were used. These ranged from straight chisels of between 4-7 millimeters in width, to flat chisels with head sizes of 3-4 centimeters and pointy chisels measuring 8-11 millimeters wide at their point. These are believed to be dating to Roman times (Nilsson et al 2015:159).

For the quarrying of granite, the Egyptians used pear-shaped dolerite stones as pounding hammers (see Figure 2-14). The larger dolerite pounding stones, weighing about 4-7 kg, were held with both hands to pound the channelling[8], for delineating granite blocks. The mason would turn them regularly to exploit a new percussion edge,

[8] The source text uses channelling, with double 'l'.

and when they had become fully rounded the stones would be used as rollers under slabs (Lehner 1997:211).

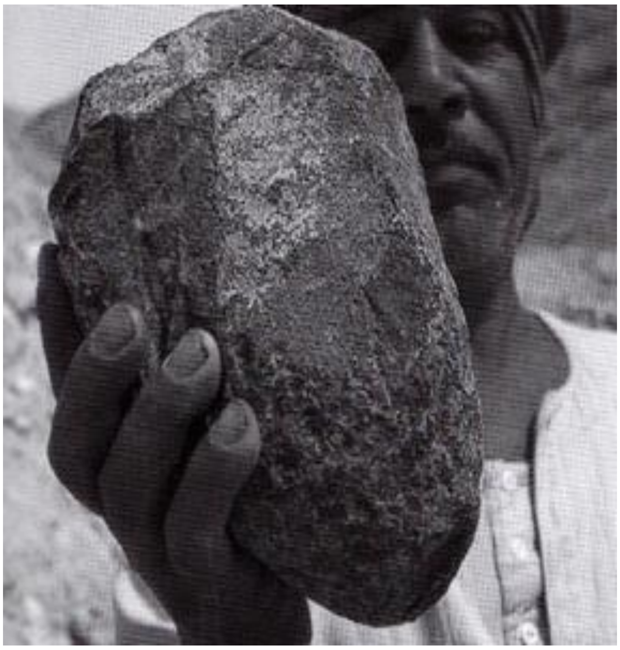


**Figure 2-14: Dolerite pounding stone with percussion edge (Lehner 1997:211).**

The masons would mount a smaller pear-shaped dolerite stone between two branches and then use it like a hammer held with both hands (see Figure 2-15) for the finer detailed work (Lehner 1997:211).

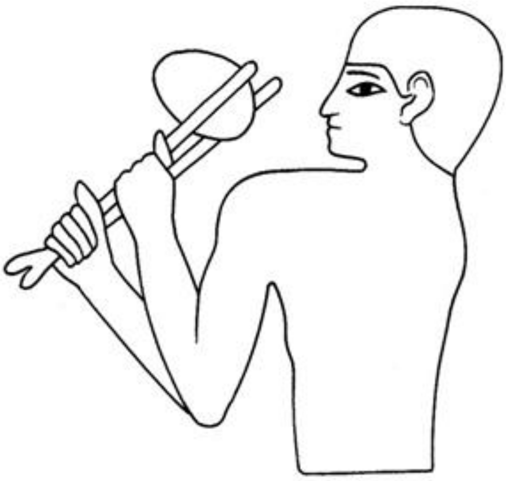


**Figure 2-15: A smaller dolerite stone mounted between two sticks and used with two hands like a hammer (Lehner 1997:211).**

### 2.6.6 Other tools

#### *2.6.6.1 Drills*

Besides hammer-stones, wooden hammers and copper chisels, also drills were used during the construction of the pyramids. No actual drills have been found, only drill holes in granite used in various monuments dating to the 4$^{th}$ and 5$^{th}$ dynasty. These holes show pronounced striations, but even Mark Lehner admits to be totally perplexed by the fact that ancient builders cut through stone as hard as granite and basalt, but he does not know how they did this exactly. The only comment he makes is that whatever was used to cut or drill had to be at least as hard as the hardest of minerals that granite is composed of, and that is quartz (Lehner 1997:210). I hold it possible that diamonds were used for drilling purposes, see for a further discussion of this possibility 4.2.6.2.

#### *2.6.6.2 Saws*

Saws were also used in the construction of the pyramids, and the same problem applies as to the drills: it cannot exactly be determined with what kind of tool the sawing was done (see Figures 2-16 and 2-17). Lehner states that the saw blade was probably made of copper, but that the blade only served as a guide and that the actual cutting was done by means of abrasion with the use of a sludge consisting of water, gypsum and quartz sand (Lehner 1997:210). He has personally observed the dry remains of this kind of sludge, coloured green from the copper, in deep cuts in basalt blocks in the mortuary temple of Khufu.

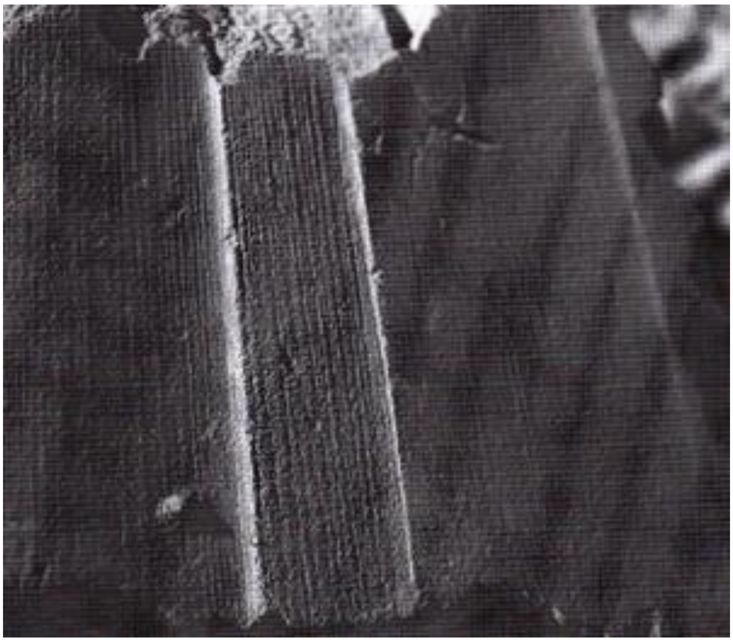


**Figure 2-16: Basalt which has been cut with a saw blade in ancient Egypt (Lehner 1997:210).**

I believe that also in this case it is possible that diamond dust was used as an abrasive. My husband, Neil Smith, who worked many years as a materials scientist at Siemens here in South Africa, is of the opinion, that even though copper saw blades may seem to have been too soft to cut through very hard materials such as granite or basalt, this is very possible. The softness of the copper saw-blade would have allowed the pulverised diamond dust to become embedded into it, and the copper saw became the matrix, that moved the diamond particles to do its abrasive work of cutting the stone. In the material testing performed in the Siemens materials' laboratory, the researchers would also use an abrasive in a soft matrix to achieve the cutting work to be done.

Another, and later example of sawing can be found on the Greek island of Naxos where large blocks of marble were cut in antiquity with the use of corundum sand and iron saw blades. The corundum sand was found at Apiranthos and Koronos and a saw blade was used by moving it forth and back on a thin line to press the sand on the block and into the cut, which was effectuated in this manner (Malacrino 2010:18).

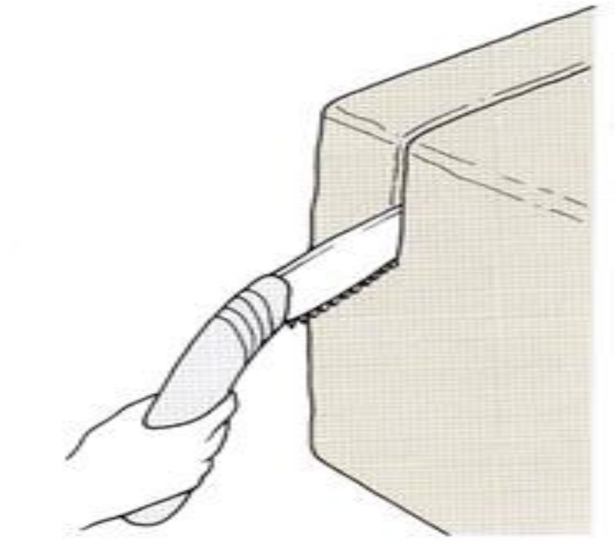


**Figure 2-17: Reconstruction of how basalt may have been cut with a copper blade, using water, gypsum and quartz sand as the abrasive and the saw-blade as a mere guide to slice through the material (Lehner 1997:210).**

### *2.6.6.3 Measuring tools*

In order to shape the stone blocks correctly, measuring tools were used as well (Lehner 1997:210; Stocks 2003:573-574). These comprised the following: the set square, with which right angles were measured and the plumb bob, which was suspended from a rod to make vertical adjustments. Then there was the square level. This consisted of a wooden A-shaped frame with a plumb bob suspended from the top corner. The measurements were checked against a mark in the middle of the cross piece of the A-shaped instrument (see Figure 2-18).

Besides these, string or rope was used to mark out the building site (Lehner 1997:210) or blocks of material (Mannoni 1985:104). The rope was made of flax (Goldhill 2005:43).

In order to level the bases of the pyramids, it has been suggested that water, poured into levelling trenches, was used for this purpose (Casson 1966:132-133). Lehner is of the opinion however, that this is very unlikely, due to the fact that water transport in the Old Kingdom was limited to the use of shoulder-poles with pots (as Casson shows, 1966:133) and that the base area of Khufu's pyramid, comprising 5.3 ha, is far too large for such a technique to be used. It would be impossible to bring a sufficient amount of water from the Nile up to the plateau where the pyramids were built, and there would have been far too much evaporation to fill the levelling trench to a sufficient height, to level the base of a pyramid with the use of the water trenches (Lehner 1997:210). It is much more likely that a system of poles was used, which were posted into the ground in holes, of which remains have been found. Rope was used, strung along from one pole to the next, to provide measurements for the setting line of the first corner of Khufu's pyramid (Lehner 1997:212).

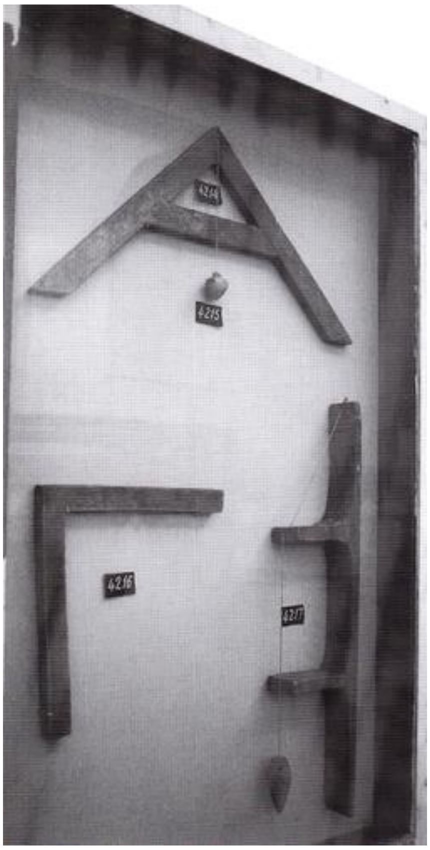


**Figure 2-18: Ancient wooden tools used for the construction of the pyramids. A square level with a plumb bob (top), a set square (left) and a vertical plumb rod (right) (Lehner 1997:210).**

To this latter method, further credence can possibly be given by the following: in the Egyptian pantheon, there was a goddess called Seshat. She was the goddess not only of writing, but also of measurement (Wilkinson 2005:223). In this capacity, she was involved in the foundation ceremonies of temples, whereby she assisted the king in the ritual of the 'stretching of the cord', which means the laying out of the temple (Wilkinson 2005:223). The great pyramids each had a mortuary temple (Lehner 1997:108; 122; 134), and as temples, these must also have had a ritual of the 'stretching of the cord', before construction. As these mortuary temples were connected to the pyramids, the ‘stretching of the cord’ very likely included the actual pyramid itself.

Besides this, there is a further explanation to the ‘stretching of the cord’. This is also called ‘snapping a line’ by Hartenberg and McGeough (2019:23). According to my husband Neil Smith (discussion June 2019), it is identical to what is called the ‘chalk line’ in modern terms and this method is still in use to this day (see Figure 2-19). It functions as follows: a rope or cord is thickly covered with chalk, or with a powder substance of some colour. The rope is tightly stretched from point A to point B over a flat surface, and then lifted a fraction in the middle of the cord, after which it is allowed to snap back onto the surface where it is stretched over, and in this process, the powder substance falls off the rope and leaves a perfect straight line on that surface. This is how straight lines were set out 5,000 years ago by the Egyptians and how it is sometimes still done in modern construction. The Egyptians used wet red or yellow ochre, and these days wet white or red chalk is used (Hartenberg & McGeough 2019:23-24).

**Figure 2-19: Method of the chalk line to draw a straight line in construction (Stock photo, open source).**

This in turn also ties in with what Mark Lehner found when he first came to do research in Giza, namely red lines outlining limestone blocks, which had been left behind in the limestone quarry in Giza, where the material originated from which the pyramids were built (Morell 2001:87; see also section 3.2.5.1).

String was probably also used to flatten the surface of the stone blocks with which the pyramids were built (Stocks 2003:575). This was done as follows: three small wooden rods were cut of identical length. Holes were drilled into two of the rods, to allow for string to be attached to both of them. The rods were placed and held in an upright position with the string stretched tautly between them, and then the third rod would be positioned under the string. By sliding it underneath the string stretched between the other two rods, the surface of the block was checked. If it was uneven, the string would be pushed up between the two rods holding the string into place, indicating where the surface of the block needed to be smoothed further (Stocks 2003:575).

#### *2.6.6.4 Compass, divider and caliper*

Besides the above-mentioned measuring tools, which were in use in Egypt, the Greeks and Romans are known to also have used the compass, divider and caliper. The terms compass and divider are often used interchangeably, but differ in the following in that a compass has one sharp point, which is positioned in the center and one pencil point which is used to draw a circular line. A divider has two sharp points and one of these is used to mark or scratch a line. Both are used to draw circles, as well as for small measurements, or transfer of measurements (Hartenberg & McGeough 2019:23; see Figure 2-20). The divider would have been the instrument to mark for instance the outline of a rosette on stone material before the stonemason would start chiselling it. These rosettes were a very popular motif in Herodian architecture and were widely used to decorate parts of the Temple Mount, for instance the ceiling domes of the Hulda gates, as decorative elements of a neutral nature (Ritmeyer 2006:73).

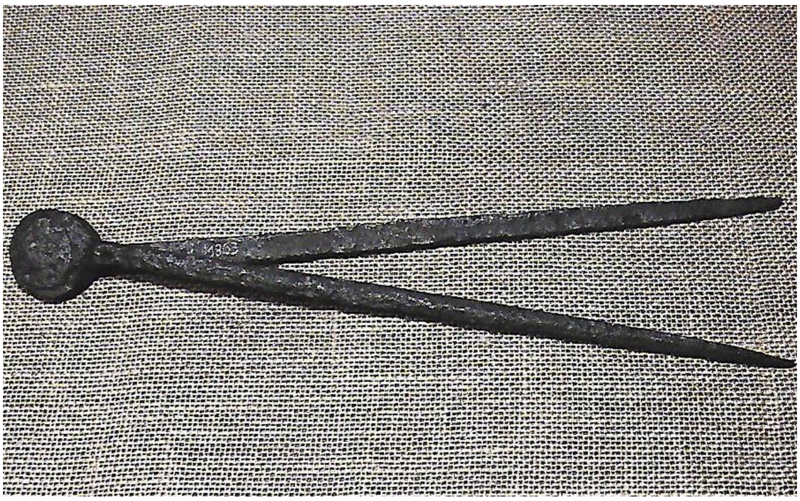


**Figure 2-20: A divider to mark a circle on stone (De Nuccio & Ungaro 2002:505).**

A caliper has curved legs and is used to measure a spherical object, such as something produced with a lathe (Hartenberg & McGeough 2019:23; see Figure 2-21).

**Figure 2-21: Example of a caliper of bronze found at Pompeii in Italy (De Nuccio & Ungaro 2002:505).**

The only time I have seen a caliper used in my years in the stonemason industry was when a sculptor in Carrara, Italy had to copy a design of a sculpture executed in plaster of Paris, in granite. He used a caliper to measure the rounding of the design to copy that measurement in the granite sculpture he was working on.

#### *2.6.6.5 Further development of hammers and chisels*

Besides the simple chisel and hammer shown in the Figures 2-12 and 2-13, over time chisels and hammers were developed in different models and shapes. Figure 2-22 below shows various types of hammers dating to the Greek and Roman eras. Unfortunately, it cannot be indicated exactly which hammer dates to which specific era, but is does provide an idea of what was developed over time.

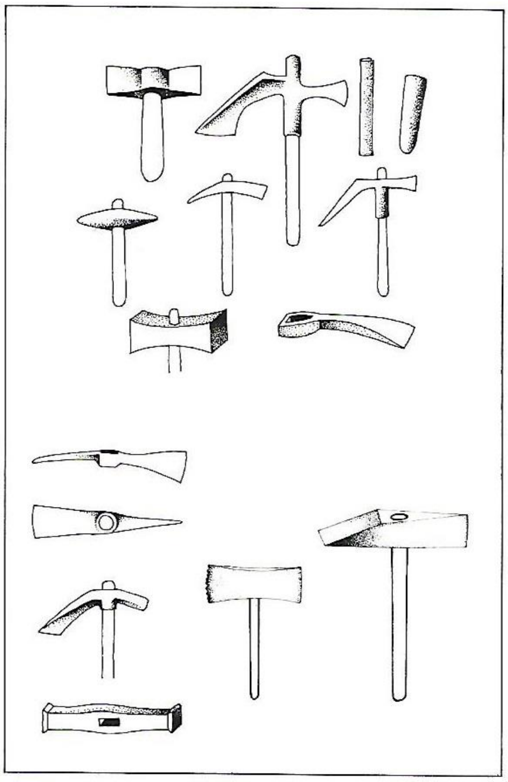


**Figure 2-22: Various types of hammers developed in the Greek and Roman eras (Mannoni 1985:73).**

Similarly, there also was a development in the shape of chisels, which were adapted for the task they were intended for (see Figure 2-23).

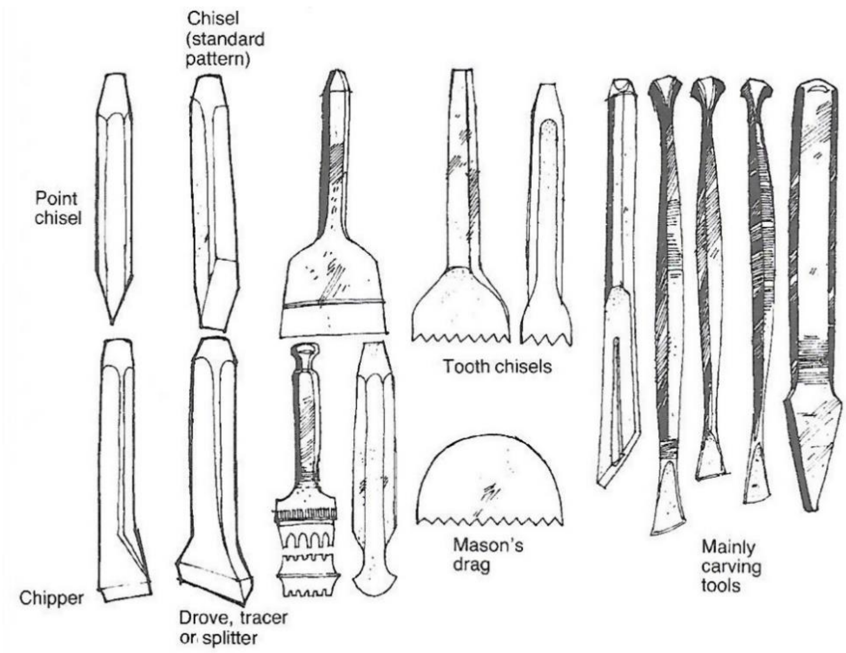



**Figure 2-23: Various types of chisels for working stone were developed over time (Shadmon 1996:81).**

The tooth chisels, as shown in the middle of the above image, were used to chisel the edges of the blocks which were used for the outer walls of the Herodian extension of the Temple Mount in Jerusalem (Ritmeyer 2006:24).

## 2.7 CONCLUSION

An attempt has been made in this chapter to give an overview of the development of tools with which stone was worked in antiquity. It is clear that as time progressed, better tools became available for that purpose. Some developments took a long time to materialise, and sometimes there was more rapid progress. These developments enabled the stonemasons in each successive era to achieve a better final result, but even so it still never was an easy task.

When we take all the factors mentioned in this chapter into account, it can be concluded, that working stone has not been the same experience for all those involved in the construction of monuments or buildings in antiquity. The differences in the hardness of the various materials used for construction, as well as the availability of particular kinds of tools, have influenced the ways in which stone was worked. Most monuments and buildings were made of limestone, but the use of the much harder materials such as granite and basalt for certain elements of the buildings, elicit the question how this was achieved with the copper tools available at the time of construction, as those stone materials are much harder than the hardness of the materials that the tools were made of. It is possible that use was made of diamond dust for cutting purposes, and of diamonds for drilling. This will be discussed in Chapter Four. Once iron tools became available, it became easier to work the harder materials such as granite and basalt.

All in all, it is impressive what was achieved in the construction of buildings and monuments in antiquity, when we take into consideration what basic kind of tools were used.

# CHAPTER THREE

## QUARRYING, TRANSPORT AND HOISTING; STONE VESSELS AND MOSAICS

## 3.1 INTRODUCTION

In many parts of the world there are massive stone constructions, which remain of long-lost cultures. If they had not been made of stone, we probably would not even know that the culture had existed (Shadmon 1996:2). When looking at these structures, one cannot but wonder how the builders managed to obtain the stone with which they were built. If they were constructed with large squared blocks, these of necessity came from a quarry, which raises the question of how it was possible to remove such massive pieces of stone from the bedrock. The sheer weight of the blocks brings us to the next question of how it was possible to transport these blocks to the building site, especially when there was quite a distance to cover, as well as how it was possible to put these blocks into place, possibly by means of hoisting.

The focus of this chapter will be on the different quarrying methods needed for the differing levels of hardness of the materials, used in the construction of buildings or monuments in antiquity. Furthermore, an overview will be given of the various methods of transport of the materials to the building site once they had been quarried. This transport could be over land, but also over water. The final part of the chapter will deal with how materials were put into place, and whether this was done by means of hoisting or other methods. The intention of this all is to establish a basic amount of knowledge about stone working, so that insight is gained about the practical aspects of the entire process involved in constructing a large building, temple or monument.

## 3.2 QUARRYING METHODS IN ANCIENT TIMES

### 3.2.1 Use of field stones

The oldest experience of using stone was probably by collecting field stones and using these for the construction of walls (Shadmon 1996:102; see Figure 3-1). Good examples of these would be the walls of ancient Mycenae in Greece (Albanese, et al

2010:64; Malacrino 2010:6), as well as the stacked stone walls of Göbekli Tepe, which surrounded the solid pillars (see Figure 2-6, and Figure 6-1; Mann 2011:44-45).

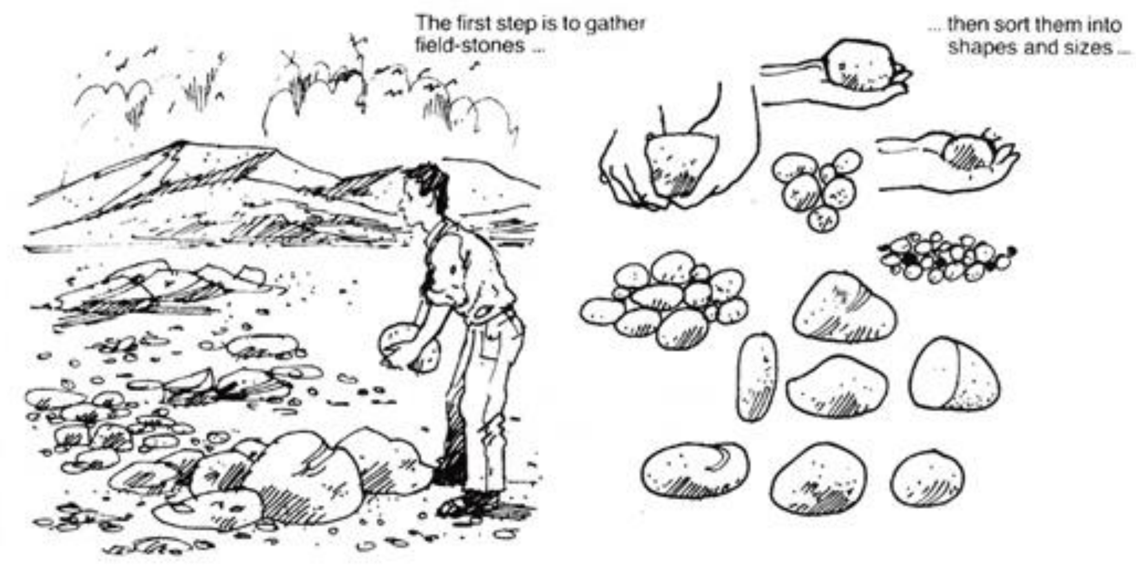



**Figure 3-1: Steps in the collection of field stones for construction purposes (Shadmon 1996: 102).**

The next stage of development would entail the splitting of field stones and boulders that had been collected, which would enable the builders to create straight sides, by stacking the rounded sides to the inside of a wall under construction and the straight sides on the outside. This would provide a straight edge to both sides of the wall (Shadmon 1996:102-103).

### 3.2.2 Use of squared stones

Once the field stones had been exhausted, or in the absence of this type of stones, builders would have looked at solid deposits of rock to obtain stone for building blocks. Opening up a quarry would have been the easiest by making use of natural cracks in the rock (Malacrino 2010:31), once the overburden had been removed (Shadmon 1996:170;).

Overburden or burden is the term used for material which needs to be removed before the quarrying of a useful deposit of material can begin (Shadmon 1996:168, 170). It can consist of soil and plant-growth on that soil, loose rock and also of the top layer of material which has weathered to such an extent that it is no longer useful to be quarried as blocks (Mannoni 1985:75; Adam 1994:23)[9].

By inserting wedge-shaped pieces of wood, copper, bronze or iron (depending on what was available at the time) into a crack in the bedrock, and hammering these down, the crack could be opened up further and a large piece of rock could be dislodged in this way. This could be further shaped into building stones. These could differ in size according to what was required. To give a few examples: the size of stone building blocks in Saqqara in Egypt initially was the same as that of the mudbricks, which had been used in the Predynastic Age (Stierlin 1995:34). The stone building blocks were finished smoothly and properly squared and were laid in carefully constructed horizontal courses. Subsequently the Egyptian builders realised that by using larger building blocks, they could build taller structures, such as the pyramids, because the use of larger blocks increased stability in the structure (Stierlin 1995:36). What is remarkable is that the transition from mudbricks to the same size stone blocks only took 100 years and from the mudbricks to the very large blocks only 200 years, which was a very rapid technological development (Casson 1966:13). However, in the Amarna period under Pharaoh Akhenaten, which lasted 17 years and ended in 1336 BC (Hessler 2017:126,134), smaller limestone blocks called '*thalatha'* were used[10]. The name derives from the Arabic word for 'three', because the stones measured three hands in length (Gore 2001:43). It is thought that the reason for this change was that a block of this size could be lifted by a single worker (Hessler 2017:133). It also allowed for a quick building process (Hessler 2017:127). Another reason for the use of smaller building blocks may have been that the workers employed for the construction of Amarna were very young (Hessler 2017:126). So, blocks of different sizes were used under different circumstances, depending on what was needed, or what was possible to extract from a quarry.

[9] Sometimes part of the overburden still gets used these days for decorative purposes, as rough, unworked lumps of stone to delineate borders in a garden for instance. I recall a trip in the 1980's to go and buy this kind of material at a limestone quarry in eastern France, where the quarry master referred to this kind of material as the 'croûte', the top crust of the quarry.

[10] Some articles refer to these stones as '*talatat'* (Gore 2001:43; Kucharek 2012:4).

### 3.2.3 Opening up a quarry

A quarry could be started from the summit of the rock vein, also called the ‘head’ (Malacrino 2010:33). This would be followed by the progressive removal of parallelepiped (parallel shaped but not exactly squared) elements, which would result in a stepped quarry (Malacrino 2010:33; Pensabene 2016:36). The material which was obtained in this manner could be split further by means of the use of wedges, or by using hammers and chisels (Shadmon 1996:44). If wedges were to be inserted, the best way to do this was by first making a groove in the material and putting a support, possibly a branch under the block where the material was to be split (see Figure 3-2). The groove on top of the stone would make it easier to try and insert wedges into it and the support underneath the material would distribute the weight of the material unevenly, thus using its own weight as a method to create a break in it (Shadmon 1996:44). By hammering the wedges down one by one with short quick blows, the block would eventually be split (Shadmon 1996:44).

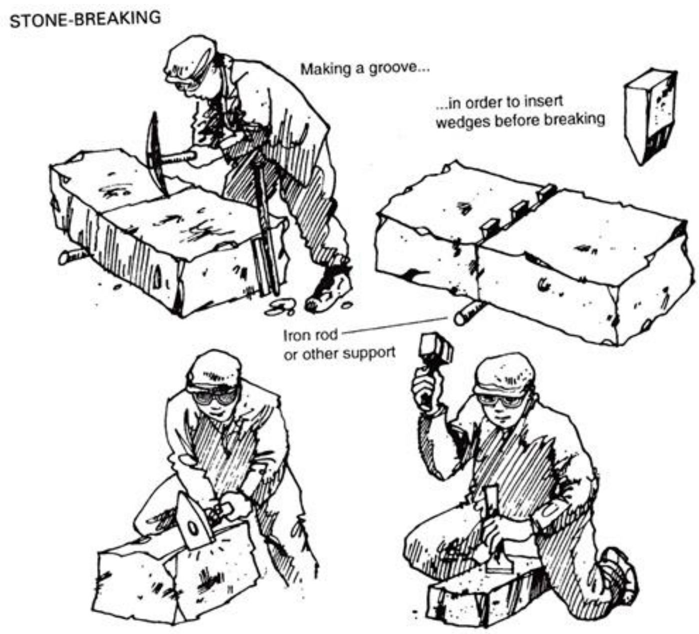



**Figure 3-2: Steps in the process of splitting a block (Shadmon 1996:44).**

### 3.2.4 Types of quarries

For the construction of a large building or monument, the builders would have to look for a rock deposit of sufficient quantity, suitable quality of material (Malacrino 2010:32), and preferably as close as possible to the prospective building site, to prevent transport over long distances. An example which can be mentioned in this respect would be the discovery of a suitable deposit of material to build the temple of Artemis in Ephesus as recounted by the Roman author Vitruvius (see Figure 3-3). As the story goes a shepherd called Pixodaros discovered a sizeable deposit of white-grey crystalline marble about 12 kilometers north-east of the city near lake Belevi in the 6$^{th}$ century BC after the decision had been taken that a temple would be built for the goddess in Ephesus (De Nuccio & Ungaro 2002:215; Malacrino 2010:32).

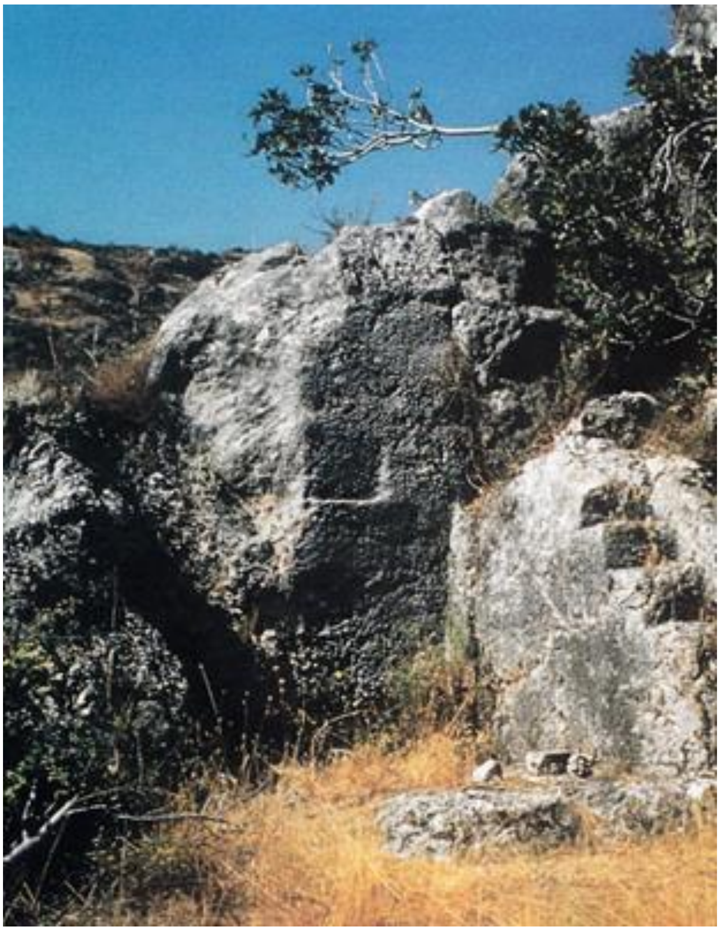


**Figure 3-3: The stone quarry at Belevi from which the material for the construction of the temple of Artemis in Ephesus was obtained (De Nuccio & Ungaro 2002:215).**

The quarry was connected by a canal to the river Kaystros, which flowed into the sea close to the harbour of Ephesus, thus providing a rapid way of transport for the material, which was extracted from a gallery type quarry (see section 3.2.4.1.; De Nuccio & Ungaro 2002:215).

The quantity of marble extracted from the quarries at Belevi was very large if one takes into consideration that the temple in Ephesus was 425 foot long (115 meters), 220 foot wide (55 meters), and consisted of 127 columns of 7 feet (about 2,3 meters) in diameter, which were 60 feet tall (18 meters) and were topped with Ionic capitals (Edwards 2016:27).

Depending on the location of the quarry, roughly three different types of quarries can be distinguished according to Shadmon. These are hillside quarries, pit quarries and underground workings (Shadmon 1996:41).

#### *3.2.4.1 Hillside quarries*

Hillside quarries are the most commonly occurring type of quarry (Shadmon 1996:41). These are the easiest to work, as there normally is not that much of an overburden layer to be removed. The blocks are detached from the vertical rock-face and are allowed to slide down to the quarry floor (see Figure 3-4), where they usually land on a bed of stone chips and rubble (Mannoni 1985:75).

The hillside quarry usually will develop into banks of material being quarried on different levels, and after the extraction of a number of blocks will have a stepped appearance (De Nuccio & Ungaro 2002:276; see Figure 3-4).

Once they have been quarried out, hillside quarries can become pit quarries, and can eventually even be worked underground (Shadmon 1996:41). As an example, the world-famous marble quarries of Carrara in Italy can be mentioned, which usually started as hillside quarries, often became pit quarries and now also are worked underground in large galleries (Mannoni 1985:87, 89-90, 94).

Once a block has been dislodged and lies on the quarry floor, it can be split if the block is too large (see Figure 3-1), the sides of the block are straightened and it can then be transported further down the slope. In this way there is no need for any vertical lifting.

**Figure 3-4: Quarry which has been worked from the top by dislodging blocks along horizontal layers, thus creating 'steps' or 'banks' as seen in the bottom left corner (Mannoni 1985:94).**

### *3.2.4.2 Pit quarries*

If deposits of rock are in flat areas, the quarry will start out as a surface quarry, as for instance the quarries developed in Egypt during the Old Kingdom in the early 3rd millennium BC (Malacrino 2010:33). This type of quarry will then become a pit quarry (Mannoni 1985:89). In Egypt the blocks out of this quarry were not lifted to the level where the pyramids were built, but the blocks were hauled on sledges over a ramp to the higher level where they would be used (Lehner 1997:204-205). As already mentioned, the other manner in which a pit quarry comes about is that the floor of a hillside quarry still has material left after the terraced part of the quarry has been worked out. However, pit quarries have two main problems, which are the fact that water tends to accumulate in the lowest part of the quarry (Shadmon 1996:42) and that it is very difficult to hoist blocks out of the quarry after extraction. This was very difficult in antiquity due to the absence of large cranes (Mannoni 1985:89).

### *3.2.4.3 Underground quarries*

Underground quarries have the advantage that no layer of overburden needs to be removed, before quarrying can start (Shadmon 1996:41). A further advantage of underground workings is that these can be exploited year-round, as they are not influenced by the vagaries of the seasons such as cold, snow or rain (Shadmon 1996:41).

Sometimes though, quarrying methods would try to mimic the way weathering, by means of heat and cold, splits rock over time. A good example of this would be the way in which Lapis Lazuli was quarried in Afghanistan already 6,000 years ago. In the province of Badakshan, the Lapis Lazuli mines of Sar-e-Sang are located forty miles north of the Panjshir valley, near the ancient trade routes linking China, Kashmir and central Asia (Mortenson 2009:87). To mine the seams of Lapis, fires would be lit in the tunnels, after which the hot rock would be cracked by packing it with ice. The material thus dislodged was traded all the way to Assyria, Babylon and Egypt, where it was used in seals and decorative jewellery, most notably in the death mask of king Tutankhamun (Mortenson 2009:87-88).

A great advantage of underground quarries is that they tend to produce material of a higher quality than material quarried at the surface, as there is less influence of weathering (Shadmon 1996:41-42). This is an interesting aspect, and can be illustrated by the following example: the great pyramid of Khufu on the Giza plateau was constructed with an outer pyramid casing of Turah limestone (Lehner 1997:207). This material came from a gallery type quarry, and was transported across the Nile Valley over a distance of about 30 kilometers to the Giza plateau (Lehner 1997:207; Klemm & Klemm 2001:638). It was a very fine, white limestone, and with that as its covering, the pyramid must have been a white, gleaming, perfectly shaped pyramid when it was just completed. The gallery type quarries at Turah show that the ancient quarrymen tunnelled to extract the layers of the highest quality stone (Lehner 1997:207). The stepped, beige coloured pyramid of Khufu, which can still be seen to this day, was built of nummulitic type limestone (Morgan 2015:12) and was quarried from the Giza plateau itself, but used to be hidden underneath the cladding of the better quality Turah limestone (Lehner 1997:202).

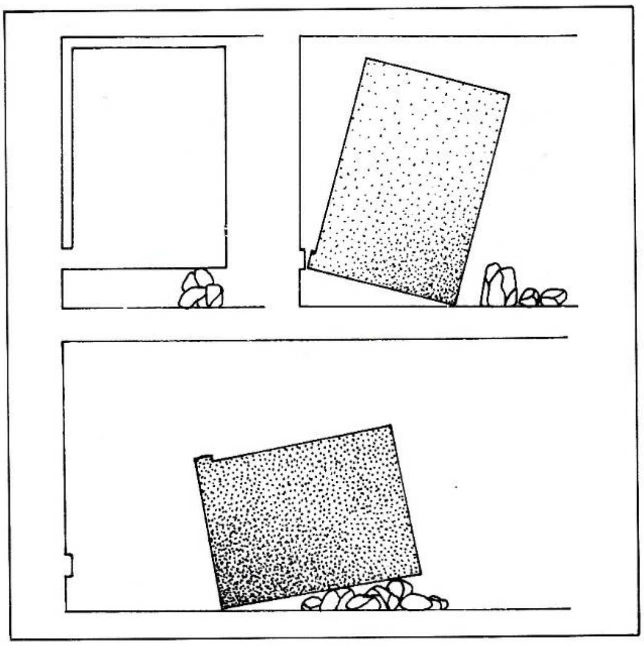


**Figure 3-5: Method of dislodging blocks in underground quarries by means of the undercutting method (Mannoni 1985:92).**

Quarrying methods in underground gallery quarries can differ as follows: blocks can be dislodged from the top of the block to the bottom, as was done for instance in the ancient Greek quarries of Naxos, Thaxos and Karystos (Mannoni 1985:86), or from the bottom by means of an undercutting method (see Figure 3-5), through which the blocks turn over by the force of gravity, as was practised in the quarries of Thaxos, Skyros and Pentelic (Mannoni 1985: 86, 92).

Another example is the ancient marble quarries of Paros in Greece from which the *statuario* marble was quarried. The Italian word *statuario* indicates a saccharoidal (sugar cube-like) marble, which has been formed by contact metamorphosis and which is used for statues (Mannoni 1985:86). It is also called *lychnites* marble and an estimated 50,000 $m^2$ was removed there over time. In the quarries in Paros the useable banks of this material were only a few meters thick and they were quarried by the light of oil lamps (Mannoni 1985:86). Disadvantages of quarrying underground or in galleries are the need for lighting and problems of ventilation (Shadmon 1996:42). These quarries need to slope slightly towards the outside to facilitate drainage and transport (Mannoni 1985:86).

**Figure 3-6: Interior of a gallery type quarry. Note the stacked stone pillars on the right (Mannoni 1985:92).**

Moreover, not all the material can be removed (see Figure 3-6), as part of it needs to remain standing as pillars to prevent the collapse of the ceiling of the galleries. Sometimes these pillars are quarried anyway, but are replaced by pillars of stacked stones (see Figure 3-6; Mannoni 1985:86).

#### *3.2.4.4 Trenches, adits and tunnels*

Besides the main types of quarries, Shadmon mentions that these can still be subdivided into adits, tunnels and trenches (Shadmon 1996: 41).

These terms can be explained as follows: an adit is a nearly horizontal passage from the surface of a mine (Merriam Webster's 1977:15), and a tunnel in the context of mining is a subterranean gallery from which material is removed (Merriam Webster's 1977:1259). These two terms clearly belong to the underground or gallery type of quarrying, whereby the tunnel is on a deeper level than an adit. Tunnels are also narrower than gallery quarries.

To provide an example of a tunnel type quarry, I have been in one of those myself in Belgium in about 1981. That was the scariest quarry I have ever visited. To get down into it, there was a cage, suspended from a crane, in which one was let down through a narrow, vertical hole deep into the quarry. Once below ground, there were narrow and low tunnels in different directions from which black marble was quarried. The workers were small of stature, which was an advantage to work there. It was only possible to quarry very small blocks there due to the size of the tunnels. I found it very claustrophobic and was glad to be back on level ground afterwards.

The quarrying in trenches however, is a surface method of quarrying, which is very old. The pillars of Göbekli Tepe were quarried by means of the trench method, whereby a surface deposit of rock on a level surface was excavated by chiselling around the contours of the pillar to be made and then levering the pillar out of the bedrock (see Figure 3-7). The researchers determined that this was the method that was employed for the quarrying of the pillars used in the construction of the temples at Göbekli Tepe, as a partially excavated pillar was left in the bedrock there, due to the fact that it was cracked (Mann 2011:55).

**Figure 3-7: A partially quarried pillar in the limestone hills around Göbekli Tepe, which was left behind in its trench (Mann 2011:55).**

Also, the *moai,* the statutes of Easter Island, were quarried by means of the trench method out of the tuff on the slope of the volcano (Bloch 2012:38). The *moai* would be carved all around, until only a small 'keel' held the statue still in place underneath its entire length. As the last step of the manufacturing process, the keel would be cut away and the statue would be lowered down the slope attached to ropes to control its movement, into a trench, where it would await transport to its site on the island's shoreline (Bloch 2012:38).

**Figure 3-8: The huge statue of Apollo at Naxos, which was abandoned in a trench quarry (Mannoni 1985:143).**

The same fate as the cracked pillar at Göbekli Tepe, befell a huge statue of Apollo on Naxos, which was quarried from a trench, but abandoned halfway through the extraction process (see Figure 3-8), because the material was flawed (Mannoni 1985:143).

And a fourth example would be the damaged obelisk, which is still visible in the bedrock at Aswan, as mentioned to me by the Dutch master stonemason Anne Krikke[11], who provided me with the picture he took there (see Figure 3-16).

[11] Anne Krikke is a Frisian-Dutch master stonemason who worked for the renowned restoration company Woudenberg in Ameide, the Netherlands, for most of his working life. He has a keen interest in stone working in ancient times and has visited many sites with ancient monuments. He is now retired and lives in Franeker, Friesland.

Besides the different types of quarries, there are also different methods of quarrying, which will be discussed in the next section.

### 3.2.5 Quarrying methods

Over the millennia there must have been many different methods of quarrying, depending on the material to be quarried. When we analyse the origin of the blue stones from which the inner ring of standing stones at Stonehenge was built for instance, we see that its builders made use of the fact that the rock formation in the Preseli Mountains from which the stones were believed to have been quarried, were vertical standing shards of rock (Alexander 2008:54-55; see Figure 3-9). This means that those who came to quarry the material only had to loosen the rock pillars at the bottom in order to remove them from the bedrock (Alexander 2008:53).

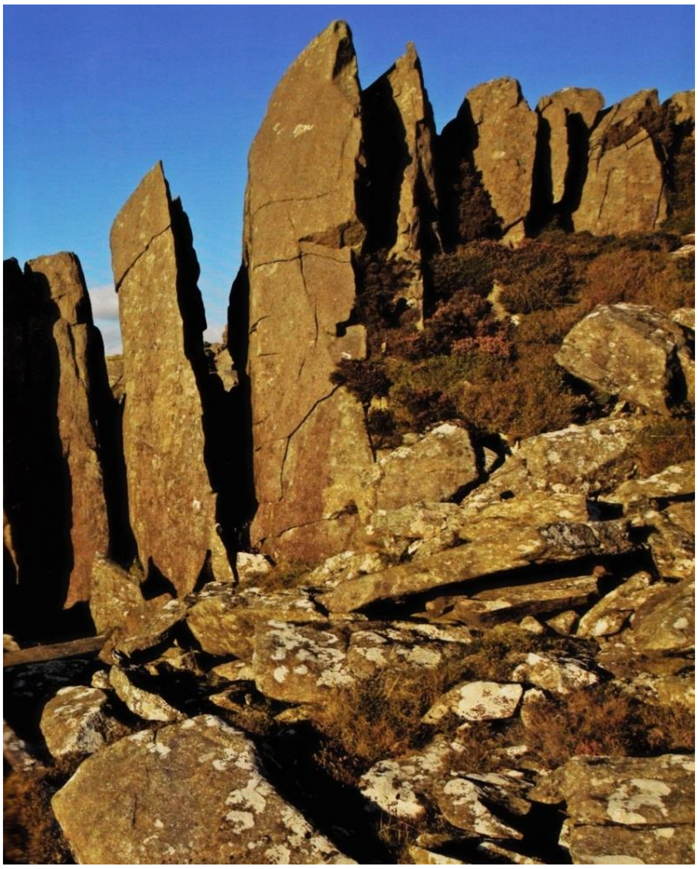


**Figure 3-9: Site in the Preseli Mountains in Wales from which the standing blue stones are thought to have been extracted (Alexander 2008:55).**

In this way they prevented a lengthy quarrying process by not having to hew around the entire contours of the pillars. This is also the reason why the pillars do not all have perfect straight sides. The builders may have taken the worst of the protrusions off the stones and cut them to the same height, but left the sides mostly as they had been when they were still *in situ* as rocks in the Preseli Mountains in Wales. These stones make up the oldest stone ring at Stonehenge, weighing about 4 tons each and date to about 2,500 BC (Alexander 2008:39).

Since the discovery as described here above, another opinion has been expressed about the origin of the blue stones by Professor Mike Parker Pearson and a large multi-disciplinary team of researchers from University College London. They maintain that the rhyolite blue stones did indeed come from the Preseli Mountains in Pembrokeshire, Wales, but from another site, called Craig Rhos-y-felin (see Figure 3-10), and the small number of dolerite spotted blue stones from Carn Goedog (https://www.ucl.ac.uk/news/2015/dec/stonehenge-bluestone-quarries-confirmed-140-miles-away-wales).

**Figure 3-10: Alternate possible site at Craig Rhos-y-felin from which the bluestones used at Stonehenge may have been quarried in the Preseli Mountains in Wales (Image by Adam Stanford, https://www.ucl.ac.uk/news/2015/dec/stonehenge-bluestone-quarries-confirmed-140-miles-away-wales).**

At this second site the quarrying method would have been different. Professor Parker Pearson states that the method used, would have been for wooden wedges to be hammered between the cracks separating the pillars, and then to wait for the rain to swell the wood, which would have cracked a pillar loose from the rest of the rock-face.

I believe that winter frost could also have helped in this process, as moisture remaining between the pillars would have increased in volume when it froze, thus cracking the pillar loose at the bottom.

After this, the slab would have been lowered onto a platform of wood and stone for transport further afield (https://www.ucl.ac.uk/news/2015/dec/stonehenge-bluestone-quarries-confirmed-140-miles-away-wales).

If I had to choose between the two sites shown in Figures 3-9 and 3-10, I would side with Professor Parker Pearson regarding Craig Rhos-y-felin, as this really looks like a quarry, with quarry debris at the foot of the rock-face. Besides that, the shape of the rock pillars is much more like the shape of the blue stones at Stonehenge.

The large standing stones of the outer ring at Stonehenge, called the Sarsen Circle, which is made up of 16-foot high stones, topped in pairs by lintels (Alexander 2008:39), did not come from as far afield as Wales, but were fashioned from large sandstone boulders found on the Marlborough Downs, some 20 miles from Stonehenge (Wernick 1974:122-123). Sarsen is a variety of irregularly shaped sandstone, and large boulders of this material were found lying on the surface of the Downs (Wernick 1974:122). These boulders did not have to be quarried, but only needed to be shaped and transported in order to become the stones for the Sarsen Circle.

Professor Parker Pearson is of the opinion that Stonehenge was part of a ceremonial landscape, to which worshippers would flock for celebrations during the winter and summer solstices. The stones had special spiritual significance (information from 'Stonehenge decoded', broadcast on 16 September 2017 on Channel 181, National Geographic).

The latest research into the construction of Stonehenge is to determine whether pig grease could possibly have been used to slide the Megaliths into place by greasing the rollers or the slipways that were used. During the celebrations, pigs were roasted and archaeological finds of pig lipid residues in Grooved Ware pottery vessels found at the site of Durrington Walls, may indicate that this may have been a possible use (Smith 2019:1-2).

Over against the use of the Sarsen stones at Stonehenge, the builders of Göbekli Tepe had a more difficult task, as they had to hew the pillars for their place of worship from the bedrock by means of the trench method. This meant that they had to chisel around the entire contours of the pillar to be made, and also a certain distance underneath it, in order to be able to lever the entire pillar out of the bedrock by applying pressure on the levers and making use of natural fracture lines (Mann 2011:44, 55; see Figure 3-7, and Figures 3-11, and 3-12).

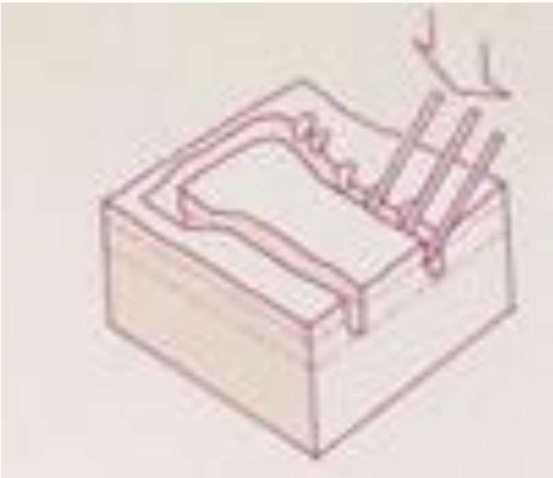


**Figure 3-11: Levering a T-shaped pillar directly out of the limestone bedrock (Mann 2011:44).**

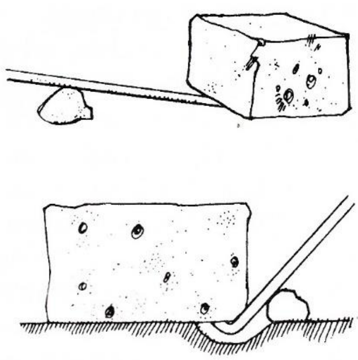


**Figure 3-12: Close-up image of levering (Shadmon 1996:42).**

Their advantage was that the material they were using was much softer limestone (Mann 2011:41), over against the harder bluestone used by the builders of Stonehenge (Alexander 2008:56). At Göbekli Tepe flint, shaped into blades was found to have been used to chisel with (see 2.6.2). At Stonehenge deer antlers were found, which may have been used (https://www.ucl.ac.uk/news/2015/dec/stonehenge-bluestone-quarries-confirmed-140-miles-away-wales).

#### *3.2.5.1 Quarrying limestone blocks*

Whereas the builders of Stonehenge were still making use of pillars of stone partially shaped by nature around 2,500 BC (Alexander 2008:39), the pyramid builders in Egypt around the same time (Morell 2001:81) were already able to quarry straight blocks from the limestone of the Giza Plateau. What worked in their favour was the fact that the limestone was much softer than the blue stone from Wales and the Sarsen sandstone both used at Stonehenge, and that they had better tools, among which copper chisels, at their disposal (Morell 2001:83). The copper for these chisels came from the Sinai (Lehner 1997:202). At the limestone quarries below Menkaure's pyramid, the red lines with which the blocks had been marked out, were still visible when the excavations led by Mark Lehner started there (Morell 2001:87). The masons would first square a block all around by cutting channels wide enough for a worker to pass through, by means of stone axes (Lehner 1997:206). These axes were of a harder stone material than the material being quarried, because a harder stone can be used to work a softer stone material (Shadmon 1996:74). Then slots would be hewn at the bottom of the block after which large wooden beams were used to lever the blocks from the bedrock (Lehner 1997:206; Shadmon 1996:41-42). This levering method required a wide corridor between the rows of blocks, so that there was space to manoeuvre the levering beams in place and apply sufficient downward pressure on them to 'pop' a block loose. Where possible the quarry men would make use of a softer, thinner band of rock layers at Giza to separate the blocks of thicker, harder stone above it with more ease (Lehner 1997:206). The blocks would then be squared more precisely with the use of copper chisels (Lehner 1997:211).

For the construction of Herod's temple, roughly 2,500 years later (see 6.2.5), the same process of hewing out the sides of the blocks would still be used, but by this time iron pick-axes were available. This enabled the masons to separate the blocks with narrower channels of about 10-15 cm between them (Ritmeyer 2006:134; see stonemason on the right-hand side on Figure 3-13). In order to separate the blocks from the bedrock underneath them though, a different technique was used (see stonemason on the left-hand side on Figure 3-13). Wooden beams would be inserted tightly into two of the channels separating the blocks. Then water would be poured over these beams, which would make the wood swell up and the resulting pressure was sufficiently strong enough to detach the blocks from the bedrock underneath it (Ritmeyer 2006:134).

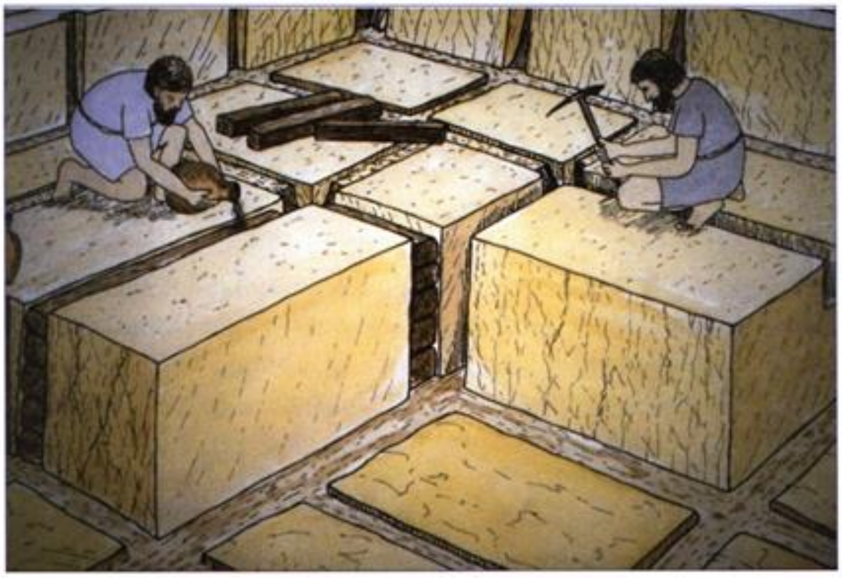


**Figure 3-13: The blocks to build the Temple were detached from the bedrock by wetting the wooden planks stacked in the channels (Ritmeyer 2006:135).**

Ritmeyer also mentions an alternative method of detaching the blocks, which would be as follows: long metal strips would be placed opposite each other in the channels, which in this case would be V-shaped towards the bottom. In between these strips the workmen would hammer down wedges, thus creating the pressure necessary to detach the blocks from the bedrock beneath them (Ritmeyer 2006:134). This method is called ‘plug and feathers’ (Shadmon 1996:44) and has been used until at least the early 20$^{th}$ century, as my late father remembered it from his youth (see Figure 3-14).

As the limestone deposits in Jerusalem occurred in natural horizontal layers, it was possible to quarry them in a straight horizontal line. The thickness of the layers varied from 45 centimeters to 1,50 meters, and sometimes even thicker, and a whole layer would be removed, resulting in blocks of the same thickness (Ritmeyer 1989:46; Ritmeyer 2006:134). This will be discussed in more detail in 6.2.5.

All materials with a similar hardness as limestone, such as the many varieties of marble and serpentine were quarried with similar methods as mentioned above. Quarrying the much harder materials such as the different varieties of granite and gabbros required a different approach. This will be discussed under the following heading.

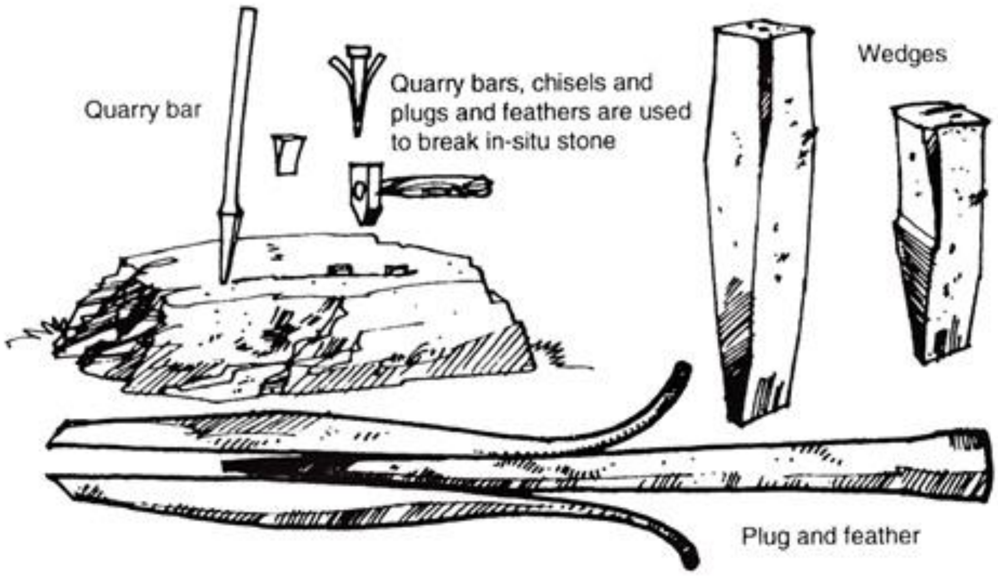



**Figure 3-14: Various tools to detach a block from the bedrock. Horizontally at the bottom the so-called 'plug and feathers' tool (Shadmon 1996:44).**

*3.2.5.2 Quarrying granite*

In comparison with limestone and marble, which have a hardness of about 3.5 to 4.5, granite with a hardness of 6.5 to 7, is a much more difficult material to quarry (see section 2.3). The copper chisels, with a hardness of about 3 needed to be re-sharpened regularly to work the limestone from which the pyramids were built (Lehner 1997:211). These chisels were of no use to quarry granite. Therefore, a different method was used. To make channels in order to quarry blocks from the granite quarries at Aswan, dolerite pounders were used (Lehner 1997:211). Dolerite is a material of similar hardness to granite and the pounders, or hammer-stones, weighing 4-7 kg each, would be pear-shaped at the start of the work. As the labourers would turn them regularly to make use of a new percussion edge, they would eventually become rounded and useless for the task at hand (see section 2.6.5; Lehner 1997:211). With the pounders, channels were pounded in the granite to extract blocks (See Figures 2-14 and 3-15).

**Figure 3-15: Piece of granite with channels pounded into it (Lehner 1997:206).**

When Mark Lehner tried this pounding process himself in the course of his research into the quarrying methods, he found that it took him five hours of pounding to mark out a patch of 30 x 30 cm (Lehner 1997:207). So quarrying granite was strenuous and laborious work, which in the heat of Aswan and with the deafening noise of a number of labourers working together must have been the worst type of labour imaginable (Lehner 1997:207). The Dutch master stonemason Anne Krikke, who has been to Egypt, told me during my visit to him on 1 August 2016, that the cracked obelisk, left in the granite quarries at Aswan, is 41.5-meter long, at the basis 2.90 x 2.90 meters square and weighs about 900 ton (see Figure 3-16). In his estimate it would have required 42 workers pounding alongside each other to pound out a channel on one side of the obelisk. From personal observation I can also still add, that granite absorbs much heat in the daytime and radiates this out again, which would have made the conditions of work probably even worse.

**Figure 3-16: Obelisk left in situ at Aswan, Egypt due to cracks in the material (photograph courtesy of Dutch master stonemason Anne Krikke, no date available).**

Lehner does not provide any further information about this quarrying method, for instance whether the granite would break as a result of the pounding process. The pounding was probably intended to weaken the crystalline structure and cohesion of the granite, as well as causing a vibration, but whether this would result in the breaking off of a block from the bedrock, needs to be seriously put in doubt. Even Anne Krikke does not know how granite was quarried in ancient Egypt. However, Shadmon mentions fire-setting as a method of quarrying in combination with pounding and describes this as follows: fires would be lit along the line of the intended break, over which cold water would be poured, while the material was pounded with heavy stones (Shadmon 1996:1). He also mentions that this process was still observed by Stukely in the village of Avebury in the United Kingdom in the 18th century AD (Shadmon 1996:1).

**Figure 3-17: The first step in the fire setting process (Wernick 1974:123).**

A more detailed description of the fire-setting method is provided by Wernick. He describes the method as follows: along the precise line where the rock was to be split, twigs soaked in animal fat were laid (see Figure 3-17). These were set on fire, and the heat caused the strip of stone underneath it to expand slightly. Then the fire was doused, the embers brushed aside and cold water would be poured over the hot strip by one worker. At the same time other workers would pound the rock beside the heated strip in unison (see Figure 3-18). This would cause the rock to contract and split open (Wernick 1974:123). This seems to be the method that was used in the United Kingdom.

Malacrino also mentions this method of the application of fire and cooling with water, which resulted in a thermal shock, as a method to quarry stone that was more difficult to extract (Malacrino 2010:36).

**Figure 3-18: The second step of the fire-setting process (Wernick 1974:123).**

If Lehner is correct and the pounding of the channels took place first, this would have created a narrow trench in the granite deposit, in which wood could be stacked, which was then set on fire (Lehner 1997:206). Once that burned well, the cold water was poured on it, with the result that the material cracked and a block could be removed. As the granite quarries in Aswan are close to the Nile, there would have been water available for this process.

Another opinion is expressed by Adel Kelany, and that is that fire-setting was more widely used in quarries of hard stone in Egypt than researchers have been willing to believe for a long time. His chapter in the book *'From the delta to the cataract, studies dedicated to Mohamed el-Bialy'* (2015:88-97), provides information about two ancient *inscriptions* which have been found regarding the fire-setting method. The clearest of these inscriptions is the one found in the Wadi Hammamat, in a greywacke quarry between Gift and Qusser City. It is from the Vizier Amenemhet of the 11$^{th}$ dynasty in the 2$^{nd}$ year of King Mentuhotep IV and says the following: 'Then the neck was cut and what the flame had brought was pounded from it' (Kelany 2015:90). The word 'neck' probably refers to the last strip with which the block that was being quarried, was still connected to the bedrock. Once the block of stone was loose, the outer layer of stone that was damaged by the fire, was pounded from the sides of the block where the fire-setting had taken place.

In order to put this theory to the test, Adel Kelany went to Aswan, to the site where the abandoned obelisk is located, and tried out the fire-setting method in that area with a group of assistants (Kelany 2015:93). In a number of quarries in Egypt remains of mudbricks, charcoal fragments and ashy layers had been found in quarry waste (Kelany 2015:91). Therefore, the test was conducted with the use of mudbricks to delineate an area of 3.40 x 1.20 x 0.40 meters, and wood was burnt within that enclosure (Kelany 2015:93). They allowed it to burn for 16 minutes, till the wood had turned to charcoal and then they used water to extinguish the fire. This was followed by a loud sound of cracking granite. After this they waited about 10 minutes for the burnt surface to cool down and then half the team started pounding the burnt area with dolerite stones, and the other half of the team pounded an area of granite that had not been subject to the fire (Kelany 2015:94). After pounding for half an hour, the team working where the fire had been, had pounded a 26-centimeter-deep trench, whereas the other team pounding on granite that had not been subject to the fire-setting, had only pounded 6 to 100 millimeters (Kelany 2015:94). The only different result of the test, in comparison with the old mudbricks was, that the mudbricks used in ancient Egypt, showed red or yellowish patches and the mudbricks used by the team had black patches (Kelany 2015:94). A further result was that a parallel crack developed in the granite, where the fire had been set, which would have been useful to produce a channel around the block. The researchers concluded that highly skilled workmen had been involved in the process of controlling the fire-setting (Kelany 2015:94). From this description it is also clear that the pounding was done after the fire-setting.

In the above account Adel Kelany (2015) has shown that fire-setting is indeed a method by means of which hard stone can be loosened from bedrock. In order however to further approximate the methods used by the ancient stonemasons, I would recommend to look at how bricks are fired. The mudbricks used by Kelany showed black patches after the test, whereas the ancient mudbricks found in Egyptian quarries had red and yellow patches. I believe that there is an explanation for that. In this context I want to share what I know about making bricks. When I grew up, we lived only a short 15-minute drive away from the river Rhine. At that time there were lots of brick factories dotting the river shores and my father once explained to me how the manufacturing process of bricks worked. The river clay would be shaped into bricks and these would be stacked in the brick making factory. Then all the entrances would be bricked up, and cemented close, before heat from a furnace was allowed to circulate in the stack. After a certain amount of time of firing the bricks, everything would be allowed to cool down, after which the openings, that had been cemented closed, were opened again and the bricks would be taken out, ready for use. These bricks were reddish in colour. It was important that very little oxygen was present during the firing process of the bricks.

Another aspect that needs to be looked at is how clay pots are fired. This I learned about when studying a course about the Indian tribes of the American South-west in Arizona in 1972. I learned that when pots are fired in a closed oven, they come out in the colour related to the clay. When pots are fired over an open fire however, the pots come out black. So, oxygen has an influence on the firing process. Adel Kelany used an open fire surrounded by a parallel row of mudbricks and his bricks came out with black patches. I want to recommend that the test conducted by Adel Kelany should be repeated by placing the mudbricks closer together so that they can be covered on top and so that the fire on top of the granite can smoulder for a while in between and underneath this covering. Then the fire should be extinguished and the mudbricks analysed for changes in colour after cooling, to see what colour patches they have developed. It is possible that the ancient Egyptian stonemasons allowed a smaller kind of fire to smoulder on the granite surface for longer under a covering of mudbricks, before applying the water cooling and further pounding process. In this process the mudbricks may have developed the red and yellow patches of a reduced oxygen environment.

Once a block had been loosened from bedrock, it still needed to be shaped further to the required size and shape. It is clear though, that quarrying granite was a much more difficult undertaking than quarrying limestone.

#### *3.2.5.3 Quarrying materials which are layered*

Then there is still a third method of quarrying which has already been referred to in Chapter Two (see 2.2.2). This is the method of splitting layers off materials such as slate, quartzite and layered sandstone. This is probably one of the oldest quarrying methods, for the simple reason that it is easier to remove shards of material from bedrock which is layered, than whole blocks. Unfortunately, so far, no clear description of this method has been found in the literature which I have accessed, but there is circumstantial evidence. The shards of stone are called ‘flagstones’ in the trade even to this day. The dictionary refers for the meaning of the word ‘flagstone’ to the second meaning of the word ‘flag’, which means: a hard evenly stratified stone that splits into flat pieces suitable for paving, and also: a piece of such stone. The dictionary then also still adds, that in Middle English the word was *flagge,* from Old Norse *flaga* meaning ‘slab’ and is akin to Old English *flēan,* to flay (Merriam Webster 1977:434). Webster refers further to the meaning of the word ‘to flay’, also of Old Norse origin, for which it gives the meaning: to strip off the skin or surface (Merriam Webster 1977:438). So, based on the age of the word, this was an extremely old method which was used to split layered rock into shards and slabs by means of hammering in wedges.

As there are large quantities of slate and quartzite in Norway, as well as slate in Wales and layered sandstone in the Orkney Islands, the origin of the word or of the quarrying technique should not come as a surprise. The definition given by Shadmon for the word ‘slate’ is: ‘a fine-grained metamorphic rock, easily split into flat smooth plates’ (Shadmon 1996:171). He also adds that slate sometimes occurs in near vertical positions (see Figure 2-2), which makes extraction easier, unless it is found at an inconvenient angle (Shadmon 1996:25). Slate and sandstone are soft enough to be quarried by means of hammering wooden wedges between the layers and then levering these apart with longer wooden sticks. Alternatively, the dry wooden wedges, once they were hammered into the sockets, could be wet with water. The result would be that the wood expanded and the resulting pressure would crack the slab loose. My late father mentioned this method of extraction when I questioned him regarding methods of stone quarrying in ancient times[12]. According to Malacrino, another possibility is that the wedges may have been wrapped in wet cloths to make the wood swell up (Malacrino 2010:36). Over against this it is interesting that Lehner mentions that this method of using wooden wedges which were made wet with water was not used for the quarrying of blocks for the construction of the pyramids at Giza (Lehner 1997:206).

[12] My father passed away in 2006, and it is unfortunately impossible to give an exact date for this conversation. We talked a lot with each other, and this was probably discussed about 20 years ago.

The layered material quartzite is harder, due to its quartz content, and may have needed flint blades to be split. However, there does not seem to be much slate in the ancient Near East and quartzite is only mentioned by Lehner as a material which was used for polishing other materials, but did not appear to get used for building purposes (Lehner 1997:202), so this particular method of quarrying does not seem to have been used much in the ancient Near East.

In conclusion it can be stated that these three methods of quarrying as described above are the main methods to be used for the different types of materials, due to the differing degrees of hardness and whether a material is found in a solid or layered state.

## 3.3 TRANSPORT METHODS

Once the blocks had been quarried, there were two options, in that they could be transported as a whole, or could be split or hewn into the required dimensions for the purpose the material was intended for. If the stone was shaped at the quarry, it would mean that there was no excess weight to be transported. In view of the fact that stone is heavy, it was better to leave all excess waste material at the quarry site. Even if the quarry was very close to the building site, the blocks or worked pieces still needed to be moved there and the question is how this was done. A number of possibilities, which have been suggested over time, will be discussed in what follows.

### 3.3.1 Tumbling

In the course of his research into the building methods of the pyramids at Giza, Mark Lehner conducted a number of experiments to determine what theoretical solutions which had been proposed, would actually work in practice. In the course of this research, he and his hired Egyptian workers discovered that blocks of stone of up to 1 ton could easily be moved by tumbling them. About 4 or 5 men could lever up a block and then let it flip over (Lehner 1997:209). Blocks of up to 2.5 ton could be tipped over by looping a rope around the top and pulling with about 20 men and a few men using levers at the back of the block. His conclusion was that this technique was useful for moving blocks around the building site, but not suitable to shift them up a ramp for the construction of a pyramid, because this would not go fast enough (Lehner 1997:209). In my opinion the risk of damaging the blocks is greater when blocks get tumbled.

Corners are vulnerable and repeated falling over could also lead to the material getting cracked.

That worked stone is easily damaged and requires careful transport, I remember from my youth, when I would see the workers load the worked stone pieces carefully and pack them with pieces of carton, wooden wedges or handfuls of wood-shavings in between them.

### 3.3.2 Wooden sledges on rollers

Lehner and his men then tried to move the blocks on wooden sledges on rollers. They discovered that loading a block onto a wooden sledge is a tricky operation requiring a fair amount of skill (Lehner 1997:209), and that nothing really moves on soft sand (Lehner 1997:203). As the next step they built an artificial track-way of planed timber, with a surface of hardened gypsum or packed clay, following the example of the transport roads, which have been discovered through excavations in Lisht in Egypt (Lehner 1997:209). Those were 11 m across and consisted of a fill of limestone chips and mortar, with wooden beams inserted, which provided a solid bedding. Alluvial mud may have acted as a lubricant for the runners of the sledge to slide over the track (Lehner 1997:203).

In the first experiment though, they tried to get the sledges to roll on wooden rollers. These consisted of cylindrical pieces of wood which would be inserted under the sledge when it was lifted with levers (Lehner 1997:209). Once enough rollers were placed underneath the sledge, the process of rolling forward would begin. The most important task in this method was for the man who had to collect the roller rolling free behind the sledge, to pick it up and run to put it down in front of the sledge again. Putting the roller skew on the roadway, would get the sledge to roll off the track (Lehner 1997:209). Due to the scarcity of wood and the huge need for rollers to move all the blocks up the pyramid, this method may not have been used at the pyramids (Lehner 1997:209), but was the most likely method of transport at the site of Göbekli Tepe (Mann 2011:44; See Figure 3-19).

**Figure 3-19: Use of rollers to move a block of stone at Göbekli Tepe (Mann 2011:44).**

I have still seen this method of the rollers in use in the Netherlands in the late 1950's to move a large gravestone from the trailer on which it had been brought to the cemetery, to where it needed to be installed on a grave. The workmen carefully tipped the trailer and allowed the slab to slide slowly onto the rollers, while guiding it with crowbars. No use was made of a sledge. The workers rolled the slab forward and the roller coming free at the back of the slab was taken to the front and placed there for the forward movement to continue. The moving of the slab off the trailer was tricky, but the rolling process was smooth and seemed almost effortless once the slab had been put into motion. This method works well on solid and level ground.

### 3.3.3 Sledges on tracks

After experimenting with the wooden rollers, Lehner tried to move the blocks on wooden sledges over artificial hauling tracks (Lehner 1997:203), which he also calls slide-ways (Lehner 1997:209), without the use of rollers. Following the example found at Lisht, where boat timbers were used as part of the tracks east of the pyramid of Senwosret I (Lehner 1997:203), Lehner had his men build two parallel retaining walls at Giza, which were filled with debris to make an inclined ramp. On top of this, a roadbed was made with wooden crosspieces, more or less following the specifications found at Lisht. On this hard and solid track, a 20-ton stone on a sledge could be pulled with the use of ropes by 20 men or fewer (Lehner 1997:209). According to images found in Egyptian tombs, cattle was also used to haul stones, or to assist humans in hauling stones, which is also still confirmed by the find of carcasses of draft cattle in the builders' debris of the Mentuhotep complex at Deir el-Bahri (Lehner 1997:203).

Based on all these findings, Lehner has concluded that the Egyptians transported the bulk of the stone to the building site by hauling the blocks on sledges over hardened tracks (Lehner 1997:209).

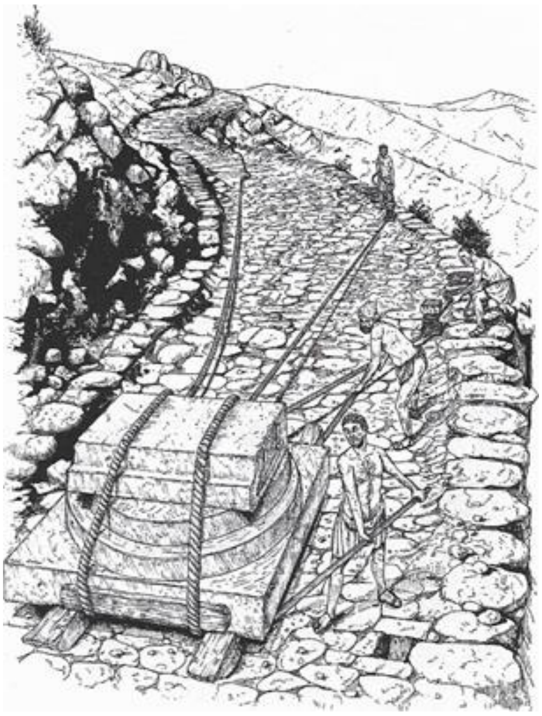


**Figure 3-20: Drawing of the way in which a block would be lowered down a slope from the quarry over a specially made track (De Nuccio & Ungaro 2002:185).**

If these tracks were sloping downwards, gravity would also have assisted in the moving of the blocks. This system has been used extensively in many areas where stone is quarried in the mountains and paved tracks to lower blocks exist for instance in Greece (Mannoni 1985:113) and Italy (Mannoni 1985:114-115). The Italian term for this is *lizzature,* meaning 'stoneboats' (Mannoni 1985:114). To prevent the sledges with the blocks from moving down the sloping track too fast, ropes made of hemp (Mannoni 1985:114) would be used to restrain the sledges by means of capstans which were strategically placed along the side of the track (De Nuccio & Ungaro 2002:184-185; see Figure 3-20).

### 3.3.4 Levering or ramps

There has been much debate on how the blocks were moved upwards to build the pyramids. While some researchers propose the use of ramps, others, such as for instance Martin Isler, believe that the blocks were levered upwards (Lehner 1997:209).

This would imply that levers were used to first lift a block on one side to place a support underneath it, and then the other side would be lifted for the same purpose, for the process to be repeated again and again. The problem is though, that after a number of layers of wood have been inserted underneath the block, the stack becomes unstable, even when planed timber is used (Lehner 1997:209). It would also require two deep notches in both sides of the block to be levered, which are not found in the core building blocks of the pyramids (Lehner 1997:209), so this method is unlikely to have been used. This makes the use of ramps to move the blocks upwards much more likely. With the blocks having been brought to the pyramid building site on sledges, it would also have been much easier to continue to haul the blocks upwards along the ramps on the same sledges, instead of off-loading the blocks for the levering method to be used.

Even though the use of ramps for the construction of the pyramids seems to be generally accepted by now, there is by no means agreement on what type of ramp that was. Lehner provides about nine different possibilities of the use of ramps, each with their own pros and cons (Lehner 1997:216; see Figure 3-21).

In my opinion the first example left on the top row would require an enormous amount of fill to construct the ramp, which would also become too steep to haul blocks upward as the pyramid got higher, and as shown in the middle picture on the top row, with the hauling surface getting too narrow. The right-hand picture on the top row also shows a ramp which is too steep. On the left-hand picture in row two from the top, the incline of the ramp is also too steep, and the removal of the ramp out of the pyramid at the end of the construction period would be a problem, because the one side of the pyramid would have to still be rebuilt, which might have been problematic from a stability point of view. The middle image on row two lacks a ramp coming from the quarry site and only starts at the bottom of the pyramid, which might have made the second stretch too steep. The right-hand image on row two has a slope with a lower gradient, but so many turns to navigate with the large blocks, which may have been problematic and time consuming. The zig-zag pattern in the left-hand picture on row three would also have had the problem of tight turns to be negotiated with the blocks on the sledges and the risk that the entire hauling track might have slipped off the slope of the pyramid. The right-hand image next to it is the preferred method which Lehner advocates (1997:216) and shows a long track with an onramp and a low

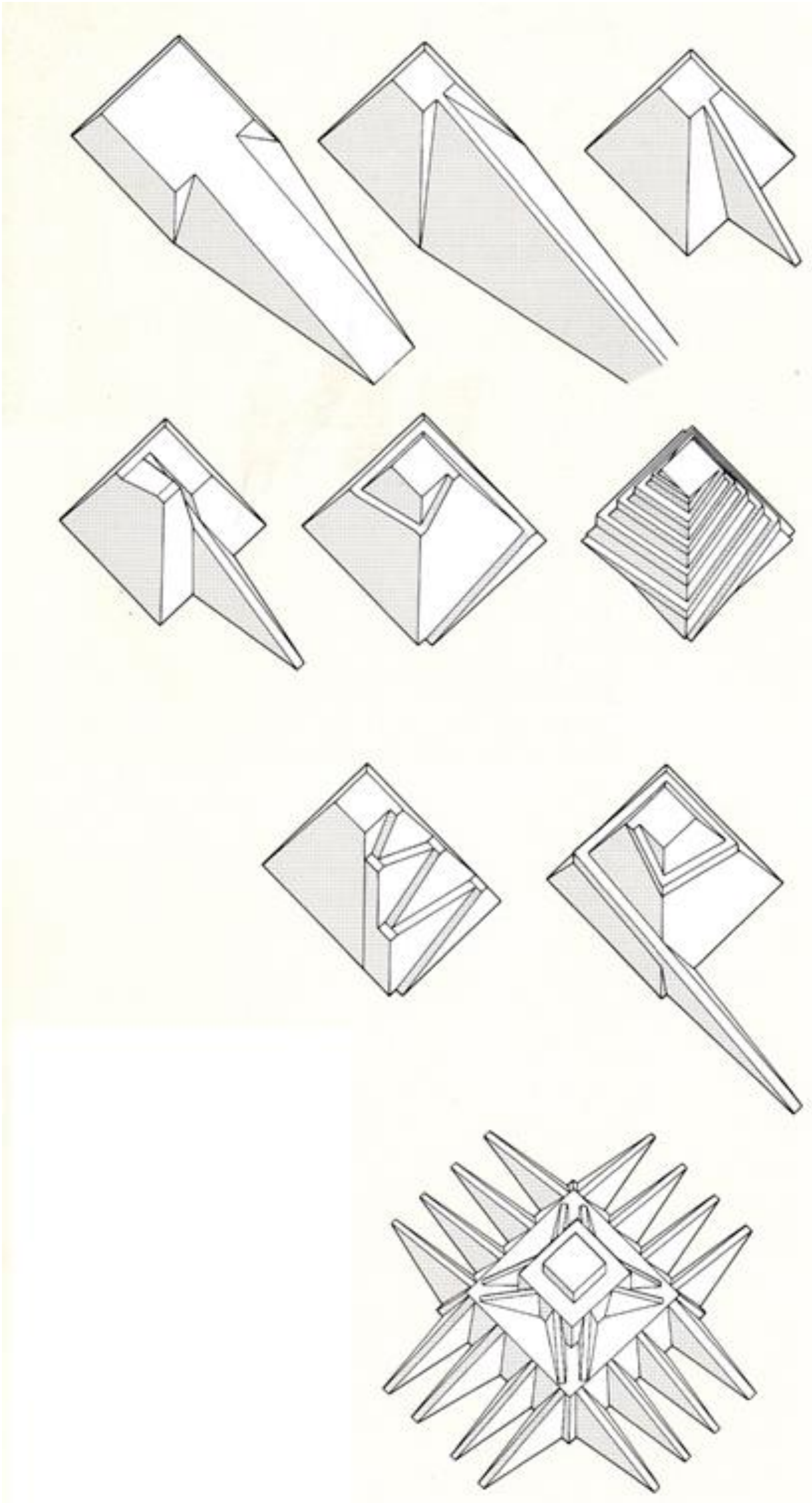


**Figure 3-21: Many different possibilities have been suggested over time regarding the type of ramp or ramps, which were used to transport the blocks for the construction of the pyramids upwards (Lehner 1997:216).**

gradient winding its way around the pyramid, with only a few corners to negotiate. The image at the bottom with the many hauling tracks looks interesting, but the gradient of the tracks may also be too steep. It also has the problem that for the higher elevations of the pyramid only the corner tracks could have been used for the blocks to be hauled up to the next level, with very little manoeuvring space for the blocks.

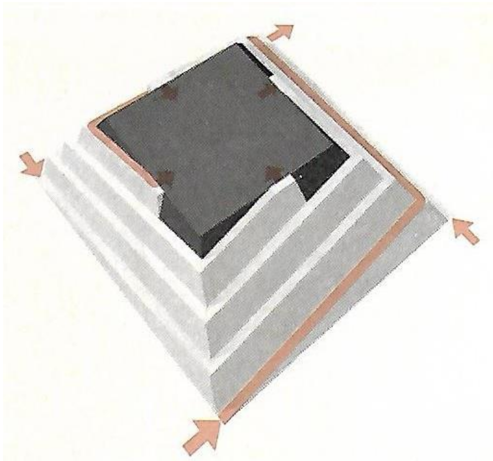


**Figure 3-22: Alternative possibility of a ramp with an exit (Casson 1966:134).**

All previous possibilities mentioned by Lehner only suggested ramps to go upwards on the pyramid under construction. Only one (Casson 1966:134) suggested that there should be a downward ramp as well, for the workers who had delivered their block and needed to exit the site. This is visible on Figure 3-22 (Casson 1966:134).

### 3.3.5 Ramps with steps

There may still have been a different method to move the blocks upwards on slopes, and this has been discovered very recently. To describe this method, the background to the discovery will have to be explained first.

In September 2018 Doctor Roland Enmarch, who is a Senior Lecturer in Egyptology at the University of Liverpool and Doctor Yannis Gourdon of the Institut Français d' Archéologie Orientale (IFAO) of Cairo, went to the alabaster quarries of Hatnub, which are located in the desert, about 18 kilometer south-east of Amarna in Egypt. They went there as co-directors of the Hatnub Survey to fully document the *inscriptions* on the walls of the quarries (Rawlinson 2018:1). The quarries at Hatnub are very old and are the source of not just any kind of plain alabaster, but of 'alabastro cotognino' as De

Nuccio & Ungaro (2002:264) call it in Italian, which is a type of onyx. It is of a soft caramel yellow colour, with white veins like lace. This Egyptian onyx is very beautiful, but also a very soft type of stone (https://www.stonecontact.com/stone/egypt-onyx).

The *inscriptions* in the Hatnub quarry had already been discovered in 1891 by Howard Carter, who also discovered Tutankhamun's tomb (Rawlinson 2018:1), and were documented by Georg Möller in 1907. The results were eventually published by Rudolf Anthes in 1928, but no further detailed survey had been done since (Enmarch 2018:1). The *inscriptions* were mostly applied directly to the rock face of the walls of the quarry and were executed in red pigment, which has been fading over time. This fact, combined with patination and the unevenness of the rock face makes it difficult to read them. In order to search for and record both the known texts from Möller's study and to see if there were additional texts to be found, digital technology equipment was used to investigate the quarry walls. Besides the known texts, quite a number of other texts were discovered, some quite lengthy, which are barely visible with the naked eye. In total 100 'new' images and texts were found in this way in the area of Hatnub's Quarry P (Enmarch 2018:2).

What the researchers were not even looking for and had definitely not expected to find, was a haulage ramp with a set of steps on either side (see Figure 3-23). The ramp was found when debris blocking the sloping entranceway to the quarry was cleared, and the discovery is a most interesting one. The ramp was not excavated in its entirety, as there is an inscription dating from the time of Khufu over the bottom of the entrance way (Enmarch 2018:2). The researchers decided to have a closer look and discovered that there were stairways on either side of the ramp with postholes at certain intervals, and also that this ramp was much steeper than previously thought possible (Rawlinson 2018:1).

As a result of this discovery, both researchers have come to the conclusion that the blocks from the quarry were pulled upwards on the ramp by means of a pulley system, instead of by workers hauling them straight up the ramp by sheer muscle power alone. The postholes would have been used to insert vertical posts alongside the track-and-stairs construction. Doctor Yannis Gourdon (in Rawlinson 2018:2), is of the opinion that a sled with a block on it, would have several sets of ropes attached to it, which were slung around the posts to pull the sled with the block upwards. This pulley system would still have required manpower, but a number of men pulling ropes together on either side of the ramp, probably got the blocks moving upwards much faster (Rawlinson 2018:2).

**Figure 3-23: The haulage ramp with stone steps on the sides in the alabaster quarry of Hatnub, Egypt (Jarus 2018:1).**

According to Doctor Gourdon, the oldest inscriptions in the quarries at Hatnub have been dated to the time of Pharaoh Khufu (or Cheops), for whom the largest of the three pyramids at Giza was built (in Rawlinson 2018:2), and therefore the conclusion may be drawn that the quarries were already being operated during his time. The discovery of the ramp with the steps and postholes shows that the Egyptians probably already had this kind of technology available for the construction of the pyramids as well (Jarus 2018:3). As the discovery of the haulage ramp was made in September 2018, the researchers have not yet had the time to publish their findings in a peer-reviewed academic journal, but intend to do so in the near future. The only information available is what has been published in the public domain and of which the internet references were provided to me by Doctor Roland Enmarch (Private email communication with Doctor Enmarch, 7 November 2018).

If we compare the haulage ramp found at the quarry of Hatnub, as shown in Figure 3-23 with the image as shown in Figure 3-24, where the haulage ramp is flat and smooth, without any steps, we can see how much heavier the hauling of the blocks would have been on the smooth haulage ramp alongside the pyramid. If we would imagine standing posts on the sides of the haulage ramps, around which to sling hauling ropes, and steps on both sides, we can imagine that the work of hauling the blocks up the pyramids would be much easier to accomplish. We have to keep in mind that it is much easier for labourers to move feet upwards on steps, than to try and pull up a block while moving feet, and bracing them, on a steep slope. The system of ropes slung around posts standing up in holes along the side of the ramp would have made the pulling up of the load lighter, as several pairs of workers could pull more than one set of ropes attached to the sled at the same time, thus moving the sled faster and easier.

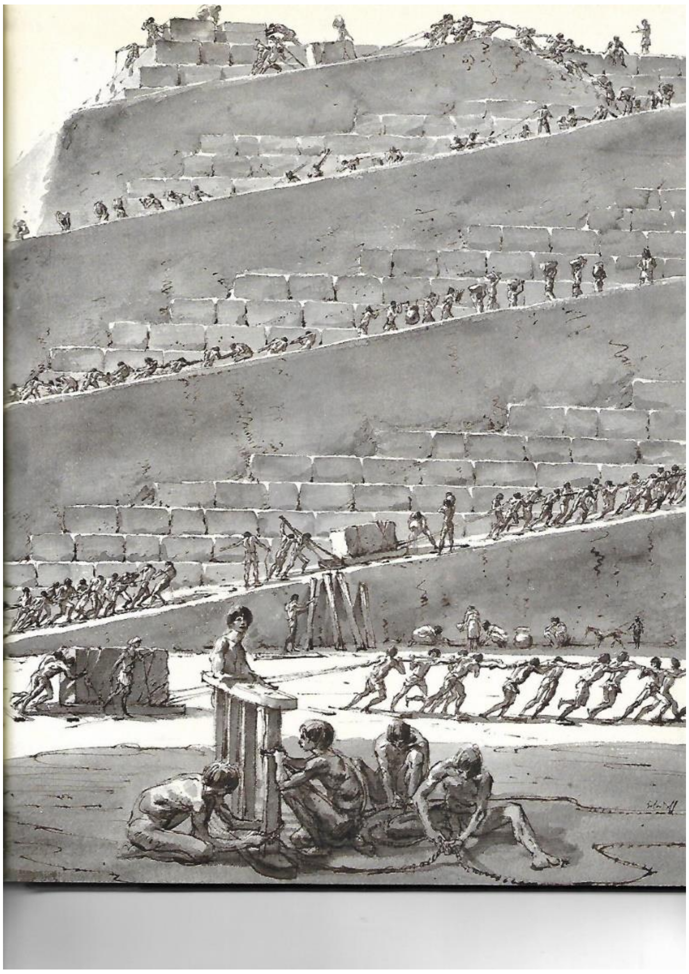


**Figure 3-24: Suggested method by which blocks were moved for the construction of the pyramids (Casson 1966:135).**

As an aside, another interesting find at the site of Hatnub was an area for stone working at the top of the entry way, dating to the New Kingdom era, with a large inventory of rough limestone tools, of locally sourced limestone, to work the alabaster/onyx in order to produce vessels of the material (Enmarch 2018:2). As already stated, the material found at Hatnub is very soft, and it would have been fairly easy to work it, with the use of tools made of the harder limestone.

### 3.3.6 Transport with ships

#### *3.3.6.1 Transport of stone in Egypt*

Stone was not just transported over land, but also on board of ships. For the bulk of the construction of the pyramids the local limestone from the Giza plateau was used, which was quarried right near-by, but granite had to be brought from Aswan and Elephantine by boat (Lehner 2016:119). The fine-grained white limestone which came from the quarries of Turah, which were located to the east of the Nile, and which were used as outer cladding for the pyramids, was also transported over water (Lehner 1997:202). Moreover, alabaster for statuary, dolerite for pounding stones and quartzite for polishing, as well as gypsum and basalt had to come from elsewhere in Egypt (Lehner 1997:202). A few images found on reliefs in Old Kingdom tombs depict how this was done. The smaller items were transported on the cargo ships, shown on these *reliefs*. They would have a hooded mat-work cabin at the stern and the cargo on the decks (Lehner 1997:202). To transport the larger pieces of material was more difficult. A relief from the causeway of Unas's pyramid shows a boat transporting 2 granite palm columns coming from Elephantine (see Figure 3-25). These columns indeed are found at Unas's pyramid and range from 5.5 to 6.5 m in height (Lehner 1997:202).

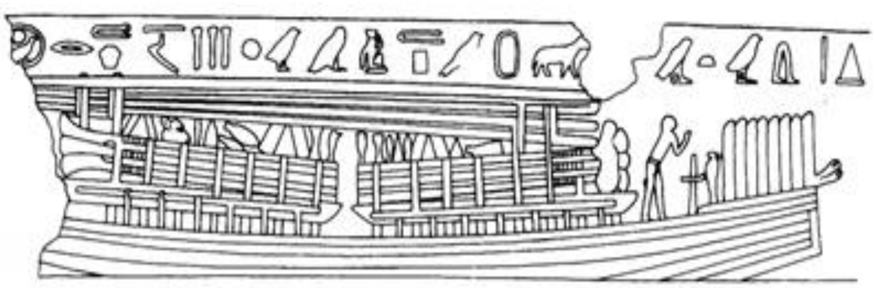


**Figure 3-25: Granite palm columns being transported by boat for Unas's pyramid temples (Lehner 1997:202).**

Loaded end-to-end on sledges, which were transported on the deck of the boat, the columns seem to be raised off the deck by a support framework of beams or girders, so as to lighten the weight on the deck or assist with the loading and unloading (Lehner 1997:202).

A very spectacular example of this kind of transport is depicted on the walls of Hatshepsut's temple in Deir el-Bahri. The two large obelisks which she had had made in Aswan for the temple of Karnak at Luxor, were transported on the deck of a very large barge (Lehner 1997:202). According to Gibbons both obelisks were transported at the same time, and side by side (See Figure 3-26). The barge did not have its own propulsion with a mast and sail, but instead was towed by 27 small oared vessels, with a total crew of 900. The two obelisks weighed circa 700 tons together (Gibbons 2001:16-17).

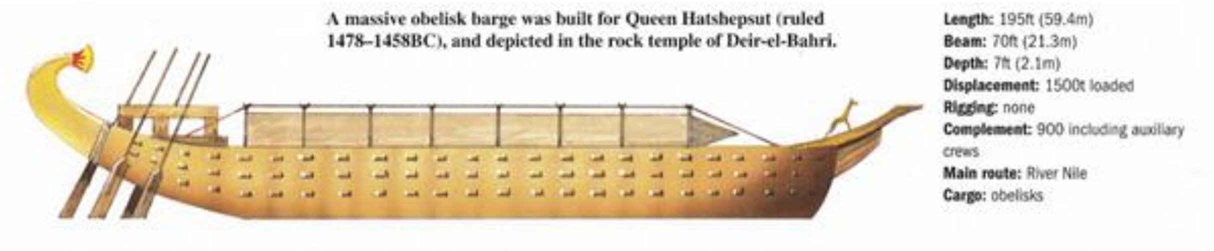



**Figure 3-26: Massive ship used for the transport of Queen Hatshepsut's obelisks (Gibbons 2001:16).**

As for the loading of this barge, Lehner mentions that R. Engelbach proposed that the obelisks were loaded onto the barge by means of an earthen embankment which would have been built up around the barge as high as the deck (Lehner 1997:202). That would have meant though that the two obelisks would have to have been pushed or pulled up against the embankment in order to be loaded onto the barge. A heavy task indeed! If the barge had been lowered with a load of ballast first, the embankment would not have been as steep, and the loading would have been much easier. A requirement for lowering a barge with ballast would be to have sufficiently deep water, which mostly occurs during the flooding of the Nile. This would however have had the added problem of increased current in the river. What may have been the solution to this problem is the fact that there were canals parallel to the Nile, and harbours close to the pyramids (Lehner 1997:230-231; Lehner 2016:119), as well as near the quarries, away from the main flow of the river. These may have provided a quieter environment for the loading and unloading of very heavy cargo, such a pillars and obelisks.

The suggested method to off-load Hatshepsut's obelisks as mentioned by Lehner, would be that the barge would have been brought into a narrow canal, and great cedar beams would have been thrust beneath the load between the supports. With the ends of the beams resting on the canal banks, the barge could have been weighted down with ballast and slipped out from under the load (Lehner 1997:202). How this could have worked is anybody's guess. In my opinion this method would have been highly unlikely, because then the obelisks would have been left hanging on the cedar beams right over the canal. If the beams had broken under the weight, the obelisks would have landed into the water, which would have made retrieval almost impossible. The narrow canal would have to have been very deep to allow for the barge to be brought down with ballast, having just lost its very heavy load of obelisks, in order to slip away from under the beams.

For the loading of Hatshepsut's obelisks this would be my personal proposal: Lower the barge with ballast till the gunwale was level with the water's edge, then transport one obelisk on huge sledges, or rollers, (or even on rounded pounding stones), to the barge and slide these on board. Remove part of the ballast, until the barge sits at the same level as before the first obelisk was loaded, and bring the second obelisk on board, then remove the remainder of the ballast and get the barge to float again. Transport the obelisks to their destination and reverse the process to unload.

After writing the above, a programme on the History Channel of DSTV entitled 'Ancient impossible' in 2014 showed more or less what I had postulated. The researchers showed that the quarry of pink granite at Aswan had a canal, which had been dug alongside it, where water would enter during the flooding of the Nile. They showed in a simulation how the barge built to transport the obelisks was brought into this canal, lowered with ballast and the obelisks were brought aboard by lowering them down from the quarry by means of gravity and were shifted aboard one by one, while ballast was removed after each obelisk was loaded. This was possible, because the quarry was located higher than the bank of the canal. Further confirmation of the existence of a canal near the red granite quarry at Aswan is provided by Adel Kelany (Kelany, et al 2006:5). A rock trench of 2.5 meters deep, filled with groundwater that prevented the investigating team to expose the granite bottom, is hypothesised to have been a harbour, which was linked by means of a small canal to one of the wild river branches of the Nile, which filled during flood conditions (Kelany, et al 2006:5). This would indeed have been the best possible way to transport the large granite obelisks, as also shown in Figures 3-25 and 3-26.

#### *3.3.6.2 Transport of stone for Stonehenge*

At about the same time as the Egyptians were building the large pyramids at Giza between about 2,550 and 2,470 BC (Morell 2001:82), and were transporting stone on ships, the builders of Stonehenge are also assumed to have been transporting the blue stones from Wales over water in about 2,500 BC (Alexander 2008:39). Even though it was initially postulated that the stones were hauled all the way over land (Wernick 1974:124-25), researchers have come to the conclusion, based on the fact that there is an avenue leading from the river Avon to the site of Stonehenge, that the stones may have been transported over water either part of the way or most of the way (Alexander 2008:36, 56). If that seems impossible, taking the present-day sea conditions into account, then we need to remember, that we do not know what the climatic and sea conditions were in about 2,500 BC. They may have been quieter than they are now and thus more favourable to allow for this kind of transport, which also may have been seasonal, that is, only in summer and not in winter.

More recently this theory of transport over water has been discounted in favour of transport over land again. With the megalith quarries at the north side of the Preseli mountains, it is now believed that the 80 bluestones, each weighing about two tons, were transported eastwards through the valleys by teams of people or even with the help of oxen and then followed the route of the present day A40 motorway. This according Professor Mike Parker Pearson, who also is of the opinion that these megaliths may have been used at an earlier stage for a stone circle in Wales and then were transported to Stonehenge about 500 years after they were first quarried (https://www.ucl.ac.uk/news/2015/dec/stonehenge-bluestone-quarries-confirmed-140-miles-away-wales).

#### *3.3.6.3 Transport of stone in the Greek era*

As there was an abundance of stone materials in many parts of Greece, locally available types of stone seem to have been the preferred materials for the construction of a particular building in a specific place. Only if material of a higher quality was desired, did blocks get purchased and transported from elsewhere. This would be over land, via river or sea, and would add a considerable amount to the total construction expenses (Malacrino 2010:8). Whether locally quarried or brought from further afield though, each piece of stone destined for a construction site, had to be transported there, and the Greeks devised some truly remarkable methods to do so (Malacrino 2010:139).

The white marbles found on the islands of Paros and Naxos, which were of excellent quality, were in use for statuary since the 7th century BC and also were incorporated in some of the major constructions of the Archaic period (circa 750 – circa 500 BC). These had to be shipped over sea to their respective destinations (Malacrino 2010:16). The white Paros marble was also used for the construction of the treasury of the Athenians in Delphi. This treasury was erected in 490-489 BC after the battle of Marathon, from one-tenth of the proceeds of the spoils of the battle. Its style represented a transition from the Archaic style to the Attic style (Petrakos 1977:19). The islands of Paros and Naxos are located closely together about halfway between the Peloponnese and the West coast of present-day Turkey (Map accompanying article by Alexander 1999:54-75), so the distance to ship marble to Delphi was considerable. From Paros the material may have been shipped over water to Athens or to Corinth and would have to have been taken from either of these by ox-cart to Delphi for the construction of the above-mentioned treasury.

In order to ship the material from Thaxos, used for the reconstruction of the temple of Apollo at Didyma, large blocks would be lashed with cables to wooden boards, held crosswise between two ships. This is according to an *inscription* dating to the Hellenistic period (Malacrino 2010:139). The pieces would be immersed in water and its force would lighten the load (see Figure 3-27; Malacrino 2010:140). One advantage at Thaxos was that the quarry was located along the coast close to the water, which made shipping easier (Malacrino 2010:139).

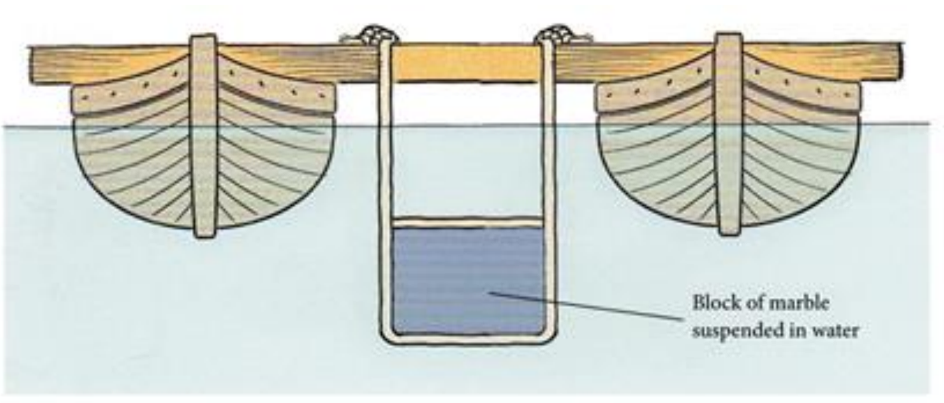



**Figure 3-27: Block of marble suspended with ropes underneath a wooden board between two ships (Malacrino 2010:140).**

The material was quarried on the southern side of the island, on the Aliki Peninsula, and the massive quarry floor there has now practically disappeared under water as a result of earthquake activity. Quarrying of the highly prized, coarse-grained white calcitic marble there began in about the 6$^{th}$ century BC and ended in the early 7$^{th}$ century AD (Storemyr 2006:1). I hold it possible that because so much weight of marble had been removed from part of the peninsula, this was the cause of the earthquake.

Transportation costs varied according to the method of transportation and the distance to be covered. Transport over sea was cheaper than over land. An *inscription* regarding limestone blocks from Corinth, which had Delphi as their destination, shows that a cornerstone could be bought for 61 drachmas, but that its price would rise to 240 drachmas by adding the transport over sea and to 420 drachmas for the additional transport over land from the port of Kyrrha to Delphi (Malacrino 2010:141).

Another interesting aspect with regard to the Greeks transporting and working stone is that their artisans became so specialised at working a particular type of material, that they would be called on to travel to a building site once the blocks had arrived there, to work the material (Malacrino 2010:31). *Inscriptions* have been found referring to the reconstruction of the temple of Apollo at Delphi during the 4$^{th}$ century BC, where Peloponnesian stonecutters were summoned because of their experience with limestone. Artisans, experienced in working the white marble of Paros, accompanied blocks being shipped from the quarry as far afield as Magna Grecia to go and ply their trade there (Malacrino 2010:31).

*3.3.6.4 Transport of stone in Roman times*

The Romans in their quest to build with many different coloured stone materials, procured these from many destinations across the Roman Empire. De Nuccio & Ungaro (2002:264) provide a list of 56 sites dotted all around the Mediterranean, as well as in Egypt along the Nile, from which different materials are known to have been obtained. The stone was transported by means of ships and inevitably some of the ships would flounder in a storm and sink. While searching underwater along the route from Carthage to Rome, Robert Ballard has found a number of Roman wrecks on the seabed, dating from about 100 BC to 400 AD, one of which also contained a number of carefully packed stone blocks (Ballard 1998:34-35). These had been hewn into the required dimensions and were probably destined for use in the construction of a building (Ballard 1998:35; see Figure 3-28).

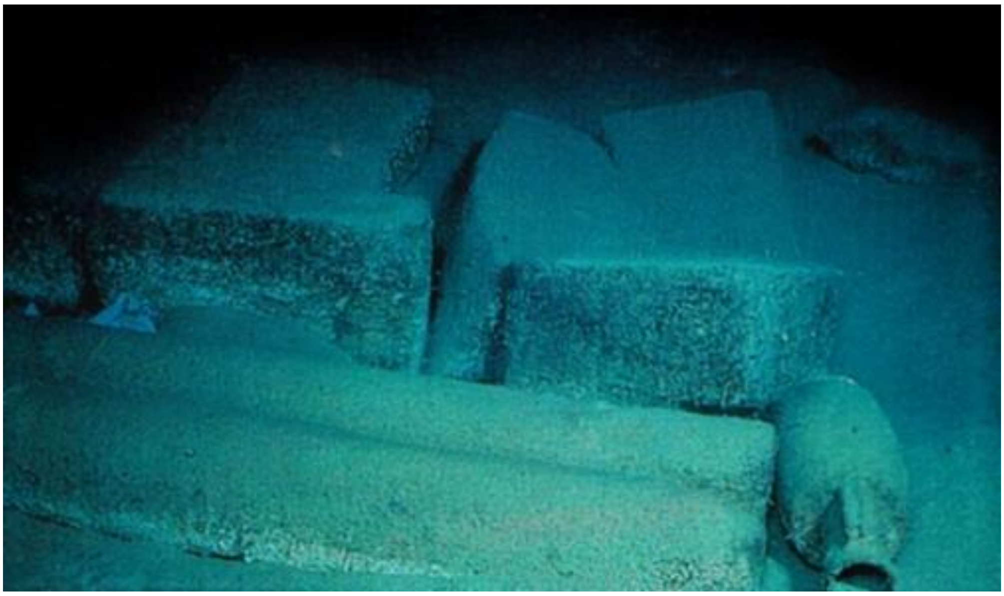


**Figure 3-28: Stone blocks packed together from a first-century AD Roman wreck found on the bottom of the Mediterranean Sea (Ballard 1998:35).**

Ballard also discovered finished pieces of stone on the seabed, which most likely had been jettisoned from ships to lighten them during a storm, in the hope of remaining afloat (Ballard 1998:34, 39). De Nuccio & Ungaro also show a few images of stone pillars and sarcophagi found during under water excavations off Cape Methone in Greece dating to the 2nd and 3rd century AD (De Nuccio & Ungaro 2002:41-43; see Figure 3-29).

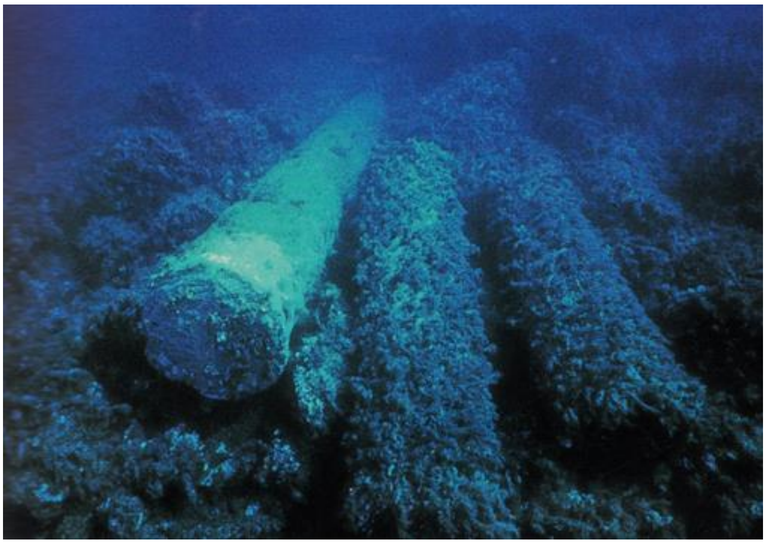


**Figure 3-29: Granite columns found in a ship wreck off Cape Methone in Greece, dating to the 3rd century AD (De Nuccio & Ungaro 2002:43).**

All in all, it is clear that transport of stone over water was quite common in antiquity. And it was not just used in antiquity, but even in more modern times as well, as my great-grandfather established his business in the late 1800's near the Rhine river-harbour of a town called Wageningen in the Netherlands, and my grandfather established his business in the early 1900's near a canal in Veenendaal, which was navigable from the Rhine, in order to ship in the very large pieces of stone over water.

### 3.3.7 Transport with wheels

In order to use wheels with draught animals to transport stone, there needed to be a fairly level surface over which to transport the load, or there needed to be rudimentary roads. In Greece small blocks were transported on carts drawn by oxen or mules (Phoca & Valavanis 1999:107). The two-wheeled wooden carts used for that transport were however not suitable to transport large column shafts. For the construction of the temple of Artemis at Ephesus, the architect Chersiphron devised an ingenious way in which these column shafts were to be transported. He made a wooden frame of four-inch timbers (Malacrino 2010:144). This would consist of two long beams, which were placed alongside the two long sides of the column, and two short beams, which were placed along the two ends of the column. Rings would be fixed in the center of these short beams and the two ends of the columns had holes drilled in their centers. Into these iron dowels were fitted and attached to the stone with molten lead. The dowels were placed into the rings of the frame and the column inside the frame could then be rolled like a bicycle wheel. With the use of oxen, attached to one of the long sides of the frame, the entire frame with the column could be pulled to the building site (Malacrino 2010:143, see Figure 3-30).

This same method was still used in the time of the reconstruction of the Temple Mount in the time of King Herod (Ritmeyer 2006:134; to be discussed further in 6.2.5). The ashlars which now still form part of the western wall, had to be very heavy so that they would withstand pressure from within the enlarged Temple platform. The engineers working for King Herod reckoned that their sheer weight would increase their state of inertia and used blocks 11 to 14m long, 3m high and 3m deep, which weighed 325 to 415 tons (Cohn 1987:87).

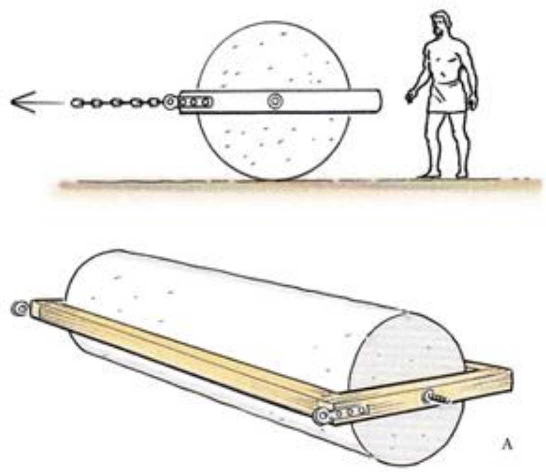



**Figure 3-30: Method designed by Chersiphron to transport pillars by rolling them in a wooden frame (Malacrino 2010:144).**

In order to transport them from the quarry near the Damascus gate, these blocks were produced as massive cylinders, which were rolled down a very broad, smoothly paved road through Jerusalem, called the 'hewn' one, which translated into Greek was called: Xystus (Cohn 1987:88). Once these blocks had arrived at the construction site, a segment was cut off to make a flat side. The stone block would then be rolled into position in such a way that it would land on the flattened side in exactly the right position, after which another segment would be hewn off to produce a straight front with a finely chiselled margin. After this a flat top side would be created by carefully taking off the third segment, so that the next layer of ashlars could be laid without the use of mortar or cement (Cohn 1987:89). The inward facing segment did not get removed and during excavation of a stretch of the wall, a 5m long partial segment of a column was found lying parallel to the wall (Cohn 1987:89).

Even though this method solved the problem of transporting shafts which could roll, there was still a solution needed to transport the straight pieces of material which were to be used as the architraves. For this Metagenes, the son of the above-mentioned Chersiphron, came up with a solution (Malacrino 2010:143-144). He made wheels of about twelve feet in diameter and fixed these on the ends of the architraves. Then he affixed the wheels to a frame with pivots and sockets at the ends of the architraves and had this drawn by oxen to the building site. The architrave served in this way as the axle for the wheels (Malacrino 2010:143-144). This method was also still used in Roman times (Ritmeyer 1989:46; Ben Dov 1986:46), but could only be used over short distances and a fairly level surface (Malacrino 2010:144; see top image of Figure 3-31).

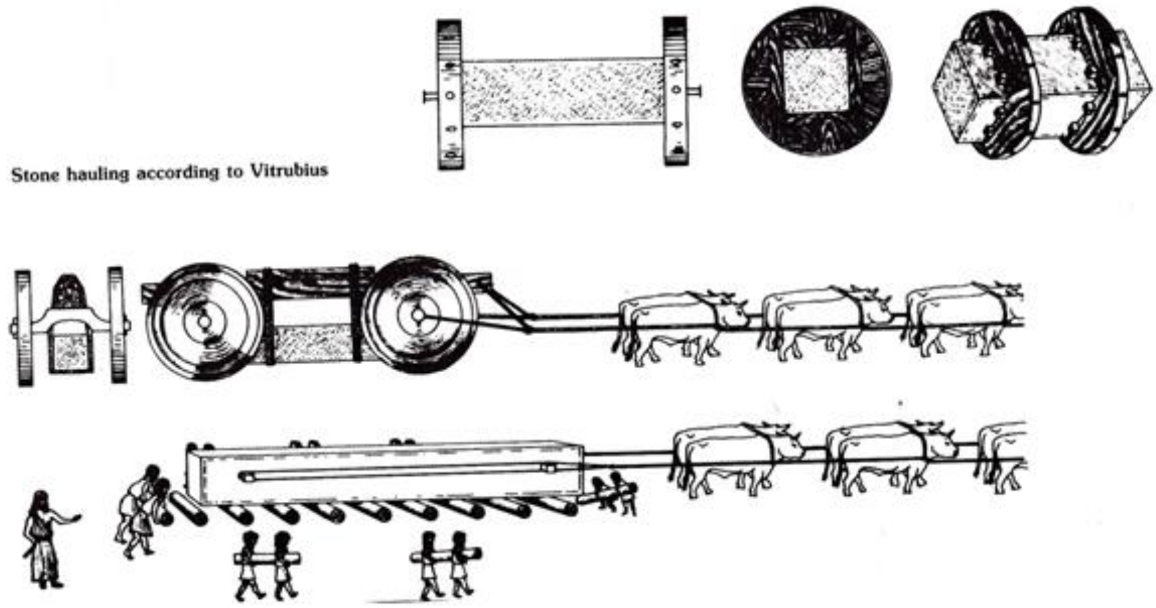



**Figure 3-31: Various methods to transport stone with wheels (Ben Dov 1990:82).**

Another method to transport an architrave would be by suspending it in an iron cradle between four wheels, drawn by oxen (Ben Dov 1990:82, see center image of Figure 3-31). The image below this shows the method of transporting a block drawn by oxen with the use of rollers.

## 3.4 HOISTING

### 3.4.1 Hoisting in Egypt

In the absence of images on walls of temples or tombs depicting the hoisting of loads, it is not entirely certain whether the Egyptians made use of hoisting equipment. There is however an interesting mystery tool, examples of which have been found at Giza, dating to the Old Kingdom. This mystery tool is a mushroom-shaped hard stone, with one or two holes in the stem and three parallel grooves cut into the head (see Figure 3-32). This type of stone may have been a bearing-stone or a proto-pulley, with the stem mounted into the top of a pole or scaffold. The grooves could have served as guides for the ropes, as the Egyptians did not yet have pulleys with a rimmed wheel, and the direction of the pull may have been changed by running the ropes through the grooves (Lehner 1997:211).

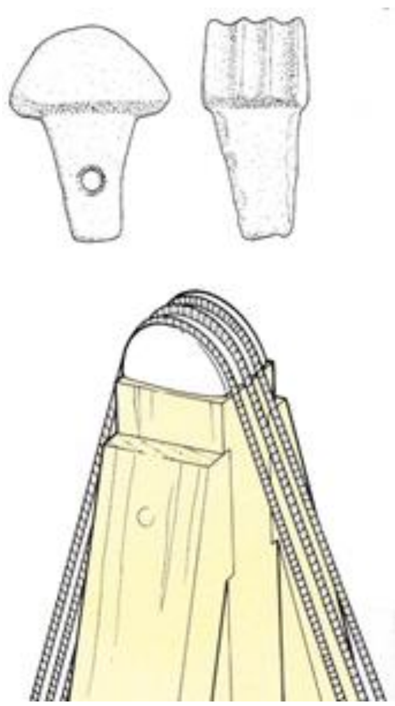


**Figure 3-32: The mushroom-shaped mystery tool with grooves over the head, which may have been mounted in the top of a pole or scaffold and served as bearing stone or proto-pulley for guiding hoisting ropes (Lehner 1997:211).**

After the discovery of the hauling ramp in the quarry at Hatnub (see 3.3.5), I was in contact with Doctor Roland Enmarch to ask if the mushroom shaped mystery tool, which Mark Lehner believes to be the top of a hoisting pole (see Figure 3-32) could possibly have been used attached to the vertical posts alongside the hauling track, but then in a horizontal position, to be used for the pulling upwards of the sledges. The use of ropes around the posts equipped with the mystery tool would act as a ‘force multiplier’, and would make it easier to pull the sled with the block upwards on a slope with a gradient of 20 percent or more (Jarus 2018:3). He wrote that it was an interesting idea and that he would research it further (private email correspondence with Doctor Roland Enmarch, 21 January 2019). So far Doctor Enmarch has not yet communicated what he and his colleagues have concluded on the matter.

### 3.4.2 Hoisting in Greece

#### *3.4.2.1 Different types of cranes*

The Greeks are known to have used lifting devices from at least as early as the Archaic period, which lasted from about 750 to about 500 BC (Alexander 2000:125). They had invented these lifting devices themselves or may have copied them from neighbouring peoples (Phoca & Valavanis 1999:109). The Greek word *geranos* indicated both a crane to lift, as well as a bird of that kind, as the lifting device was thought to resemble the bird. The ancient cranes consisted of long wooden booms, which were controlled by means of ropes and pulley-blocks (Phoca & Valavanis 1999:109).

**Figure 3-33: The monopod crane of Heron (Kotsanas 2017:95).**

The Greeks produced a most amazing array of cranes such as the monopod crane of Heron, which used a single large beam, held in place by balancing ropes and operated with a large winch on the ground. It was equipped with two pulley wheels and served for small building-projects. The beam had a thick rope wrapped around it, which served as reinforcement, but could also be used as a ladder for urgent repairs (Kotsanas 2017:95, see Figure 3-33).

Another crane designed by Heron was the bipod crane. This was shaped like a large door-opening, and was equipped with a *pentaspon* pulley, consisting of three wheels on the top bar, a fixed pulley and two moveable wheels at the bottom. It was placed on rollers for horizontal movement and was operated with the help of draught animals (Kotsanas 2017:96, see Figure 3-34).

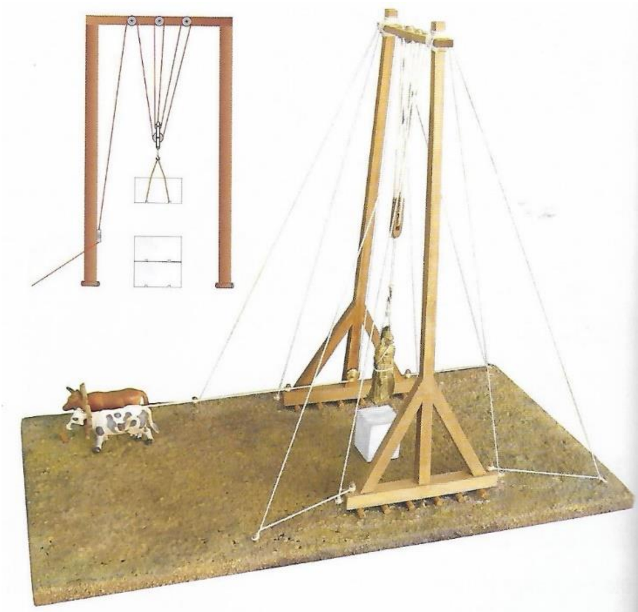


**Figure 3-34: The bipod crane of Heron (Kotsanas 2017:96).**

The image below shows both a crane with a single pulley and rope on the left-hand side and a crane with more than one pulley, as well as a treadwheel attached to it in which men could walk to provide more hoisting power on the right-hand side (see Figure 3-35). The simple bipod crane was used for medium loads and the treadwheel crane was intended for heavy loads (Kotsanas 2017:90-92).

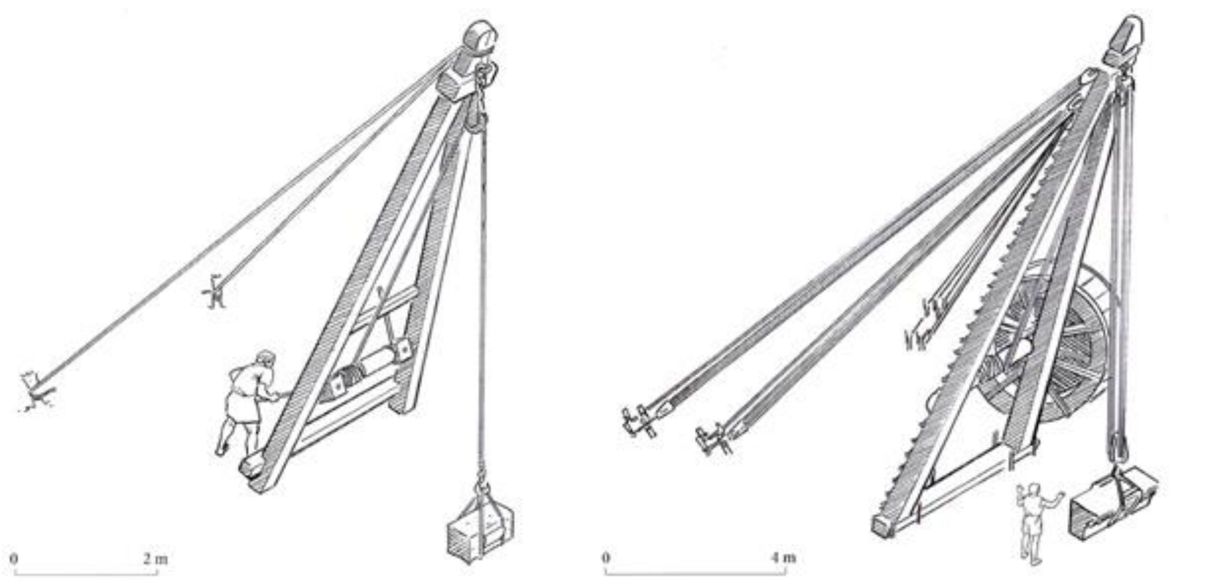



**Figure 3-35: Reconstructed images of cranes used for hoisting blocks of stone. On the left a simple crane and on the right a crane with a treadwheel in which men could walk to provide extra lifting capacity (Malacrino 2010:147).**

**Figure 3-36: The quadpod or scaffold crane (Kotsanas 2017:97).**

Besides all the above-mentioned cranes, there was the quadpod or scaffold crane with a square construction of vertical and horizontal beams, by means of which loads were lifted inside the framework by a block and tackle in the *'polyspaston'* configuration (Kotsanas 2017:97; see Figure 3-36).

The cranes were controlled by three different mechanisms. These were in the first place the pulley, which is a simple wheel with a guide groove for the cable. The second item is the windlass, which is a moveable drum around which the cable gets wrapped, thus reducing the effort of lifting. The third mechanism was the block and tackle, which consisted of several connected pulleys (Malacrino 2010:144-145).

The words: *dispaston, pentaspaston and polyspaston* were used to indicate the arrangement of a different number of pulleys working together (Phoca & Valavanis 1999:109). The use of this latter system made it possible to reduce the force needed, in relation to the number of pulleys used. The use of two pulleys divided the force which was required in half, and four pulleys reduced it to a quarter (Malacrino 2010:145; see Figure 3-37).

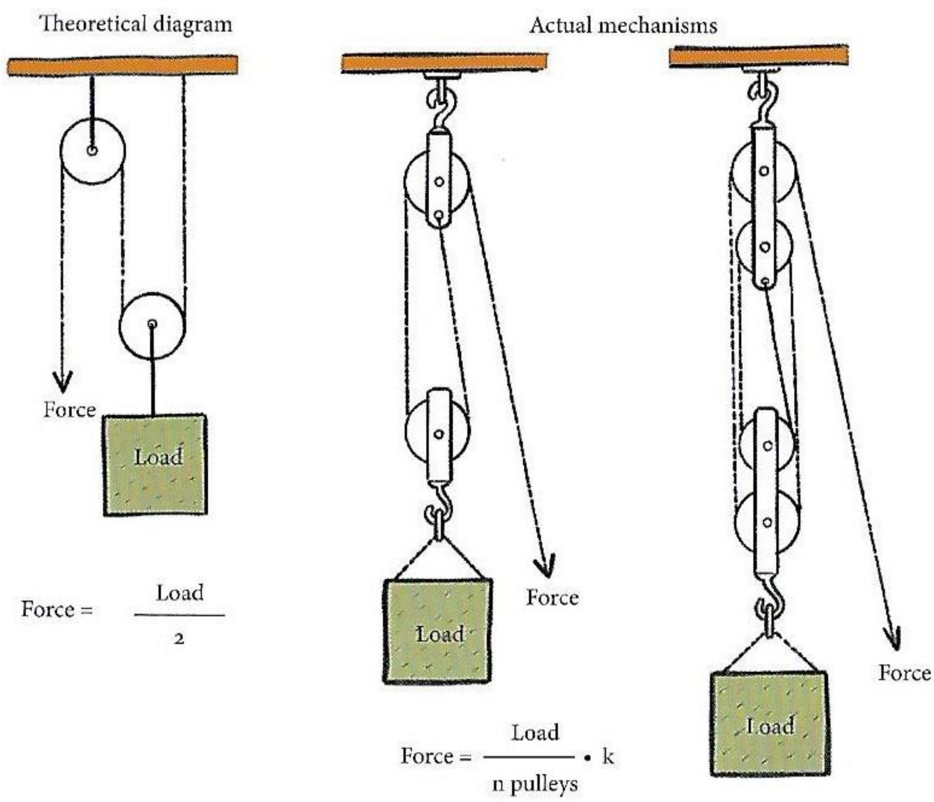



**Figure 3-37: Example of pulley systems (Malacrino 2010:146).**

The way we need to understand the drawings of Figure 3-37 is as follows: the theoretical diagram on the left shows how the force, which needs to be applied to hoist the block, is equal to the weight of the load divided by the two pulleys. The middle image of the actual mechanism shows how hoisting with pulleys works in reality, with the two pulleys linked together in a system. The picture on the right-hand side shows a more intricate pulley system, with four pulleys, which is used to make the load even lighter, because less force needs to be applied to the rope to lift the load (Malacrino 2010:145-146).

Underneath this all there is the formula, which is used to calculate how much force needs to be applied by dividing the weight of the load by the number of pulleys, and then this gets multiplied by the factor ‘k’, which is the friction that the load exerts on the rope, and which hampers the force to an extent, so that it needs to be increased to counteract the friction[13]. Malacrino does not elaborate on the ‘k’ factor, but the information was obtained from the website of the ncalculators.com, which assists in calculations of this kind (https://ncalculators.com/mechanical/block-tackle-efficiency-approximation-friction-calculator.htm). The friction also of course causes wear and tear on the rope, which needs to be monitored over time, so that the rope does not break at an inopportune moment, when there is a heavy load hanging on it.

This system of hoisting was later described in great detail by the Roman author Vitruvius. What is interesting in his description is his warning that if greater loads are to be hoisted, longer and thicker timbers must be used, as well as larger bolts at the top and larger windlasses below (Vitruvius 10.2.3-4 as quoted by Malacrino 2010:146). He also cautions not to trust the windlass when the dimensions and weight of the load are great (Vitruvius 10.2.5-7). This seems to indicate that there had been problems previously with cranes collapsing under too great a weight and windlasses unwinding the hoisting cable at an inopportune moment, causing hoisting accidents.

The development of cranes probably went hand in hand with the building of temples with large pillars. These consisted of stone drums, which were hoisted one upon the other until the required height was reached. The drums were held together in the center by means of a device called an *empolion.* This was a square block of wood,

[13] The factor ‘k’ is the so-called Sheave Friction Factor (https://ncalculators.com/mechanical/block-tackle-efficiency-approximation-friction-calculator.htm).

which was fitted into the center of the lower and upper surface of the drum, and it held a wooden centring pin called a *polos.* As a drum was lowered into position on the drum below it, it could be rotated by means of this centring pin or *polos* until it was aligned exactly with the one below (Phoca & Valavanis 1999:111). Besides being of use in the positioning of the drums on top of each other, the *empolia* also helped to protect buildings against earthquake damage. Due to the fact that they were positioned in the center of the columns, where they were not in contact with the atmosphere, *empolia* and centring pins have often been preserved in excellent condition, e.g. at the Parthenon (Phoca & Valavanis 1999:111; see Figure 3-38).

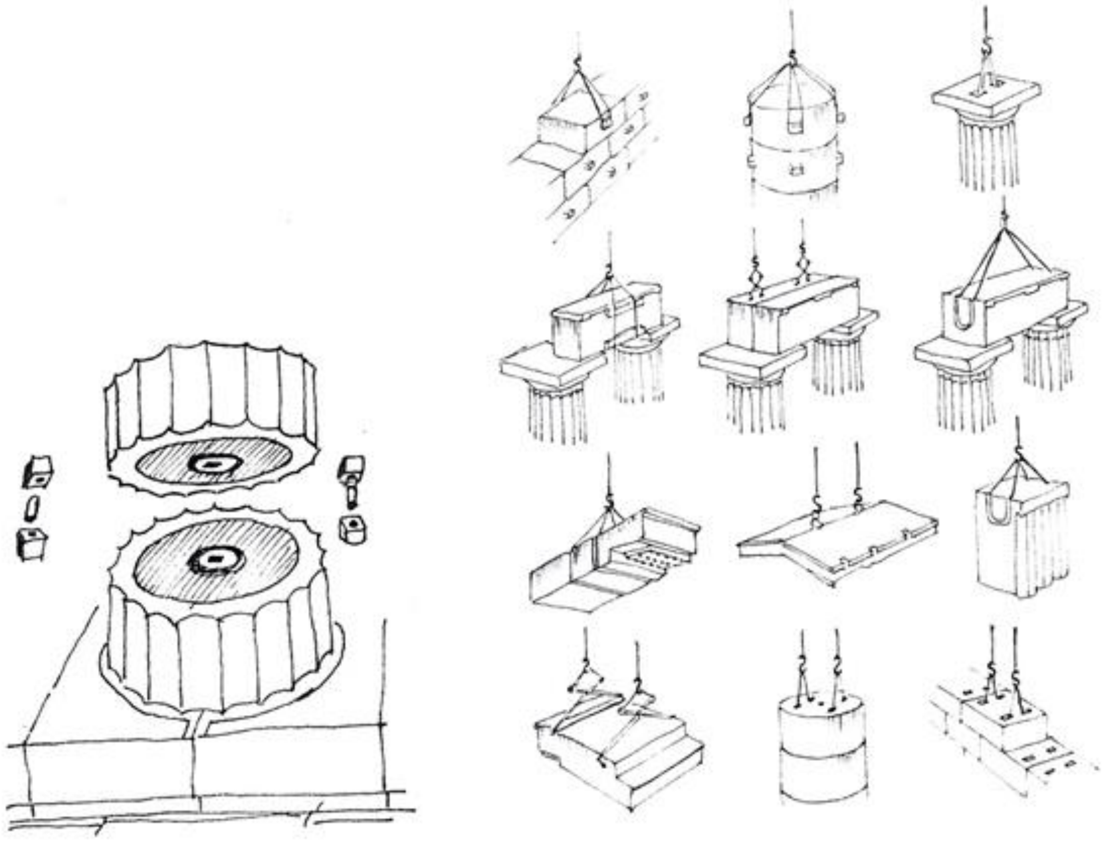


**Figure 3-38: On the left-hand side a drawing of an empolion. To the right a number of different attachment methods for hoisting stone elements (Phoca & Valavanis 1999:111).**

The use of drums for the construction of pillars was a later development, which followed the use of solid pillars (Malacrino 2010:37). There may have been various reasons why this happened. In order to manufacture solid pillars a large rock deposit was needed. Pillar shafts were hewn directly out of the bedrock by digging deep vertical holes, leaving a pillar standing, which then was loosened at the bottom by means of wooden wedges (see Figure 3-39; Malacrino 2010:34). There must however have been a limit to the size which these methods of extraction could deliver. For the vertical extraction method this was about 5 meters (Malacrino 2010:37).

The way the rounding was produced, was with the use of hammer and chisel and measuring equipment such as calipers (see Figure 2-21).

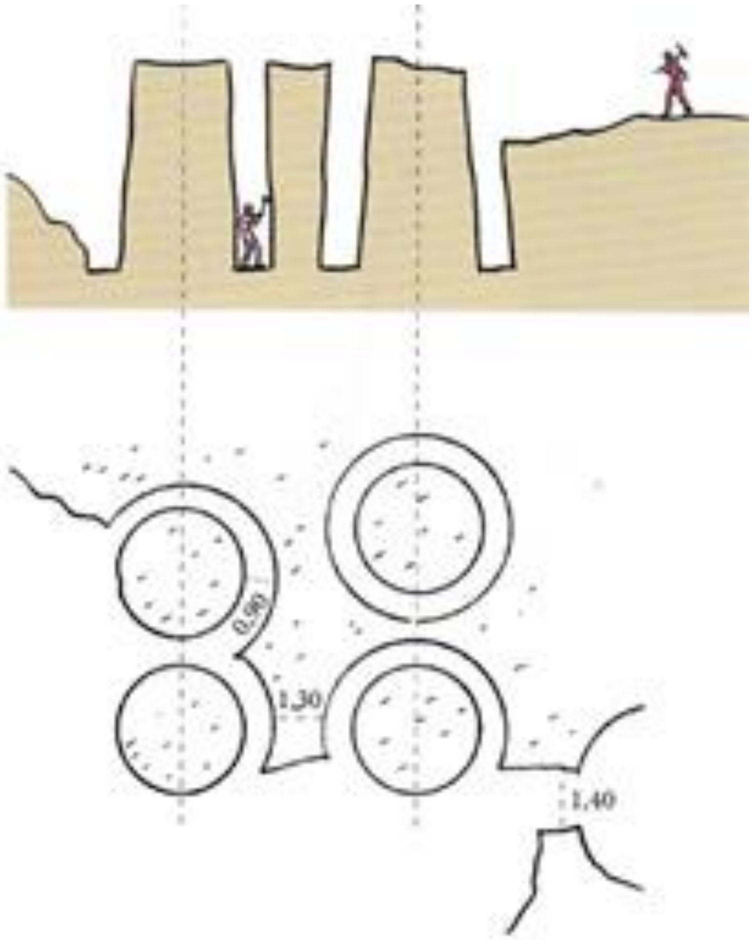



**Figure 3-39: Vertical extraction of pillars from bedrock (Malacrino 2010:34).**

Another possibility to produce pillars was horizontal extraction (see Figure 3-40; Malacrino 2010:34).

When pillars of larger dimensions, that is taller than 5 meters, were needed for more imposing temple construction, these of necessity had to be constructed of stacked drums. Another reason probably was that the size of the pieces of material which could be quarried depended on the quarry from which the material was obtained. If the quarry was a gallery quarry, so was worked underground, it would have been more difficult to extract solid pillars, and it would have been necessary to construct the pillars from stacked drums.

Pillars constructed of stacked drums in Greece would be provided with vertical grooves all around. This process is called ‘fluting’. These vertical grooves in the pillars would hide the horizontal lines of the seams between the drums and would also add a sense of height.

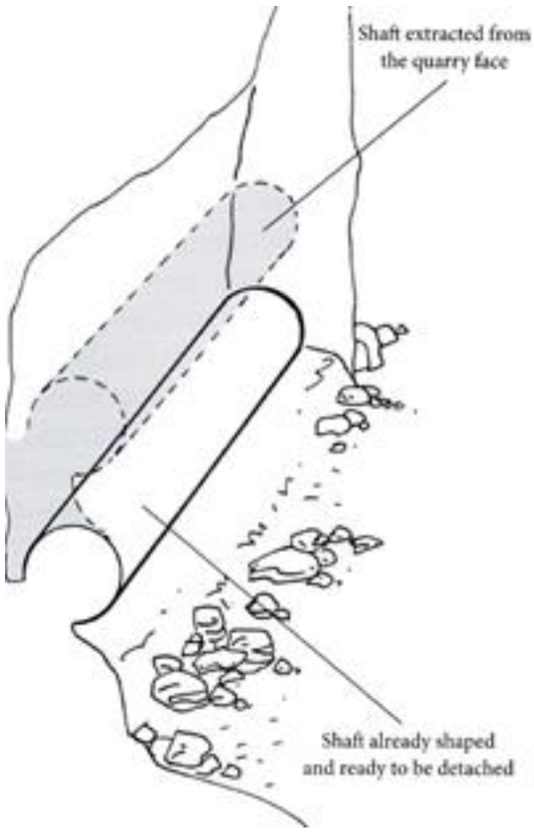



**Figure 3-40: Horizontal extraction of pillars from bedrock (Malacrino 2010:34).**

I have been told by the Classics researcher Richard Evans during the Classics seminar held on 14 June 2014 at Unisa, that if there were no grooves in the pillars of a temple in ancient times, the temple was considered to be unfinished. This is also attested to by Carpenter (1970:30).

*3.4.2.2 Methods to attach stone elements to be hoisted by a crane*

The drums and stone elements to be hoisted into place by means of a crane could be attached in different ways. A huge U-shape carved out in two sides of the piece of stone would hold ropes around it into place, thus enabling the hoisting process with the ropes attached to an iron hook. The blocks would be laid end to end, thus hiding the grooves. This method was used at Aphaia in Aigina and at Akragas in Sicily (Phoca & Valavanis 1999:111; see Figure 3-41).

**Figure 3-41: A method devised by the Greeks for hoisting consisted of cutting a U-shaped open groove at both ends of a block, through which ropes could be threaded (Phoca & Valavanis 1999: 110; Ressler 2014:27).**

Another method would be for stone protrusions to be left on the stone element, to make hoisting into place possible by means of ropes strapped around them (Ressler 2014:27). After the block had been hoisted into place, the protrusions would be removed by the stonecutters. In ancient buildings that were not completed, such as the Propylaia on the Athens acropolis, these protrusions were never removed (Phoca & Valavanis 1999:111). This method of leaving protrusions was also used in the construction of Herod's Temple Mount, and protrusions were sometimes also still left behind as is shown in the image below (Ritmeyer 2006:134; see Figure 3-42).

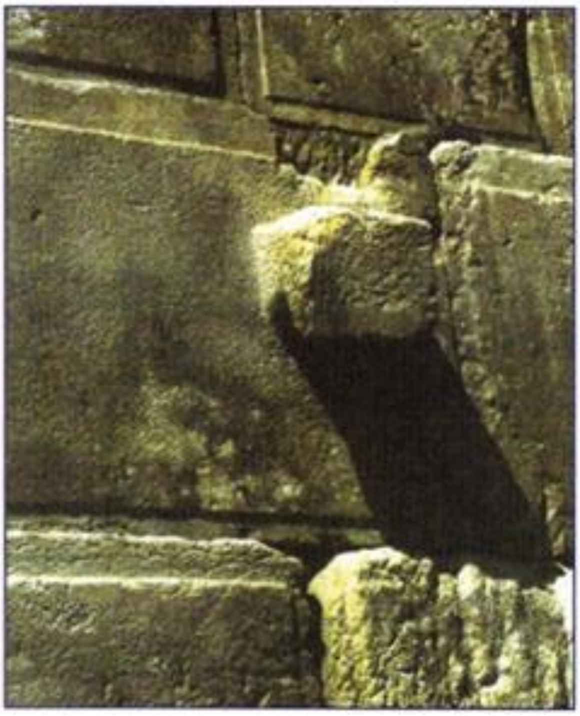


**Figure 3-42: Small stone protrusion on a block of stone left by the stonemason to enable hoisting of the block (Ritmeyer 2006:134).**

Other attachments for blocks to facilitate hoisting were scissor-shaped, or iron claws or thongs, with a name like ‘crab’. These would clamp around the block when pulled from the top hoisting hook (Phoca & Valavanis 1999:111; De Nuccio & Ungaro 2002:484; For an overview of the various methods, including the following, see Figures 3-38 and 3-45).

Then there was still another hoisting implement, called a ‘wolf’. This would work as follows: the stonemason would chisel out a square slot into the stone element, which would widen (dovetail) towards the lower part. Into this, one or two metal pins would be inserted, which would also become broader towards the bottom. Then a straight metal strip would be inserted, which would push the other metal element(s) tight into the slot. The ‘wolf’ with the three metal elements had one or two holes in the top, and these holes would line up once the three metal strips had been inserted into the dovetailed hole in the stone. A pin (or pins) would be inserted through the holes, also including a metal loop, which would provide the attachment for a hook to hoist the stone block, held by these metal pieces. After the block of stone had been hoisted into place the entire element would be removed (De Nuccio & Ungaro 2002:484). This tool is also called a Lewis bolt (Ressler 2014:27; Adams 1994:81-82).

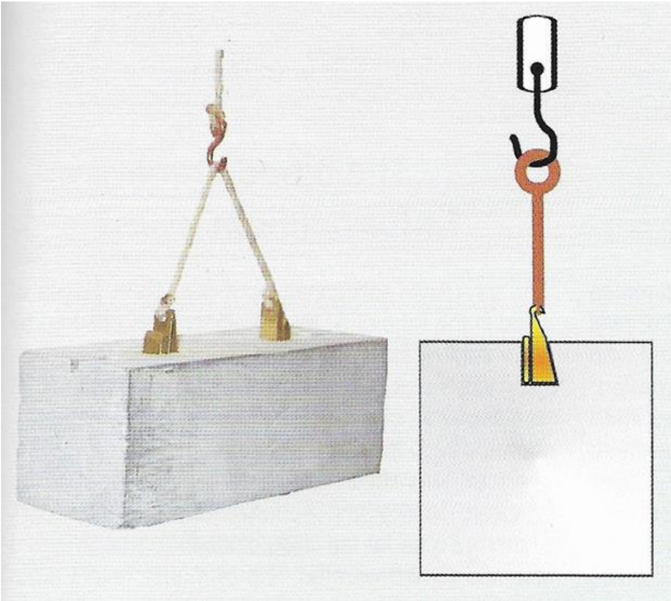


**Figure 3-43: The two-piece 'wolf', used in the Greek era (Kotsanas 2017:89).**

During the Greek era the ‘wolf’ consisted of two elements used in pairs (Kotsanas 2017:89; see Figure 3-43), and in the post-hellenistic era it consisted of three elements used as a singular unit, as shown in Figure 3-44, as well as in the bottom image of Figure 3-45 (De Nuccio & Ungaro 2002:484).

**Figure 3-44: Modern version of a piece of hoisting equipment used in antiquity called a ‘wolf’ consisting of three metal pieces (De Nuccio & Ungaro 2002:484).**

Figure 3-45 shows the following hoisting methods from top to bottom: at the top a block with stone protrusions, which would be removed after the block had been positioned into place. Then the two blocks below that with different types of 'çrab' methods, of which one required a slot to be hacked into the block and the other would hook around the edges with small slots hewn into the sides of the block. Then on the level below that a block with the U-shaped groove, which would be placed side by side so that the grooves would not be visible, and the lowest block is hoisted with the 'wolf' method, which implement is shown in detail all the way at the bottom of the image (De Nuccio & Ungaro 2002:484).

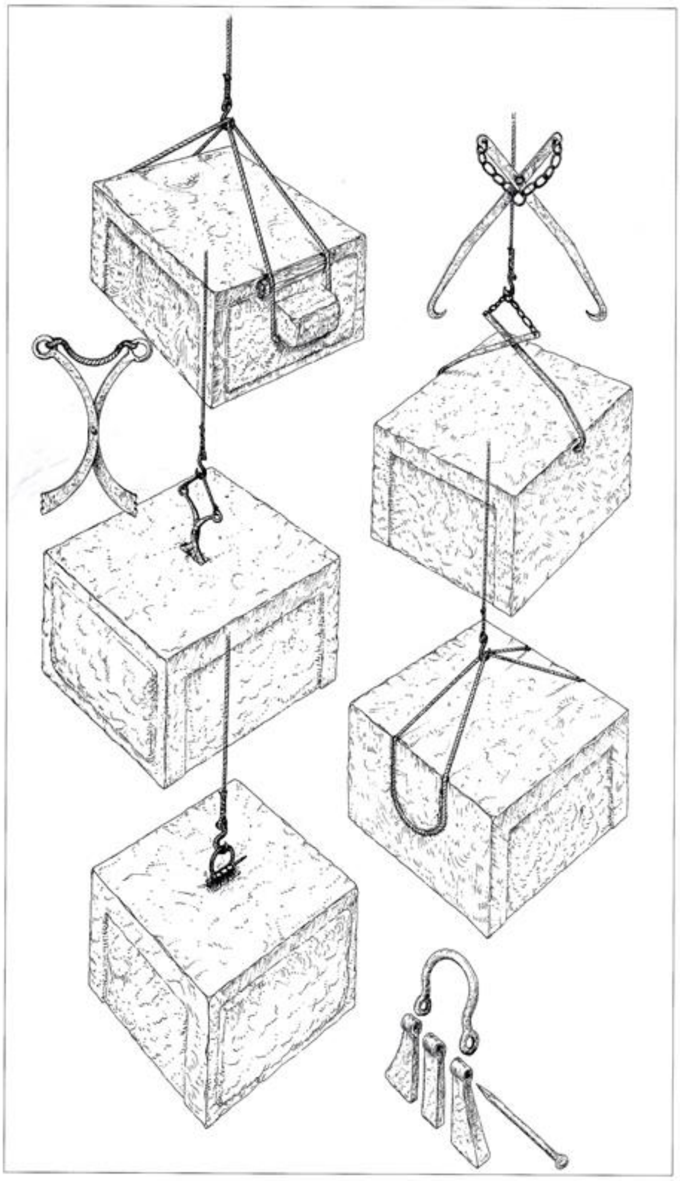


**Figure 3-45: Overview of various methods employed in antiquity to hoist blocks (De Nuccio & Ungaro 2002: 484).**

*3.4.2.3 Cranes used for the construction of moles for ports*

Another type of crane, which was developed by Greek builders, was a special crane to be used for the construction of moles for harbours (see Figure 3-46). This was a type of travelling crane, which was positioned on the part of the mole which had already been built, and was kept in place by the weight of a number of ashlars, placed on the sledge-like part of the crane sitting on the mole. It could be moved forward as the mole construction progressed. It had a U-shaped frame protruding over the water, which held the upstanding poles in place by means of guide ropes. The ashlars were lowered from this contraption into the water and then subsequently stacked above the water level as the mole was built up. This method of building was reconstructed during the excavations at the port of Amathous in Cyprus (Phoca & Valavanis 1999:60). This port was constructed at the end of the 4th century BC with ashlars measuring 3 meters x 0.70 meters, weighing 3 tons each. (www2.rgzm.de/Navis2/Home/HarbourFullTextOutput.cfm?HarbourNR=Amathous).

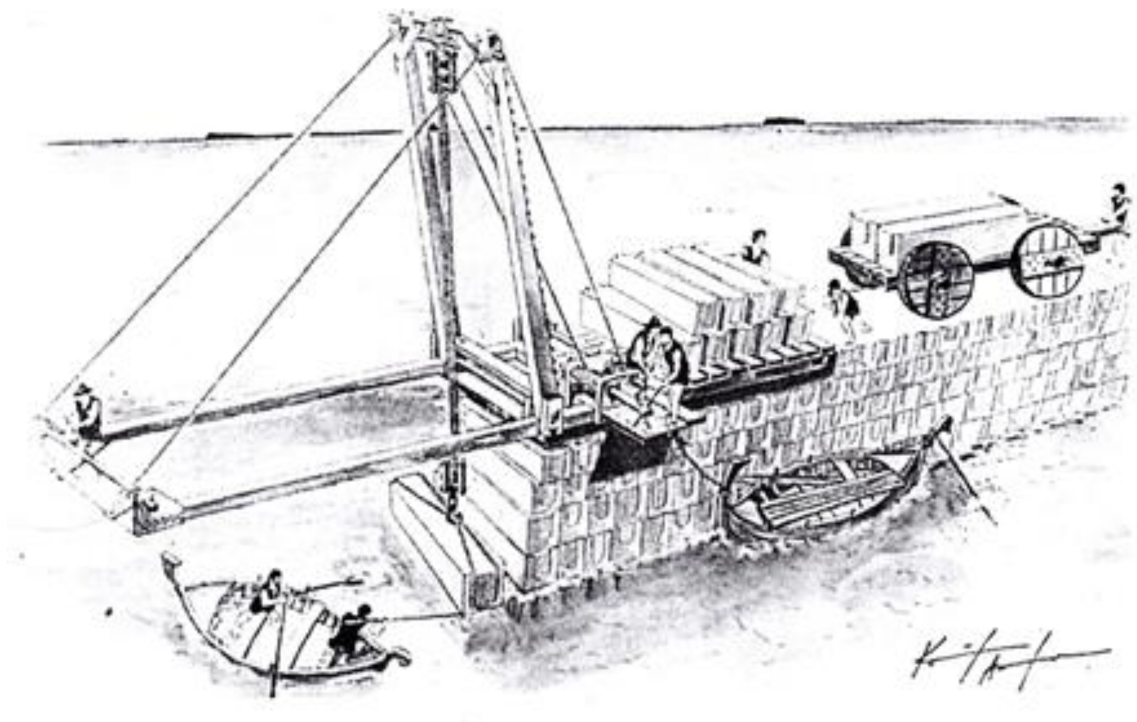


**Figure 3-46: Special crane to build a mole for a harbour (Phoca & Valavanis 1999:60).**

### 3.4.3 Hoisting in the Roman era

#### *3.4.3.1 The treadmill crane*

The Roman era saw the use of cranes developed further, of which the *relief* of the Haterii gives the most illustrative example. The treadmill attached to the bottom of the crane in which slaves were to walk, thus providing the power needed to operate the crane to hoist a heavy load upwards, was still the preferred method of hoisting, but the crane and its rigging were bigger and heavier, and could hoist heavier loads (De Nuccio & Ungaro 2002:501; see Figure 3-47).

**Figure 3-47: The relief of the Haterii showing a crane powered by workers walking in a treadmill (De Nuccio & Ungaro 2002:501).**

A more detailed drawing below (see Figure 3-48) shows more details of the treadmill crane. This type of crane was originally designed by the Greeks (as shown in Figure 3-35) and was later used in more expanded form by the Romans. Besides the use of the treadmill in which workers would provide hoisting capacity by walking the wheel, so that it would wind up the cables on a winch connected to it, there also was a circular platform underneath it so that the crane could be turned. Note the blocks of stone on the platform behind the treadmill, which acted as a counterbalance. Also notice the protrusions on the piece of stone hanging from the crane, which allowed for the hoisting cables to be held in place during the hoisting process. These were to be removed after installation of the block in its intended position.

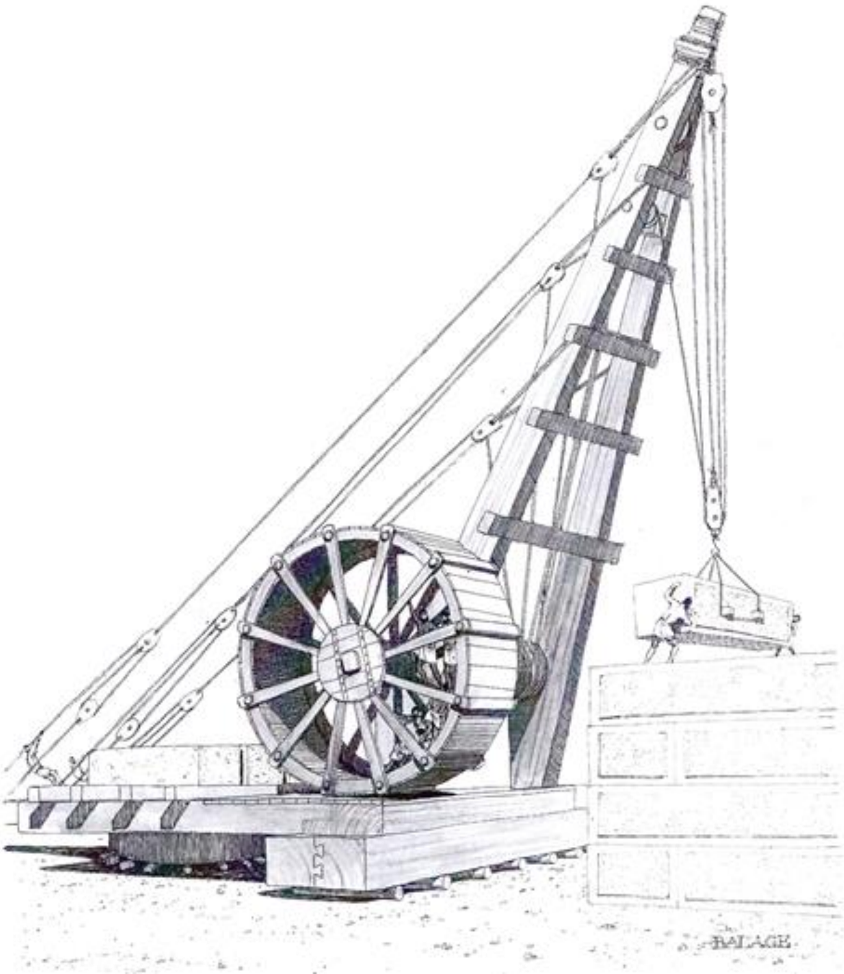



**Figure 3-48: A more detailed drawing of a crane powered by human weight and used for hoisting massive stones, as originally designed by the Greeks and described by Vitruvius (Mazar 2002:29).**

### *3.4.3.2 The tripod crane*

Besides this very elaborate crane, also simpler methods of hoisting were used, such as a simple tripod crane consisting of three wooden beams, standing up and strapped together at the top. From this top suspended, hangs hoisting tackle with blocks and ropes and with a stout hook from which a load can hang while it is hoisted into place (De Nuccio & Ungaro 2002:488; see Figure 3-49). This method was still used in our family's stonemason company 65 years ago, but replaced shortly thereafter by an overhead portal crane.

**Figure 3-49: Reconstruction of a tripod crane (De Nuccio & Ungaro 2002:488).**

#### *3.4.3.3 The 'gru' crane*

Another type of crane would have been what now is called a Derrick crane, in Italian a *'gru'* crane, consisting of an upstanding wooden pole, with an arm attached at the bottom. This arm is manipulated by means of ropes and blocks, so that it can rotate and be lowered outward. This type of crane was used to load stone blocks onto ships in Roman times (De Nuccio & Ungaro 2002:192-193; Fant 2008:125; see Figure 3-50).

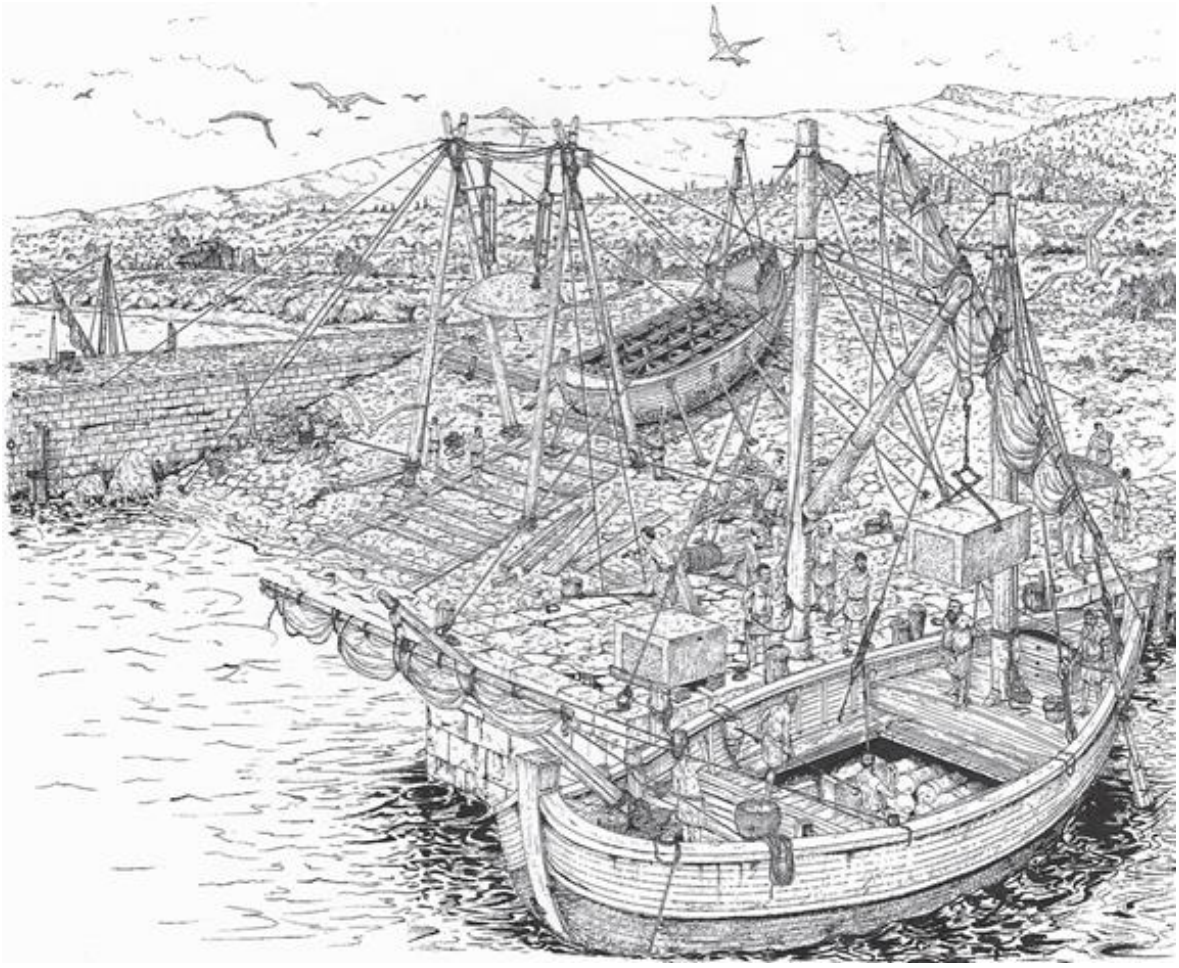


**Figure 3-50: Image of a 'Gru' type crane to hoist blocks into the hold of a ship (De Nuccio & Ungaro 2002:192).**

#### *3.4.3.4 Lowering blocks by means of a crane*

So far mainly hoisting up by means of various types of cranes has been discussed, but in some situations, blocks may have been lowered with the use of a crane. An example of this is mentioned by Ritmeyer in his analysis of how the Temple Mount was extended in Herod's time (Ritmeyer 2006:136-137). This massive undertaking saw the original square Temple Mount extended to a very large rectangular by building massive retaining walls around the original Temple site and filling in the space between the old and new with fill. This meant that very high retaining walls had to be built at the south-western corner of the new platform. These were built on bedrock, and after the first course had been laid, fill was brought in behind it. The stones for the next course were then brought in over this fill, to be placed on the first row and so course after course were brought in over the fill which had been brought in behind the new retaining wall and a crane would position the stones into place (Ritmeyer 2006: 136-137). In this way no hoisting high upwards had to take place. As some of the stones used at this corner of the platform were massive and weighed up to 570 tons, lowering them into place was the more viable way of achieving the desired result (Ritmeyer 2006:137; see Figure 3-51).

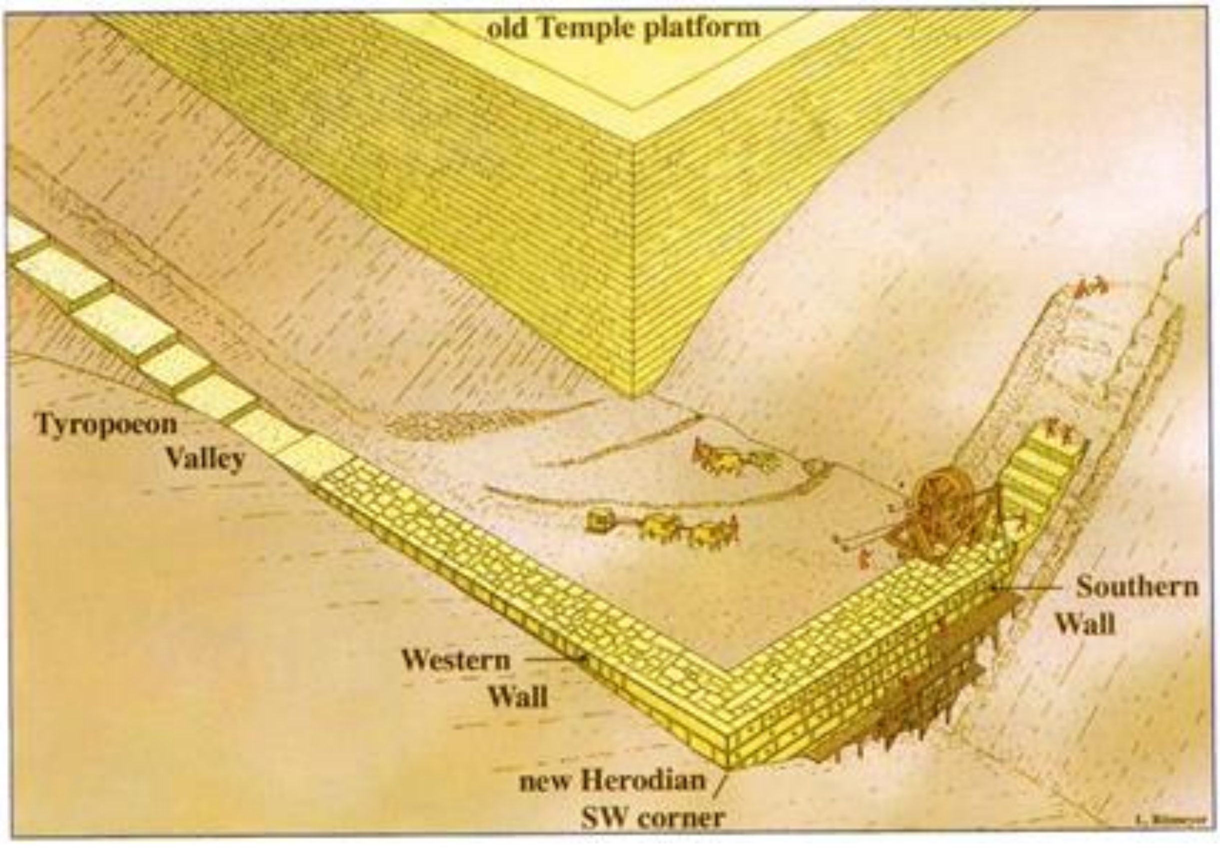



**Figure 3-51: The massive stones for the retaining wall of the Temple Mount were lowered into place (Ritmeyer 2006:137).**

### 3.4.4 Use of metal clamps

After the stone blocks used for the construction of a building had been hoisted to the correct level, they were levered into place by means of metal crowbars. To keep the blocks in the right place, they were sometimes held in place by means of metal ties or clamps (Connolly 2001:37; Malacrino 2010:107). These were made in different shapes (see Figure 3-52) for the different positions they were used in (see Figure 3-53).

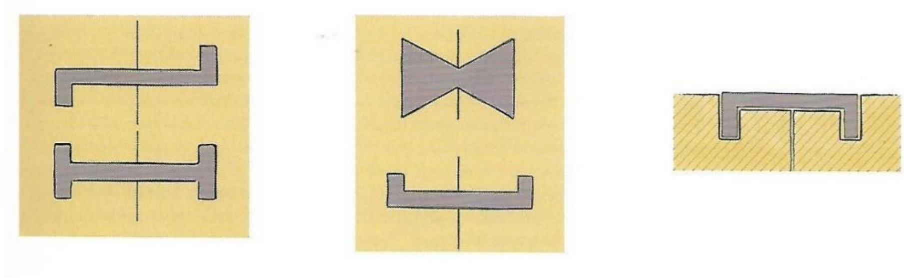


**Figure 3-52: Examples of different types of clamps (Malacrino 2010:107).**

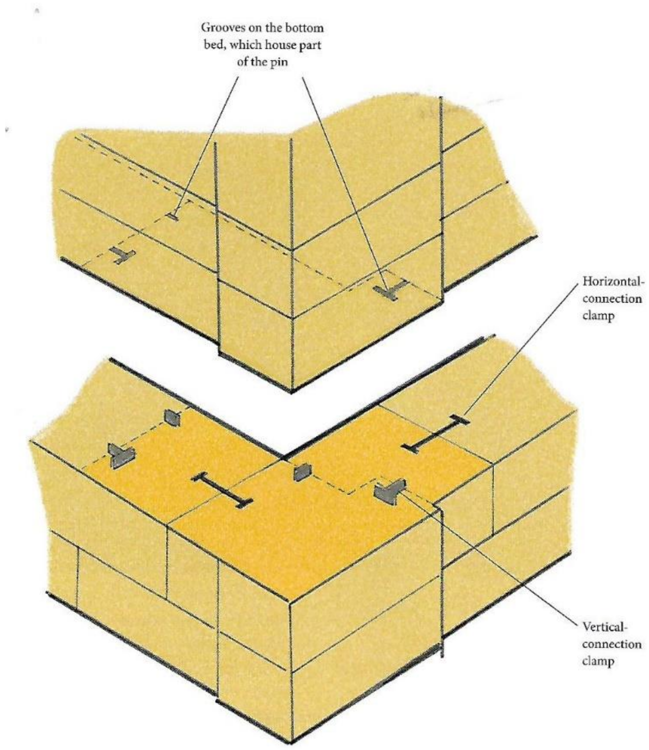



**Figure 3-53: Various methods of using clamps to hold blocks together (Malacrino 2010:107).**

This method of using clamps was used for instance in the construction of the Parthenon in Athens. There the inner chamber, or *cella,* containing the statue of Athena, was constructed of stone blocks held together with metal clamps (Connolly 2001:36). For this purpose, notches were hewn into the sides of the blocks to accommodate the use of these clamps. The Parthenon will be discussed further in 6.2.4.

## 3.5 STONE VESSELS

### 3.5.1 Introduction

Not only was stone used to build pyramids, temples and other large buildings, or to make statues, but it was also used in antiquity to make articles which were intended for daily use. This was already the case in Egypt, where stone was used to make vessels of various shapes and sizes. The quarry at Hatnub, which was discussed in 3.3.5, was one of the sites where stone vessels of alabaster were produced (Enmarch 2018:2).

**Figure 3-54: Carving of an alabaster jar with a drill weighted with stones in ancient Egypt (Hall 1977:311).**

The Egyptian stone carvers would use a drill, weighted with stones, to carve the inside of these elaborate alabaster bowls and unguent jars (Hall 1977:311; see Figure 3-54).

**Figure 3-55: Carving of inside of alabaster bowl by means of a metal curved drill in Egypt in modern times (Hall 1977:311).**

The method of carving by hand is still in use in the present time in Egypt where stone carvers make use of a metal curved implement mounted in the end of a bent rod to carve the inside of a bowl, and after shaping the bowl in this way, polish both the inside and the outside by hand (Hall 1977:311; see Figure 3-55).

### 3.5.2 Stone vessels in Israel during the Second Temple Period

An exceptional amount of stone vessels was produced in Israel during the Second Temple Period, which corresponds to Roman times, and in this section an analysis will be made of why this was the case.

According to Jewish purity laws, pottery items made of clay were considered to be not ceremonially clean, due to the fact that they might absorb impurities, which stone was believed not to do (Mazar 2002:46; Ben Dov 1990:94; Rahmani 1982:112). Therefore, certain vessels were made of stone during the Second Temple Period. Pieces of Jerusalem stone, which is a relatively soft limestone, were used to make cups, jugs, dishes, containers with lids, stoppers for bottles and even large water vats (Mazar 2002:42, 46). As an example of the use of stone for household purposes, the six large water vats which were filled with water at the wedding in Cana at Jesus' instruction (John 2:6) and subsequently were found to contain wine, were made of stone (Ben Dov 1990:94; Crossan and Reed 2001:247)[14]. John used the words: ύδριαι λιθιναι, which means 'waterpots of stone' (Green 1996:286). This does not necessarily mean that the stone vats at the wedding in Cana had been manufactured in Jerusalem, as there were also other sites for the production of this kind of items elsewhere in Israel. One such site was in the vicinity of the village of Nazareth (Gibson 2009:3). As Cana was close to Nazareth (Ben Dov 1990:94), it is not surprising that even though the family hosting the wedding was not wealthy, they owned stone water vats, as these were produced in the area. The vats in Cana were intended for ceremonial washing, according to John 2:6. I have come to the conclusion that it is also possible that the family had manufactured the vats and that these were standing at their house to be sold. This in view of the fact that Jesus asked the servants to fill the vats with water, as they were empty (Jn 6:7).

### 3.5.3 Stone vessels in Jerusalem

An enormous quantity of stone vessels has been excavated in Jerusalem dating to the early 1st century AD and even more so from the period between 50 and 70 AD, when there was an even greater emphasis on purity in Jerusalem (Gibson 2009:55, 79). Gibson even states that 'purity burst forth in Israel' (Gibson 2009:55) and that there was an 'explosion' of purity, possibly from a change in religious sensibilities or even as a form of passive Jewish resistance against encroaching traits of Roman culture (Gibson 2009:79). Gibson (2009:54) also states that in rabbinical writings reference was made to the use of stone vessels for the purpose of the ritual cleansing of hands. For this purpose, the large vessels called *qalal* were used in combination with small hand-carved mugs (Gibson 2009:54), the former most likely as containers to hold the water and the latter to scoop a quantity for use out of the larger vat. The hand-carved cups or mugs were also used at the Siloam Pool to scoop up water for purification purposes (Gibson 2009:71).

[14] It is noteworthy that Emeritus Professor Ronny Reich of Haifa University mentioned that the reference to stone vats in John 2:6 helped archaeologists to understand the finds of large stone vessels in Jerusalem (Schneider 2017:32).

There may however also have been a more practical reason for the increase in the use of stone vessels towards the end of the Second Temple Period. Mazar quotes a few facts mentioned by Josephus and these may throw a different light on the situation. Josephus wrote that there were 11,000 workers employed for the remodelling of the Temple Mount (Mazar 2002:25). This entire project was completed under the rule of the Roman procurator Albinus (62-64 BC). According to Josephus he initiated a new project to re-pave the streets of Jerusalem to provide work for the unemployed labourers (Mazar 2002:37). The archaeological finds in the Herodian street adjacent to the Western Wall of the Temple Mount show that this indeed took place, as the paving found there, was not as worn by the feet of the thousands of pilgrims, who must have passed by there over the years, as would have been expected (Mazar 2002:37). Whether this paving project would have employed all 11,000 labourers who had finished the Temple Mount project though, is doubtful and it is very well possible that a number of jobless workers, stonemasons and others, may have turned to the manufacturing of stone vessels, hence the increase in production. The glut of these vessels flooding the market may have also brought the price down and made them more affordable to the public at large.

### 3.5.4 Manufacturing methods of stone vessels in Jerusalem

The manufacturing of the smoothly finished circular containers, large and small, was done on a lathe[15], after the stone material had been immersed in water for 18 hours to soften it (Gibson 1983:185-186). In antiquity, a lathe used to consist of a block of iron on an axis, and this was turned very quickly by a wheel. The stone was attached to this axis and as it turned, the outside of the stone was carved with iron blades by the manufacturers. The inside was carved out and smoothed, most likely with pumice to make beautiful items (Ben Dov 1990:94; Gibson 1983:183, 186; see Figure 3-56).

[15] A lathe is a machine in which work is rotated about a horizontal axis and shaped by a fixed tool (Merriam Webster 1977:650).

**Figure 3-56: Some of the stone vessels which were used extensively in Jerusalem during the Second Temple Period (Mazar 2002:46).**

For the manufacturing of very large vats (see Figure 3-57), use was made of lathes which were turned with water power. Thousands of stone fragments were found at the excavations at the Temple Mount, which were the remains of this industry (Ben Dov 1990:95). The area where the vats were produced was intersected by the aqueduct running from Solomon's Pools to the Temple Mount. Water was diverted by means of a pipe from this water conduit and fell on a sort of 'turbine' or water-wheel, which made large blocks as big as mill-stones (and larger) spin to make large vats (Ben Dov 1990:95).

**Figure 3-57: Large stone vats were made with the use of a water-powered lathe (Ben Dov 1990:95).**

Of the water powered lathes no images are available, but of the smaller types of lathes, reconstructions have been made by the Greek engineer Konstantinos (Kostas) Kotsanas, based on descriptions of lathes by Vitruvius (see Figures 3-58 and 3-59).

The pedal lathe was operated by pushing the pedal up and down with a foot, which in turn would pull the rope attached to the arm above the machine to rotate the item to be worked on, which would be shaped by the cutting tool mounted on the front of the horizontal bar (Kotsanas 2017:44; see Figure 3-58).

**Figure 3-58: The pedal turning lathe (Kotsanas 2017:44).**

**Figure 3-59: The bow lathe (Kotsanas 2017:45).**

The bow lathe would work in a similar way, but here the movement of the bow up and down would rotate the item mounted on the frame, with the cutting tool mounted on the upper horizontal bar to be used to shape the rotating piece of material that was being worked (Kotsanas 2017:45; see Figure 3-59).

Besides the stone articles made with the help of lathes, also more crudely carved items were made. These were most likely carved by hand with a sharp implement (see Figure 3-60).

**Figure 3-60: Some smaller items made out of stone, a 'measuring' cup and stone stoppers, found during excavations near the Temple Mount (Ben Dov 1990:94).**

In Jerusalem the smaller articles made of stone seem to have been the most common items which pilgrims would buy to take home with them (see Figure 3-56 and Figure 3-60). These were for sale in the shops lining both sides of the Herodian street which ran along the western wall of the Temple complex. During excavations of these shops many shards and even complete vessels were found (Mazar 2002:39-41).

### 3.5.5 Other articles made of stone

Besides the stone vessels, also other articles of stone were made, such as stone weights and measures, as well as stone table tops and ossuaries (containers for bones) decorated with geometric designs (see Figure 3-61), which are characteristic for the Second Temple Period (Ben Dov 1990:94-95). According to Rahmani there were two categories of artisans involved in the manufacturing of these stone items. They were the stonemasons and the stone carvers (Rahmani 1982:112). The stonemasons used hammer and chisel and prepared items of hard stone, such as tomb facades and hard stone coffins and ossuaries out of *meleke* quality Jerusalem stone (Rahmani 1982:112). The stone carvers had workshops in the city and its surrounding areas and produced the stone vessels such as the large and small water jars, measuring cups, platters, dishes, drinking cups and boxes from the softer local limestone called *kaakuleh* or *nari* (Rahmani 1982:112). The stonemasons were able to put more elaborate decorations on the coffins and ossuaries which they produced, which often matched the decoration on the tomb facades. Their products were probably expensive (Rahmani 1982:112-113). The stone carvers produced plain ossuaries of a standard type, which sometimes were decorated with much simpler designs copied from the more elaborate ossuaries made by the stonemasons. These designs would be in simple carved and shallowly executed lines only and not with elaborately carved rosettes (Rahmani 1982:113). Both the more elaborate and the simpler rosette decorations were characteristic for the Herodian era (Ben Dov 1990:94-95). Whether there was any symbolic value attached to these rosettes is not indicated in any of the sources consulted.

**Figure 3-61: Beautifully decorated stone ossuaries dating to Herodian times on the left and ossuaries without decoration on the right-hand side (Ritmeyer 2006:356).**

It is my belief that the stone vessel industry which developed in Jerusalem during the Second Temple period can be considered a secondary development, which resulted from the fact that so much stone was getting quarried for the construction of the Temple Mount. Not all blocks would be suitable for use in the building project and also cut-offs, remnants and even waste materials of the construction process may have been used for the manufacturing of especially the smaller items.

The manufacturing of the stone items in Jerusalem ceased after the destruction of the city in 70 AD (Crossan and Reed 2001:31; Gibson 1983:187). Ossuaries continued to be used elsewhere in Israel till the beginning of the 3rd century AD (Rahmani 1982:109).

## 3.6 MOSAICS

### 3.6.1 Use of very small pieces of stone: mosaics

Besides the use of large blocks for construction purposes and smaller pieces of stone for the manufacturing of vessels for everyday use, even smaller pieces were used in antiquity to make mosaics. These consisted of different coloured materials, and were designed with images as well as with geometric patterns. Before the UNISA study tour to Greece and excavation at ancient Messene in September 2016, organised by my supervisor, Professor M. Le Roux, it had never occurred to me to include this use of stone materials in this study, but during the stay of the UNISA excavation team in Mavromati, and our work at the site of ancient Messene on the Peloponnese, (directed by Professor Petros Themelis), I was literally pushed with my nose onto this particular use of stone. As mosaic floors were part of buildings in antiquity, it also was a form of stone working, which should also be included in this study.

A large mosaic floor dating to about 400 AD, which had been excavated a few years earlier by a team from UNISA, was in dire need of restoration (see Figure 3-62). As a result of heavy rains just before we arrived in Mavromati, a large amount of dirt and debris had washed onto the mosaic from the surrounding area. This is located higher and the steep sides separating the mosaic from the chapel and cemetery situated above it, are unfinished and mostly consisting of soil, some of which had been washed down by the heavy rains. The mosaic needed to be cleaned, and due to the influence of weathering, because it is exposed to the elements for part of the year, it was also necessary that restoration should take place. A number of stones were lying loose and there were weeds growing here and there as well.

A few members of the UNISA excavation team volunteered to help with the restoration of the mosaic, which was directed by Stavroula Poulimenea, a mosaic restoration expert from the museum in Kalamata. Working with her were a few other specialists, who were only introduced to us by their first names, Panayotis and Vrenia.

**Figure 3-62: The mosaic just after the beginning of the restoration process, when the solid mud and debris had been removed but dirt was still present. (Photo A.M. Smith, ancient Messene, September 2016).**

### 3.6.2 Development of mosaics

Before the work we undertook is described in greater detail, it is probably useful to give a short overview of the development of mosaics in antiquity. It is believed that mosaics originated in the Minoan civilisation in Crete and the Mycenaean civilisation on mainland Greece with the use of pebbles to construct flooring (Cartwright 2013). In the 5th century BC this developed into the design of patterns with pebbles and only in the 3rd century BC during the Hellenistic times did the change from pebbles to small cut pieces of stone occur, now usually referred to with the Latin word *tesserae* (Malacrino 2010:13), for the use of patterned floors. It was in Roman times that mosaics experienced their greatest development and the Roman mosaics initially followed the subject matter of the earlier Hellenistic mosaics, with images from Greek mythology and historical events. By the 4th century AD and more in particular in the Eastern part of the Roman empire, there was a development of mosaics which used two-dimensional and repeated patterns to create a 'carpet' effect. This style would be used often in later Christian churches and Jewish synagogues (Cartwright 2013).

### 3.6.3 Description of the mosaic in Messene and its history

The mosaic which we helped to restore in ancient Messene was an example of this 'carpet' style with a number of different patterns used. It is believed that the mosaic floor was part of the house of a bishop and that he commissioned the floor to be made. The room may have been a library or have been used for house church meetings, this according to the information sign on site. The central part consisted of a circle with a name, Paramonos (probably the bishop's), and that he had made it (probably ordered it to be made) and was a reader (what was meant by that was not explained anywhere, but may have led to the assumption that the room was a library). Surrounding the central emblem there was a geometric pattern with straight lines and square angles. Above and below this central square pattern, there was a diamond pattern on either side, which in turn was surrounded by a border of twisted rope pattern on the left-hand side and a leaf pattern on the right-hand side (see Figure 3-62 and Figure 3-64). In the top left-hand corner, there was a narrow gutter, separating a small corner from the rest of the floor. The purpose of this gutter is not known.

The mosaic consisted of three different colours, white, dark pink/red and grey-green and had been made of stone materials which occur locally to this day according to

Stavroula Poulimenea, who showed us rough pieces, which she had collected. The white material was limestone and was softer than the other two materials. The grey-green material seemed to be layered as the occasional *tessera* (singular word used) would lose the top layer when it was brushed clean. The dark pink/red was the strongest material. I was not able to determine exactly what kind of materials they were, but the grey-green material may be similar to the porphyry from Sparta (Mannoni 1985:277), or possibly verde antico (see section 3.7.2), and the red material could have been a marble. The original pieces of material from which the *tesserae* had been cut, had not been quarried in blocks, but loose pieces had been collected in the hills surrounding ancient Messene according to Stavroula Poulimenea.

Stavroula also brought information on what tools were used to cut the *tesserae* and even provided a book in Greek (Loukianós 2011) with images of the cutting process. In antiquity a pointed hammer would be used to knock off a piece off a strip of stone which was held by hand on one or both ends (depending on the length of the strip), and was supported by a narrow, pointed pyramid made of iron underneath it (see Figure 3-63). The hammer had to be used in short, sharp blows to knock off the small *tesserae.* Stavroula said that her lecturer in college had insisted that they tried this hammering process out for themselves, when he taught them. The modern method of making the *tesserae* is by using a pair of pliers to clip off a piece of stone.

**Figure 3-63: In antiquity mosaic stones were cut with the use of a hammer and small pyramid shaped anvil (Loukianós 2011:36).**

Moreover, Stavroula showed me a report, which she had written about the entire restoration process of the mosaic. After the mosaic had been discovered, it had been excavated in stages over a few seasons. It had an interesting aspect in that a circular patch was missing just above the central circular emblem, and there was a hole in the mosaic in that place. Therefore, the decision was made to discover why this was so and about two square meters of the mosaic was lifted for that purpose. In order to do so a few layers of cloth were glued to the mosaic to hold it together and this entire panel was lifted. Once it had been removed, the circular patch that was missing from the mosaic was discovered lying underneath it. The reason it had sunk down was that there was a natural water spring right in that place. A drain had been put underneath the mosaic floor to let the water of this spring drain off into the drainage ditch running alongside the outer wall of the theatre nearby.

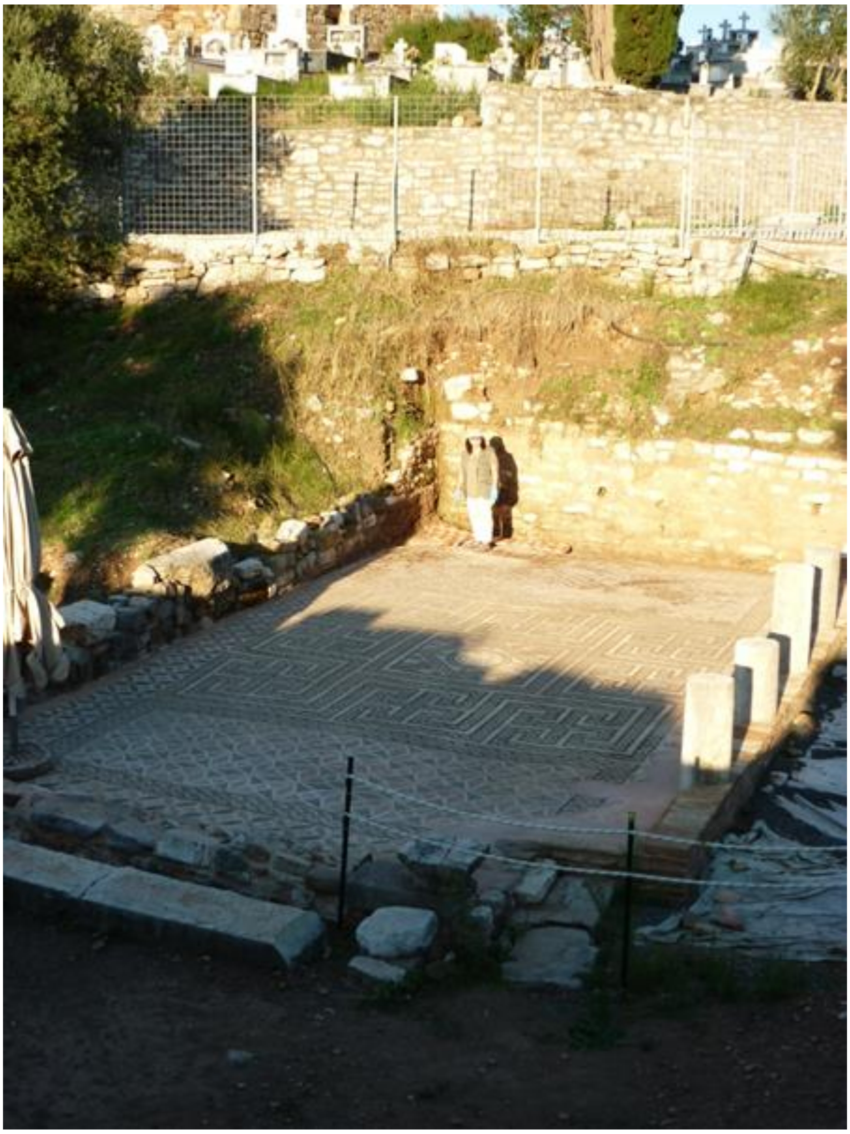


**Figure 3-64: Floor of a bishop's house in ancient Messene with Angela Jones (MA student, UNISA) standing in the corner (picture A.M. Smith September 2016).**

The circular patch that was found, was put back into the gap where it had been missing and the entire panel was put back in place after the water spring underneath it had been stopped up with stones in a better way than it had been before. This was done to prevent future subsiding. When the panel was back in place, the cloth was removed from the mosaic by dissolving the glue with acetone. It was impressive to see the pictures in the report of what had all been done.

Another interesting discovery mentioned in the report was that the layer of cement underneath the mosaic was about 6 cm thick, whereas the cement layer was much thinner underneath all the other mosaics which so far have been excavated in the entire site of ancient Messene. Elsewhere on the site there were mosaics with different patterns as well as images, and the creativity with which these had been made was very impressive.

Unfortunately, I do not have the title or the further details of Stavroula Poulimenea's report, which was unpublished, as it had been compiled for Professor Themelis, the Director of the ancient Messene excavations.

The information about the process to repair the mosaic can be found in Appendix 1.

## 3.7 MATERIALS USED IN ANTIQUITY

### 3.7.1 Rosso antico

Some of the materials used in antiquity have already been mentioned in the above, such as the white Turah limestone used as cladding of the pyramids in Egypt, the red granite of Aswan, used for Hatshepsut's obelisks, the white marbles of Paros, Naxos and Thaxos, and the diorite of the hammering stones used in Egypt. In this section attention will be given to one of the more unusual materials, namely *rosso antico.*

The name of this material occurs as *lapis porphyrites* on a list issued by Emperor Diocletian in 301 AD and is equivalent to *rosso antico* (Malacrino 2010:30). At a cost of 250 denarii per cubic foot[16], it was the most expensive material used at that time, together with *verde antico* (Malacrino 2010:30). The reason for including some information about this material in this study is that there was a piece of dark red material in the museum in ancient Messene, and further research revealed some interesting facts, which are worth recording here. During our final evening in Messene (30 September 2016), we saw a piece of a very dark red marble in the museum. When we enquired what it was, Professor Themelis[17] told us that it was *rosso antico*, and that it came from a quarry on the Peloponnesus, which had been declared a historical site and does not produce any of this material any more. He did not specify where the quarry is located. The piece of material had small square notches on the sides, which

[16] A cubic foot is a piece of material of about 30 x 30 x 30 cm. To convert both the cost of the material and the size of the piece of stone to metric sizes gets complicated, as the calculations lose accuracy. It is also necessary to take into account that when the list of materials was compiled under Diocletian, measurements were based on parts of the body, such as fingers and feet. One *pes* (foot) was 16 x 18.5 mm, which is 296 mm, which in turn is 29.6 cm. The 18.5 mm used as the basis for the calculation was the size of a *digitus* or finger, which was the smallest measurement (Hynson 2003:48-49).

[17] Professor Themelis is the Director of the excavations at ancient Messene and President of the Messenian Archaeological Society at Athens.

were the result of it having been linked by means of wall-anchors as well as two large square holes on the top. According to Professor Themelis, the two large square holes were the result of the fact that the material had been used as a plinth for a statue, which was the secondary use of the piece of stone, and that the anchor holes were remainders of the original use as part of a wall, which indicated that the material had been pilfered from a building (see Figure 3-65).

**Figure 3-65: The piece of rosso antico in the museum at ancient Messene (Photo A.M. Smith, September 2016).**

The material *rosso antico* on the list compiled by Diocletian however, came from the eastern desert in Egypt and was mined at Mons Porphyrites, near modern Gebel Dokhan. It is a red-purple material with white-pink specks called phenocrysts (Malacrino 2010:28). The material at the museum quite clearly did not come from Egypt, because it lacked the white specks, but turned out to be a Greek type of *rosso antico,* as Professor Themelis had indicated.

Further research revealed that there were quarries of this type of material at a few different places such as Akra Tainara (Cape Matapan), Skutari, Profitis Elias (see Figure 3-66) and Paganese on the Mani peninsula of the Peloponnese and that it is a calcite marble with slender black veins.

**Figure 3-66: Quarry of rosso antico at Profitis Elias on the Mani peninsula in Greece (De Nuccio & Ungaro 2002:178).**

The above information was obtained from the Oxford University Museum of Natural History (http://oum.ox.ac.uk/corsi/stones/view/61). This institution has a collection of about 1000 samples of stone used in antiquity, collected in the nineteenth century by an advocate named Corsi in Rome. This collection is also referred to by De Nuccio & Ungaro (2002:571). The image of the sample in their collection had the same colour as the material seen in the museum at ancient Messene. Another interesting fact is that *rosso antico* was a favourite material for statues with Dionysian subjects, because of the wine-coloured tones of the material (Malacrino 2010:26).

### 3.7.2 Verde antico

The material called *verde antico* in antiquity also could originate from two different sources. It appears twice on the list issued by Diocletian, both as *marmor lacedaemonium* and *marmor thessalicum* (Malacrino 2010:30). The *lacedaemonium* variety came from the ancient village of Krokeai, near Sparta on the Peloponnesus and was the more expensive at 250 denarii per cubic foot. It had a dark green colour with lighter phenocrysts (Malacrino 2010:26, 30). The *thessalicum* variety was quarried at Mount Mopsius in Thessaly, was green with darker or even black marks in it and only cost 150 denarii per cubic foot (Malacrino 2010:26, 30). In this context it is of interest to mention the following: green stone materials have the tendency to lose their colour when used outside. Due to the exposure to the elements, the dark green colour disappears and becomes much lighter. The green colour just seems to leach out over time. This is not just the case with green marbles, but also with green granites and is something I learned when working in the stone industry in the Netherlands in the 1980's from my colleague Richard van Dijk, now deceased. Shadmon (1996:11) also states that some varieties of stone tend to fade with prolonged exposure, but does not specify which materials. So, when determining what kind of material was used for a certain item in antiquity, one needs to be very careful, as what now looks pale grey-green, could have been a vivid coloured green object when it was first made. The grey-green mosaic pieces used in the mosaic in Messene may also have been a brighter green, when the floor was first constructed. The examples mentioned here show that one needs to be very careful when assuming to know where a material originates from, or what it is, as matters may be totally different and also names used for materials in antiquity may overlap.

### 3.7.3 Marble with pink patina

During our stay in Mavromati for the excavations at ancient Messene, we also visited the museum one evening (27 September 2016), and Professor Themelis gave us a private tour of the collection there. There was a whole number of beautifully carved marble statues on display and quite a few of them had a pink hue. The marble underneath the patina was white, but having been buried under layers of the reddish local soil, the surface of the statues had absorbed that colour. When the statues were excavated and cleaned, the patina remained. To clean that off would have damaged the statues, Professor Themelis told me when I asked him about it. Pure white marble is a saccharoidal calcareous material (Mannoni 1985:78) and it can act like a sugar-cube in absorbing the colour of something it comes into contact with. In the case of the statues and their pink patina, it is iron oxide (Mannoni 1985:58).

The house in the Netherlands where I grew up, had white Carrara marble slabs mounted against the wall behind the handbasins and I remember that there was a rusty mark in one of them, where one of the capped screws holding it in place, had somehow leached rust onto the marble, and this had made a permanent stain in it.

## 3.8 CONCLUSION

As we have seen in this chapter, quarrying stone was done by means of different techniques, depending on the hardness and consistency of the various materials.

It was hard and difficult work to extract blocks and shape them according to the required size for the construction of buildings and monuments with the tools which were available at the time.

Transport did not just take place over land, but was done over water as well in many different locations from early times onwards. Both transport and hoisting methods evolved to more sophisticated techniques over time in Egypt, Greece and the Roman Empire.

During the first century AD in Jerusalem, stone was not just used for large scale building purposes but also for items of everyday use, both large and small.

Even very small pieces of stone were used to create mosaics in many different patterns and in many different places throughout the Mediterranean in antiquity.

A variety of materials were used in antiquity, but care needs to be exercised to determine which material comes from where, as at times names can overlap.

Materials, especially marble can be subject to discoloration due to various influences, such as being exposed to the elements, or being in contact to other substances, such as soil or rust.

# CHAPTER FOUR

## SANDING AND POLISHING STONE MATERIALS AS WELL AS APPLYING INSCRIPTIONS

## 4.1 INTRODUCTION

In the preceding chapters we have looked at methods of quarrying stone, what purposes stone was used for, and how blocks were hewn, transported and hoisted into position. In this chapter further aspects of stone working will be considered such as sanding and polishing, as well as the engraving of inscriptions, especially in very hard materials such as granite in antiquity in order to provide as complete a description as possible of the many aspects of stone working.

## 4.2 SANDING AND POLISHING

### 4.2.1 Introduction

Sanding and polishing are basically two parts of the same process, which is the smoothing of the surface of a piece of stone. Sanding is applied to material which has been cut or hewn, to smooth any ridges or uneven spots and to give it a smooth, but not shiny surface (Shadmon 1996:140). Polishing can only take place after sanding has been done so as to achieve a shiny surface on the material being worked (Shadmon 1996:137). These two processes will be looked at more in detail under separate headings below.

### 4.2.2 Sanding

In order to explain the sanding process for stone, it may be useful to first give an example from woodworking. When one wants to smooth wood, it is necessary to go to the hardware store to buy sandpaper. This is available in different degrees of coarseness. For a rough piece of wood, sandpaper with a coarse grain is used to start with and when the worst of the rough surface has been smoothed, sandpaper of a finer grain and again a finer grain is used in order to obtain a smooth finish. Eventually the wooden object is smooth enough and ready to be varnished or painted.

When blocks of stone were used to build large buildings, they were usually shaped to the correct size by means of chisels and hammers with the use of measuring rods and plumb-lines (see Figure 2-13 and Figure 2-18). When a piece of material needed to have a smoother surface than what could be achieved by chiselling or cutting alone, it needed to be sanded. This was the case for instance for statues, which needed to be finished off smoothly. In order to do this, the process of sanding was used. As the root of the word sanding indicates, sanding was done with sand, which has abrasive qualities. Besides that, a grinding stone was used to move the sand over the surface of the piece of stone to be sanded, as well as water (Shadmon 1996:137). For softer types of marble, quartz sand was used of different grain size. For harder types of marble, emery containing corundum was used (Mannoni 1985:141). This emery sand came from the island of Naxos and also from Armenia (Mannoni 1985:141).

To begin with, a coarse and hard sanding stone was used to work the material. This sanding stone needed to be harder than the stone being worked in order to have any effect. The first stage of the sanding process is called roughing (Shadmon 1996:137). This is followed by gritting, which is a smooth finish, and then eventually honing, which is a velvety smooth finish without a gloss (Shadmon 1996:137). Every step of the process involves the use of a lesser abrasive. When sanding granite, harder grinding stones need to be used for the sanding process than for sanding marble or limestone, because of the difference in hardness of granite in comparison with marble or limestone.

In antiquity quartzite was used for sanding and polishing (Lehner 1997:202). Another material used for this purpose was basalt. With a hardness of 6 to 8 on Mohs' scale (see Table 2-2), it could be used to sand down granite (Berghuis No date:149). For the sanding of marble and limestone, pumice could be used, which is, like basalt, of volcanic origin, but softer. This was still in use when I was young, as I remember bags full of round pumice balls in the storeroom of the company and half sanded-down balls of pumice lying around in the workshop on shelves. Another material of which there used to be a quantity in the store room, was the oblong calcified internal shell of the cuttle fish, which was used for polishing marble. One sometimes still finds those on the beach. Polishing machines (used for sanding and polishing) were only developed slightly more than one hundred years ago, so all sanding from antiquity up till that time was done by hand and elbow grease (Shadmon 1996:138).

### 4.2.3 Polishing

Once a piece of marble has been sanded sufficiently and has reached honing stage, it can be polished, which means that it obtains a high gloss (Shadmon 1996:137). A high gloss polish brings out the full character of the material being polished and good quality polishing improves the durability of the polished surface and decreases the need for maintenance (Shadmon 1996:140). The polishing process is thought to slightly melt the surface layer of the material being polished, through the heat caused by friction of the polishing process, as well as through the use of polishing agents. This brings about an amorphous surface layer, called a Beilby layer (Shadmon 1996:140). In the present day and age oxalic acid, tin oxide and finely ground metallic lead mixed with putty powder are used as polishing agents (Shadmon 1996:140). It is known that in Roman times ground metallic lead was already used as a polishing agent, which my late father J.H. Buddingh mentioned to me. Where he got this knowledge, I do not know. It may have been passed down the generations, as there have been stonemasons in my family for at least 3 generations before me, and possibly more.

In antiquity marble could be polished to a fairly high gloss, but granite could not, as the latter cannot be achieved by hand polishing alone. This I can state from experience, as in a few cases where I have dealt with scratches on high gloss polished granite gravestones, those scratches could not be repaired by hand.

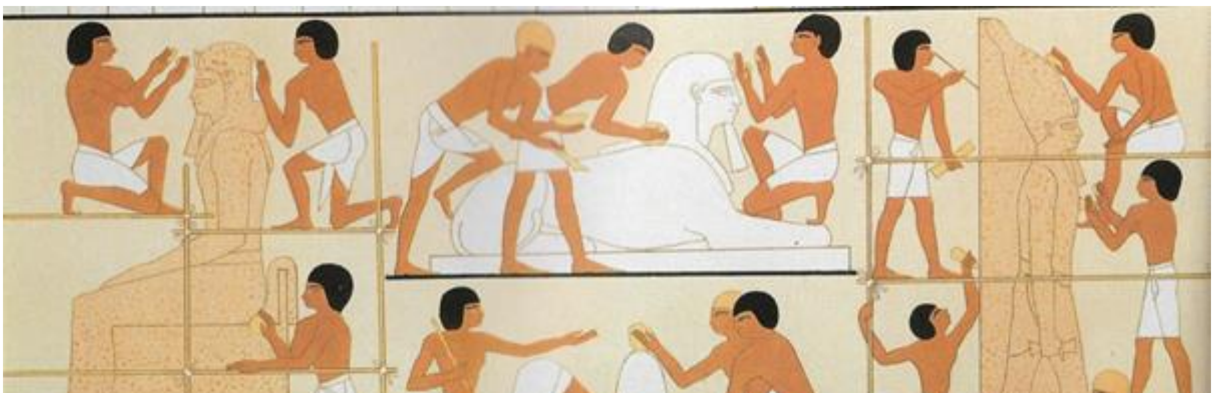


**Figure 4-1: Polishing statues in ancient Egypt (Stierlin 1995:32).**

What was used as polishing agents before the Roman era is not certain. An image from Egypt shows workers polishing a statue with a roundish stone or rounded wad of cloth in their hands, which has a yellow stain on it. I have been wondering if this could have been bees wax (see Figure 4-1). Another possibility could be animal fat (Sullivan 2001:49). This would have provided a honed surface with a shine, but would not have lasted over time, as the wax or fat would have leached out of the stone again under the influence of heat and/or moisture.

Even so, granite statues and monuments in Egypt were finished off quite smoothly, at least to honed stage, which was quite an achievement. Some of the statues which have intrigued me for many years, are the statues of Hatshepsut made of pink-red granite (see Figure 4-3; Stierlin 1995:86). How did the artists or artisans who created this statue manage to polish it to the degree of smoothness it has, with just sand, water and polishing stones? The question is: did they maybe use something else? Besides the granite statues of Hatshepsut (there are a few extant), she also had the two obelisks made, one of which still stands tall and straight at Karnak in Luxor (Stierlin 1995:88, see Figure 4-2). The obelisk's surface is also remarkably well finished.

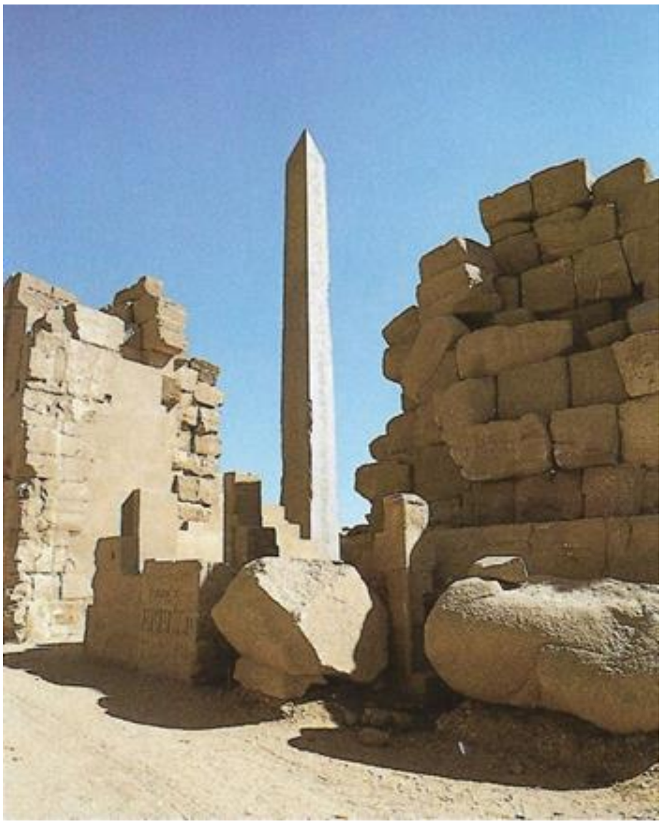


**Figure 4-2: Queen Hatshepsut's remaining obelisk in Luxor (Stierlin 1995:88).**

**Figure 4-3: Image of Queen Hatshepsut in pink-red granite (Stierlin 1995:86).**

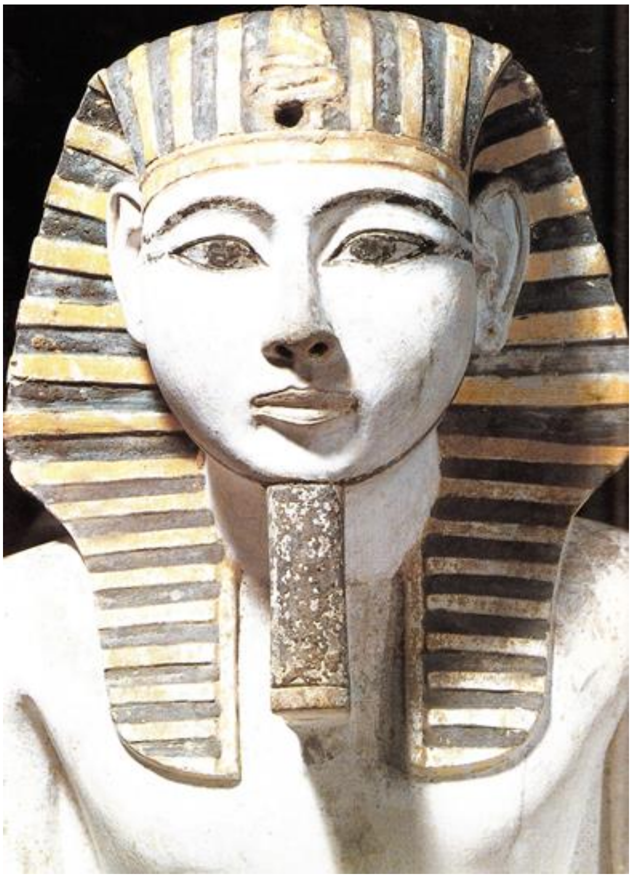


**Figure 4-4: Image in limestone of Queen Hatshepsut's father Amenophis I (Stierlin 1995:81).**

In comparison to these granite statues and monuments, the statue of Hatshepsut's father Amenophis I is totally different and mediocre (see Figure 4-4). It is a limestone image with an artificially coloured headdress, called a *nemes* (Stierlin 1995:80-81), and it is hard to believe that from one generation to the next such a total change came about in the use of materials and the sophistication of the finishes. From a fairly simple limestone sculpture to sophisticated granite statues and obelisks in such a short time is quite a jump!

Besides the fact that the surface of Hatshepsut's obelisk is finished off very smoothly, it also contains perfectly engraved hieroglyphs (see Figure 4-5).

How this could have been achieved is the main question, as the copper tools that were used would have been no match for the hardness of the granite due to the fact that copper is much softer than granite. Therefore, in the remainder of this chapter an attempt will be made to suggest possible solutions to this problem.

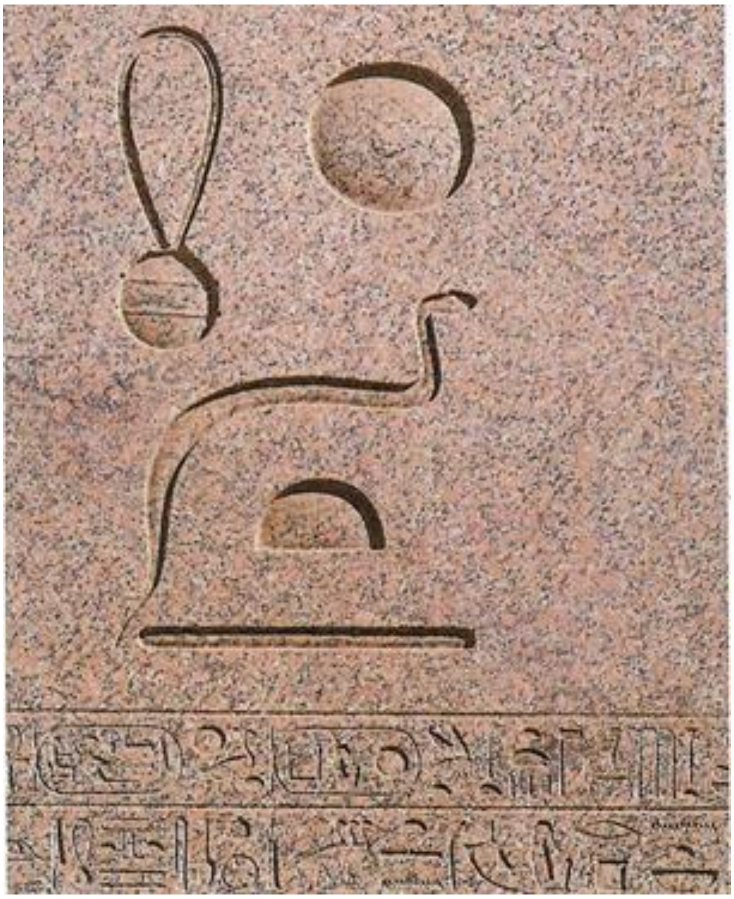


**Figure 4-5: Perfectly executed hieroglyphs in Queen Hatshepsut's obelisk (Stierlin 1995:88).**

### 4.2.4 Polishing with diamond dust

When studying the images of especially the statues of Hatshepsut, as well as her obelisk, I keep wondering how the artists/artisans were able to finish these off so smoothly and whether they may have used diamond powder instead of sand in the sanding process. I have been asking myself if the artists and artisans, who received orders from Queen Hatshepsut to make statues of her and obelisks of the very hard pink-red granite from Aswan, may possibly have replied as follows: “Majesty, in order to make statues of you and large obelisks in the pink-red Aswan granite, we need tools, which right now are not available here in Egypt. We need those very hard special stones from Punt and as there has not been a trade expedition in that direction for a long time, we do not have any in stock. Therefore, we first need to get new supplies before we can execute your orders”. Hatshepsut herself was most definitely aware of the fact that granite was a very hard material to work, as part of the inscription on her remaining obelisk states the following: ‘They are each of one block of hard granite, without seam, without joining together’ (Chipasula & Chipasula [eds] 1995:11). Also the amount of time it took to produce the obelisks was mentioned in the inscriptions, namely: ‘My majesty began work on them in the year 15, second month of winter, day 1, ending in year 16, fourth month of summer, last day, totalling seven months of quarry work’ (Chipasula & Chipasula [eds] 1995:11). What is interesting to notice as well here, is that the work was started in winter, when the weather was cooler.

This in turn brings us to the question of whether the Egyptians would have had access to diamonds and how and where. They had the entire continent of Africa as their hinterland. They exploited its natural resources such as gold, wood and ivory, and in the process of exploration may have discovered other materials as well. It may not be possible to prove this conclusively, but it is possible to line up the facts that are known, to come to a degree of plausibility.

### 4.2.5 A possible purpose of Hatshepsut’s voyages to Punt

The Egyptians already sailed down the east coast of Africa to Punt during the Old Kingdom, at the time of the Fifth Dynasty, under the rule of Pharaoh Sahure in about 2500 BC, and a list from that time mentions that myrrh, electrum and wood were obtained there (Wachsmann 1998:19). The ships were equipped with bi-pod masts and hogging trusses (Landström 1969:10-11). As there are no images of seagoing ships available from the period of the Middle Kingdom (circa 1975 BC–1630 BC; Brown 2009:96), nor from the preceding or following intermediate periods, it is assumed that there were no voyages to Punt during those eras (Wachsmann 1998:18). In the time of the New Kingdom, during the rule of Hatshepsut (circa 1479 BC-1458 BC; Brown 2009:97), the voyages to Punt resumed, which are depicted on the walls of her mortuary temple at Deir el Bahri, and which are emphasized as a very special achievement (Wachsmann 1998:18). She had ships built especially for the purpose of travelling to Punt. That her ships were seaworthy has been proven conclusively and recently by the marine archaeologist Cheryl Ward, of the Coastal Carolina University. She managed to get a replica of Hatshepsut's ships built (Schnohr 2011:36) and her 24 strong crew sailed 'Min of the Desert' for 240 kilometers on the Red Sea and found it to be remarkably fast, seaworthy and easy to manoeuvre (Schnohr 2011:41).

Judging by the distance from Egypt to Somalia, and the description in the article by Schnohr (2011) about the way in which 'Min of the Desert' sailed, a voyage to Puntland in Somalia would not have lasted years. This is because the total length of the Red Sea is about 1,900 kilometers, and Puntland is located in the horn of Africa just beyond the end of the Red Sea (https://www.worldatlas.com/aatlas/infopage/redsea.htm). Present day Puntland is located in the north-east corner of Somalia according to a Puntland Profile published by the BBC, which states that: 'The territory takes its name from the Land of Punt, a centre of trade for the ancient Egyptians' (https://www.bbc.com/news/world-africa-14114727). Since 1998, Puntland is a self-declared state, but because it never became independent from Somalia, it does not have its own foreign representation. It is therefore internationally considered an autonomous region of Somalia and as a result very little is known about it. Some of its economic activities include the production of frankincense and myrrh (https://www.worldatlas.com/articles/what-is-the-puntland-state-of-somalia.html). I am convinced that the Egyptians routinely travelled to Puntland, which was not so very far or difficult, but how far south did Hatshepsut's ships really travel and how long did they need to get there? With the ship Min of the Desert described as being so fast, it would only have taken a number of weeks to sail down the Red Sea to what is presently known as Puntland in Somalia. But the voyages to Punt in Hatshepsut's time are said to have lasted 3 years!

By way of comparison of how long it takes a ship only propelled with sails to travel long distance, it is worthwhile to look at the following example: an old sailor was interviewed in 2001. He lived on the Swahili Coast on Lamu, and this island is part of an archipelago off the far northern coast of Kenya. He regaled how he had gone to sea at the age of 15 and had sailed on dhows to India. The trip from Lamu on the Swahili Coast to India (with only sails for propulsion) would take approximately one month (Caputo 2001:106). On the map accompanying the article, Lamu is located about halfway between Mogadishu and Dar es Salaam, and just below the Equator (Caputo 2001:109). So, a dhow would need only one month to sail all the way from about the middle of the east coast of Africa to India. This was achieved by making use of the Monsoon winds. These blow for six months of the year in a southerly direction and for the other six months in a northerly direction (Ormeling 1971:150).

The Egyptian ships sailing to Punt also made use of these Monsoon winds. This means that propelled by the Monsoon winds blowing in a southerly direction for six months they could only sail southwards far down the coast of Africa. Wherever they landed, they would have to wait till the winds would change direction again, in order to sail back to Egypt. With the voyages reported to last three years, the travellers would have had ample time to explore from the coast where they landed, to areas further inland, before heading back home again. Therefore, the fabled destination of Punt in Hatshepsut's time may have been located much further south down the east coast of Africa than present day Puntland in Somalia. In fact, the area to which Hatshepsut's ships went, was also referred to by a different name, namely 'God's-Land' (Wachsmann 1998:22).

This same fact was mentioned by Emeritus Professor Alexander Duffey in a talk given on 14 April 2016 at a meeting of the Ancient Egyptian and Near Eastern Society (AENES) at the University of Pretoria. He called it *Ta-Netjer*, meaning 'God's Land'. He is also of the opinion that Punt as the destination of Hatshepsut's ships was much further down the coast of east Africa and very likely was southern Africa. His talk focussed mostly on the trade in ivory and from where the Egyptians obtained ivory tusks. Besides ivory also many other articles were obtained from Africa, such as copper ingots, baboons, cheetah, lion cubs, animal skins, myrrh trees (which not just grow in Puntland, but also in a southern latitude in Africa) and so on (Talk by Prof. Duffey 14 April 2016, also Brown 2009:100-101). In a more recent talk at a meeting of

AENES on 14 September 2017, Professor Duffey gave an extensive account of all the different kinds of wood, which were used by the Egyptians to manufacture many different items. One of these kinds of wood was *Dalbergia Melanoxylon*, which is a black or almost black hardwood from Mozambique. A piece of this material was found during the underwater excavations of the Uluburun ship near the present-day coast of Turkey, dating to the 14$^{th}$ century BC (Bass 1987:729). Wooden articles made from this type of wood have been found in Egypt according to Professor Duffey, more in particular an elegant bed, a chair and a stool, which indicates that the Egyptians must have travelled that far south along the east coast of Africa to obtain that type of wood. Therefore, based on this information we can assume that the expeditions to Punt in Hatshepsut's time may have travelled much further south than has often been thought.

### 4.2.6 Obtaining diamonds from Africa

The next question to be answered is whether there would be any indication that exploration for diamonds or diamond digging by the Egyptians could have taken place in east or southern Africa. For this there are indications in the book '*Africa through the mists of time'* by Brenda Sullivan (2001). This book came to me in a very interesting way. Olive Billett, a resident of a retirement village in Irene, with whom I was befriended, told me once about her youth, growing up in Christiana where her father was a diamond digger. When she was playing outside as a child, she often would find stones with strange engravings and she never figured out where they came from or what they meant, until many years later her grown-up daughter gave her the book by Brenda Sullivan. Mrs. Sullivan described the same sort of stones, also found in the diamond fields and Olive Billett realised that they were the same kind as what she had found as a child. So, the account of what will follow below, is not a figment of Brenda Sullivan's imagination, but was confirmed by Olive Billett as being correct.

### 4.2.7 Brenda Sullivan's story and discoveries

#### *4.2.7.1 Brenda's discoveries*

Brenda Sullivan lived for fourteen years, from 1970 to 1984, as the wife of the diamond digger Harry Sullivan in Bloemhof, and then in Boskuil in what then was the far western Transvaal. In these areas digging of alluvial diamonds took place (Sullivan 2001:19). Alluvial diamonds originate from volcanic Kimberlite pipes, which carry diamond-bearing lava from deep inside the earth to the surface, where alluvial diamond fields are formed by the action of water spreading the diamonds over a large area (Sullivan 2001:26).

The perception these days is, that diamonds are scarce and that they are very valuable, but both these ideas are a fallacy. Diamonds have been very plentiful and their value has only become high in modern times, since the time of the Rand Lords and especially since De Beers have artificially manipulated the prices by means of their production cartel. When prices are low, they hoard supplies and keep the prices high (Sullivan 2001:21). They are also the first to have promoted the wearing of polished diamonds as a sign of wealth and status with their slogan: ‘Diamonds are a girl’s best friend’. The high cost of diamonds is a matter of advertising and marketing strategies, not one of scarcity (Sullivan 2001:19).

*4.2.7.2 The artefacts and engraving sites*

While living at the above-mentioned diamond digging sites, Brenda Sullivan also first noticed the many artefacts with strange markings, like Olive Billett in her youth. Subsequently she noticed that there were many engravings on rocks in her environment as well, and that is where her research began. She discovered that the greatest concentration of rock engraving sites in southern Africa are found in the areas where there are diamond-bearing alluvial gravels, as well as near outcrops of minerals such as iron ore or red ochre, and soapstone (Sullivan 2001:15). The rocks on which she found engravings were hard, amygdaloidal diabase, allied rocks of what are known as the Pniel series and dolerite. She became absolutely convinced that the engravings were not just the doodles of bored Khoi herd-boys or San hunters, as they have been written off to be by some South African academics (Sullivan 2001:47). Due to the hardness of the rock formations on which they were found, these engravings would have to have been applied with the use of diamond-tipped tools (Sullivan 2001:47). Moreover, she also found a few ankh symbols engraved on rock faces (Sullivan 2001:58). Ankh symbols are typical for Egypt, as the symbol of life (Wilkinson 2005:27).

Through her research she discovered that the engraving of rocks with symbols is the preserve of spiritual leaders or shamans (Sullivan 2001:11) and that the symbolism represented concerns matters of fertility, rainmaking, seasons and cycles of life and death (Sullivan 2001:5-11). The pre-eminence of the shaman and the symbols discovered also correspond with the research done on these matters elsewhere in the world referring to the worship of Mother Earth (Sullivan 2001:11).

In order to see if a diamond mounted in some sort of stylus could be used to engrave, Brenda Sullivan made a primitive engraving tool by affixing a well-shaped diamond into the split end of a water softened reed, where it was held into place with the gum of an acacia tree (*acacia luederitzii*) and tied securely with a thin strip of whetted rawhide. Once this had dried, she managed to use it to make incisions into the surface of dolerite rock (Sullivan 2001:46). At a later stage she contacted a traditional healer and asked him if this could have been a method of using an implement for engraving (Sullivan 2001:48). He responded in a letter that the use of diamonds was indeed the method of engraving rocks by the ancients, but that there were different methods and implements used (Sullivan 2001:48-49). He mentioned three, namely of a diamond mounted in the hollow end of a copper rod and held in place with a kind of gum, secondly the horn of a small buck of which the hollow end would be filled with a resin in which the diamond would be mounted and thirdly the use of a hollow stick of hard wood in which a diamond would be inserted and held in place with an adhesive or bound with a thin strip of cow-hide (Sullivan 2001:48-49). Hence engraving of hard stone material with the use of diamonds was most certainly known in southern Africa in pre-historic times. It is even possible to use diamonds to engrave other diamonds, as they are not all of equal hardness. In order to do so a harder diamond is used to engrave a softer diamond (Sullivan 2001:56-57).

A further point of interest is that even though diamonds are the hardest material on earth, they are also extremely brittle and as a result they can chip or pulverize easily. In the late 19$^{th}$ and early 20$^{th}$ century many an inexperienced digger in South Africa would discover this to their dismay when they would test a large stone to check if it was a diamond by hitting it with any tool on hand, only to have it shatter into smithereens (Sullivan 2001:55-56). The fact that diamonds are easily shattered means, that the resulting diamond dust could be produced without any trouble in case anyone would have wanted to use it to sand a hard type of stone.

When one looks at the granite and gabbro statues made in ancient Egypt, one wonders how these were finished so smoothly. The use of diamond dust mixed with water or wax and a grinding stone of sufficient hardness to move it over the surface of the object to be sanded, would have made this process so much quicker and easier in order to achieve the desired result. What is also known is that ancient Africans used diamond dust mixed with eland fat to drill fine holes in very hard stones (Sullivan 2001:49).

#### *4.2.7.3 The discoveries in the diamond digging sites*

While Brenda Sullivan was researching the artefacts and engraving sites, her husband Harry was working the diamondiferous (diamond bearing) gravel claims, first in Boskuil and later at the Donkey-rush on the Vaal River near Bloemhof, and he made some interesting discoveries there (Sullivan 2001:34). His digging method would be to trench down with the long arm of the excavator into the gravel layer, in order to expose a vertical cross section from the surface to the alluvial deposits, which were located about 6 to 13 meters from the surface (Sullivan 2001:34). At both sites mentioned, he came across three-meter wide unnatural perpendicular shafts or pits. These shafts had been dug through the levels to the depth of the bottom of the otherwise unbroken 'run' of the diamond bearing deposit, and no deeper than that. At the base of each of these shafts a number of beautifully worked stone artefacts were found, which all were in pristine condition (Sullivan 2001:34). These artefacts consisted of hand-axes (2001:45), almost perfectly round stone balls, as well as bird-shaped tools (2001:32-33), and once a round stone face (2001:42). Many were with engravings, which Brenda deciphered to be symbols referring to deity. Unfortunately, they were unable to date these artefacts. Brenda was of the opinion that the artefacts had been left there as thank offerings to the Earth Mother (Sullivan 2001:34-35). This was based on the fact that it is known that in ancient times penetrating the skin of the earth was an act for which atonement had to be made by means of votive offerings or even sacrifice[18]. Moreover, the excavations were usually filled in again, which was also the case in the discoveries of Brenda and Harry Sullivan. The shafts had been roughly filled in and had at a later stage been flooded with layers of sterile mud, which had filled in and covered the entire shaft and surrounding areas (Sullivan 2001:35). The interesting thing was that at either side of the shaft at the Donkey-rush there were neatly stacked heaps of materials, which are normally found together with diamonds in diamondiferous gravels, but no diamonds! At either side of the shaft however, the 'run'

[18] Even to this day miners going down into the mines in South Africa make special sacrifices so as to not incur the anger of the Earth Mother (Sullivan 2001:12).

was rich in diamonds (Sullivan 2001:35). So, in the belief that they had found evidence of ancient diamond mining, Harry Sullivan kept the shaft open for four months while Brenda tried to convince archaeologists of the University of the Witwatersrand to come and investigate this. They never came and after four months Harry worked through the entire 'run' and destroyed the evidence in the process, as he could not delay production any longer (Sullivan 2001:36).

As for the materials found together with diamonds mentioned above, Brenda Sullivan mentions jasper, agates, 'bandoms'[19], rock crystal, garnets, corundum, 'silkies', topaz, red and yellow oxide, 'groen ertjies'[20] et cetera (Sullivan 2001:46). These other types of stones are what prospectors look for in their search for alluvial diamonds, and not just Harry Sullivan, but also other prospectors regularly would find all the other materials, but no diamonds. In combination with the finds of stone artefacts, this was an indication that the diamonds had been mined long ago by earlier peoples (Sullivan 2001:44).

Another interesting fact is that diamonds are often found with gold in alluvial deposits and that those prospecting for gold would undoubtedly have found diamonds where diamonds had been deposited with gold, as a result of the action of flooding, winds and rain (Sullivan 2001:55).

What was surprising however, was the sheer quantity of the stone tools and artefacts that turned up while Harry Sullivan was digging in the alluvial gravels. And not just Harry Sullivan, but also other gold diggers found many artefacts. A whole number of these were on display in the small museum at the Mining Commissioner's office in Barkly West (Sullivan 2001:36). In Boskuil the local Mining Inspector Frank Nienaber had his own private museum with an unusual collection of objects found by diamond diggers (Sullivan 2001:41). This was far more than could be expected if only shamans had been collecting diamonds for engraving purposes (Sullivan 2001:57).

[19] The word 'bandom' in Afrikaans indicates something with a stripe on it (Kritzinger et al 1963:59).
[20] The words 'groen ertjies' in Afrikaans probably indicate semi-precious stones that looked like green peas (Kritzinger et al 1963:159). In February 2020 I was given a carved pendant made of 'pea-jasper', which has green pebbles in a beige matrix, so this material does indeed exist.

#### *4.2.7.4 Earlier discoveries of pre-historic diamond mining*

Besides the discoveries by the diamond prospectors of buried artefacts and of diamonds being absent where there should have been, also scientists had already written about similar experiences previously. Brenda Sullivan quotes Doctor Percy A. Wagner, who in his book, '*The diamond fields of Southern Africa'* (1914:90) wrote about finding ancient workings while he was prospecting the Monastery mine (Sullivan 2001:26). Unfortunately, it has not been possible to get hold of a copy of this book, but the Unisa Library does have another book by this same Percy A. Wagner on a geological topic, which provides proof that this man indeed has existed. As a second source regarding ancient diamond workings in South Africa, Brenda Sullivan mentions a book by Doctor C. Van Riet Lowe in cooperation with P.G. Söhnge and D.J.L. Visser, who published '*The geology and archaeology of the Vaal River basin (Memoir No. 35)'* in 1937. These authors also had encountered clear evidence of ancient mining activities in the diamondiferous alluvial gravels of the Vaal River basin, where they also found a number of stone artefacts and implements (Söhnge, Visser & Van Riet Lowe 1937:13; 15; 16; 22). In a later book by Van Riet Lowe, written in collaboration with H. Breuil and F.R.S. Du Toit, '*Early man in the Vaal River basin'*, Van Riet Lowe mentions again that at various sites in the Vaal River area he had encountered tools, which had been left in the gravels as a result of the search for raw materials, and refers to his own earlier writings of 1937 (Breuil, Van Riet Lowe & Du Toit 1948:25). He considers these tools as not having rolled to the site by the elements. He also states that comparatively late tools have been found near Windsorton at depths of about six feet, which occur throughout the deposit and that he finds this a puzzling occurrence (Breuil, et al 1948:25).

It is interesting to note that Van Riet Lowe's earlier book is called: *The geology and archaeology of the Vaal River basin* (Söhnge, et al 1937). At the time of its publication, geology and archaeology had not yet gone their separate ways as academic disciplines, so he still reported on both at the same time in this book, (which he got his two assistant geologists to write). When searching in the book for any clues about possible dating of the stone implements, which had been found by him and his team, the term 'Stellenbosch artefacts' emerged (1937:27) and 'stone implements of Stellenbosch age' (1937:33). There was however no indication of any date for this Stellenbosch age. An internet search provided a journal article by David Seddon, who suggested an approximate date of 150,000 to 90,000 BC for these artefacts (Seddon 1967:57). Comparing the images of some of the artefacts shown in the book by Söhnge, et al (1937), ranging in type from Stellenbosch I to Stellenbosch IV (1937:138-157), and which are roughly knapped, rather coarse types of tools, it became clear that these bear no resemblance whatsoever to the smoothly finished artefacts, which Brenda Sullivan had found. So, the latter clearly must be dating to another time in pre-history, even though we still have no date. These may be the comparatively late tools that Van Riet Lowe referred to as 'a puzzling occurrence' (in Breuil, et al 1948:25).

Brenda Sullivan concluded from all the above-mentioned factors combined, that extensive mining activities had taken place in southern Africa long before the discovery of diamonds in Kimberley. Further research on her part showed, that the Egyptians were already using diamond tipped copper or bronze saws and drills with diamond tips in the time of the Archaic and Old Kingdoms, that is circa 3200-2723 BC (Sullivan 2001:57). If indeed copper or bronze saws had diamond tips at that time, it would explain what Mark Lehner found at Giza, namely the basalt stone which had been cut with a saw (see section 2.6.6.2). The use of diamonds would have made the result of the cut basalt stone much more likely, than just the use of a copper or bronze saw with the sludge of sand and gypsum of which he observed the residue there (Lehner 1997:210).

So, the question needs to be asked whether there would perhaps have been a link between the renewed voyages to Punt in the time of Hatshepsut (Wachsmann 1998:18), and the hugely improved quality of the statues as well as the obelisks, which were made during Hatshepsut's reign. If that is the case, then that would explain how the craftsmen in her days were able to work the hard, red-pink granite found at Aswan and produce the obelisks with the perfect inscriptions and statues with the smooth finishes that we now still admire.

Even Brenda Sullivan herself came to the conclusion that the massive scale of the diamond digging, which had been going on in southern Africa in ancient times was such, that it was unlikely that any other nation than the Egyptians were responsible for this, also taking into consideration the massive quantity of statues and stone buildings, which they produced (Sullivan 2001:57).

#### *4.2.7.5 Ways in which the diamonds could have been used*

It has already been mentioned that diamond dust could have been used for the sanding and polishing (actually to honing stage) of granite objects, possibly in combination with animal fats, or possibly bees wax. That could explain the yellow colouring on rounded tools/stones/implements in the image of the workers finishing the statues (see Figure 4-1).

Engraving of hieroglyphs on the obelisks with a diamond tipped stylus would be another possibility. A further use of diamond tipped tools could have been for the beautifully outlined eyes on the statues of for instance Hatshepsut, as well as for the perfectly parallel lines of her headdress, the *nemes.* I have often wondered how that could have been done with the use of chisels, because then there would have been chisel marks and uneven lines. However, if the lines were engraved with a diamond tip, it would be much easier to get a perfectly straight line, by first measuring and drawing the lines on the granite with perfect spacing and then by engraving them, possibly with the use of a ruler to guide the diamond tip. This would produce a much better result in my opinion (see Figure 4-3).

The one problem for which I have not found a plausible solution yet, is how the statues were shaped from the granite which had been quarried by means of the use of the fire-setting method and pounding stones (see section 3.2.5.2), to the point that the sanding process of the statue would begin, but I want to indicate a possibility and that is that there may have been iron chisels earlier in Egypt than has been thought up till now. This will be explained further below.

#### *4.2.7.6 King Tutankhamun's iron dagger*

Besides the possibility that granite, gabbro and diorite were worked with diamond tips for engraving and diamond dust for polishing, there is still another material which may have been used for working granite in Egypt in antiquity and that is iron. The perfect chiselling of the statues of Hatshepsut may have been done with the use of iron chisels. One may object that iron was not available yet in the time she ruled Egypt from 1479 to 1458 BC (Brown 2009:94), as the Iron Age most commonly is thought to have come about circa 1200-1000 BC (Scheepers & Scheffler 2000:353), but it is possible that there was iron available at an earlier stage. This contention is based on the following: among the grave goods found in the tomb of Tutankhamun, who reigned from circa 1361-1352 BC there were two daggers, one gold and one of iron (Trustees of the British Museum 1972:36; see Figures 4-7 and 4-8).

This in itself is already remarkable to encounter a beautifully worked iron dagger at this early date. Recently this iron dagger has been the subject of study by a team of Italian researchers and the Egyptian Museum in Cairo. With the use of non-invasive, portable X-Ray fluorescence spectrometry, it has been discovered that the iron of which the dagger blade was made, was metal of meteoric origin (Boult 2016:6). Meteoric iron is characterised by a high percentage of nickel and also contains cobalt (Boult 2016:6). Subsequently all meteorites found within a 2000 km radius from the Red Sea were considered and 20 were found to be iron meteorites. Of these 20 only one had the nickel and cobalt levels of the same level as the blade found in Tutankhamun's grave. This was the meteorite found near the Egyptian resort town of Mersa Matruh (which is situated along the Mediterranean coast west of Alexandria) 16 years ago (Boult 2016:6). This find in turn puts into perspective the historic Egyptian descriptions of iron used in ancient Egypt, called 'iron of the sky', showing that the ancient Egyptians were aware that these rare chunks of iron fell from the sky already in the 13th century BC according to the Italian researcher Comelli, quoted in the article by Boult (Boult 2016:6).

A perfectly worked dagger in Tutankhamun's days though, would not have come about just by itself. It must have been the end result of earlier efforts to work iron from a meteoric iron source. Considering that the recent research found that 20 meteorites were iron ones, more than just the iron from the meteorite from Mersa Matruh may well have been used to make implements with. This means that iron may have been known even earlier than in Tutankhamun's time. Technology did not develop as quickly in those days is it does in our day and age. There was only about 100 years between the time of Hatshepsut and Tutankhamun. Copper and bronze had been worked into chisels since at least the time in which the pyramids were built (Mannoni 1985:142; Morell 2001:83), so the early stages of iron development may well have brought forth iron chisels, which would have been very suitable for the chiselling of Hatshepsut's statues. The use of iron chisels which also contained nickel would definitely have made it possible to produce the perfectly executed hieroglyphs on Hatshepsut's obelisks. For the application process the hieroglyphs would have been drawn first, then overlaid with a square grid for transfer to a larger scale, as shown in Figure 4-6 (Stierlin 1995:36). The image shown is a sketch drawn for the tomb of Amenophis III, which was sketched out with red chalk first and then with pen and ink, after which the grid served to transfer the image to the stone to be worked (Stierlin 1995:36).

**Figure 4-6: A sketch drawn for the tomb of Amenophis III with a grid to transfer the image (Stierlin 1995:36).**

There is still another question as to the manufacturing of the iron dagger, and that is whether this craftsmanship was Egyptian or whether it maybe originated elsewhere. In this regard it is worth considering the following: besides both the iron and the gold dagger (see Figures 4-7 and 4-8), which were found in Tutankhamun's grave (Trustees of the British Museum 1972:62, 130-131), also gold foil decorations were found (Williams 2014:18; see Figure 4-9). These had been attached to leather trappings on the two gilded chariots, which were also found in the grave. These gold foils have recently been sent for study and restoration (Williams 2014:18).

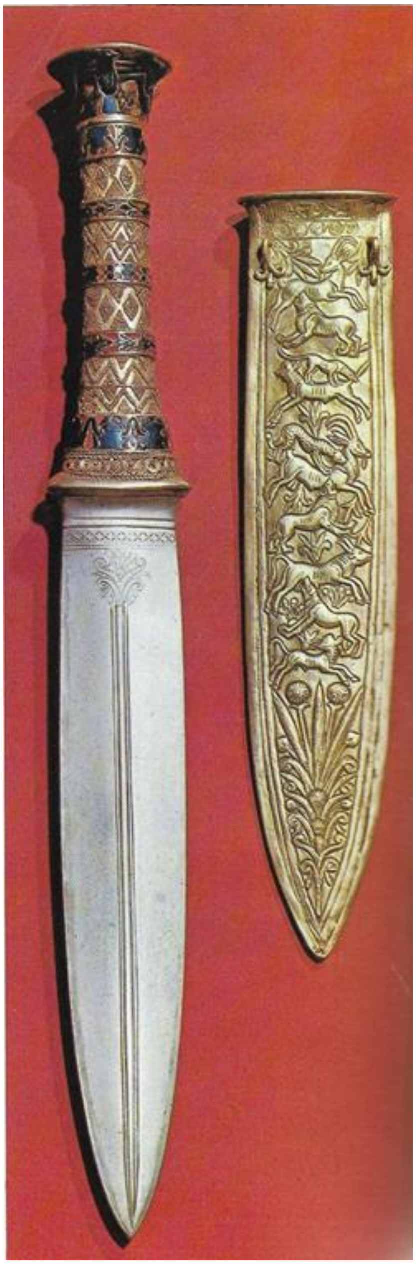


**Figure 4-7: The gold dagger and sheath found in Tutankhamun's grave (Trustees of the British Museum 1972:36).**

**Figure 4-8: Both daggers from Tutankhamun's grave, the iron one on the left (Casson 1966:172-173)**

What is interesting about the decorations on both the shaft of the gold dagger and on the gold foil is that the images on these were almost identical. They both display scenes of animals such as ibex, a bull and calves being hunted by dogs, a lion and a leopard respectively. The style of these images is also more lifelike than that of Egyptian art work, which is often more stilted in style. A mythical winged animal is attacking the ibex on the gold foil. The restorer of the gold foil, Christian Eckmann of the Römisch-Germanisches Zentralmuseum in Mainz, Germany, stated that the artwork is not Egyptian and may originate in the region of Syria (Williams 2014:18).

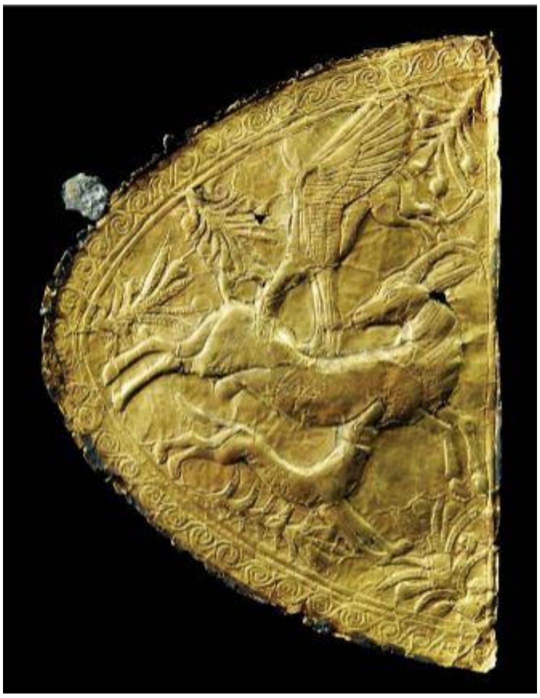


**Figure 4-9: Gold foil from the grave of Tutankhamun (Williams 2014:18).**

Another important fact is that metal working was already quite advanced in Asia Minor since the Early Bronze Age from about 3000 BC. Miners not only extracted copper and tin to make bronze, but also silver, gold, electrum, lead, and iron (Zangger 2001:236). The interesting fact about the iron dagger is that it was perfectly worked, and that its handle has decorations that are not Egyptian in origin. This in turn raises the possibility that it was made by a craftsman from Asia Minor, possibly Hittite, with whom the Egyptians had trade relations, from local Egyptian meteorite iron, and that the decorations were of the kind that the craftsman was used to make according to his own traditions. It was not unusual for craftsmen in antiquity to travel to where his trade was needed. Think for instance of Hiram (also sometimes called Huram, see the New International Version of the Bible), who came from Tyre to Jerusalem to make the metal articles for Solomon's Temple (I Ki 7:13-45). The latter will be analysed in Chapter Five.

So, for the application of the hieroglyphic inscriptions on the hard, red-pink granite of Hatshepsut's obelisk, there are two suggested possibilities. The one is the use of an engraving stylus with a diamond tip, and the other is the use of a chisel made of meteoric iron. These two materials would have been hard enough to apply inscriptions onto the granite.

For the statues, an iron chisel could have been used to shape them and diamond tipped tools for the fine details, as well as diamond dust to smooth them to the honing stage that we observe them to have. The obelisks may have also been sanded with diamond dust. According to the inscriptions on the remaining obelisk they were decorated with electrum (Chipasula & Chipasula [eds] 1995:10).

## 4.3 CONCLUSION

In this chapter the processes of sanding and polishing stone were explained, and further possibilities were explored of materials which may have been used in antiquity, and more specifically in Egypt for the working of granite, such as diamonds and meteorite iron. As granite is too hard to be worked with the use of copper chisels, the use of diamonds and/or meteorite iron may provide an explanation of how the beautifully and perfectly shaped hieroglyphs could have been engraved on the obelisks of Hatshepsut. The fact that both scientists as well as diamond diggers have found evidence that diamonds were extracted from the soil in southern Africa, long before the discovery of diamonds in modern times, may be an indication that these were extracted for a specific purpose. As Egypt was the major power in Africa in times past, I concur with Brenda Sullivan’s conclusion that the Egyptians were the most likely as having secured diamonds from Africa in order to work very hard stone.

# CHAPTER FIVE

## CONDITIONS FAVOURABLE FOR THE CONSTRUCTION OF LARGE MONUMENTAL BUILDINGS IN ANTIQUITY BASED ON THE DESCRIPTION OF THE CONSTRUCTION OF SOLOMON’S TEMPLE IN JERUSALEM IN I KINGS 5

### 5.1 INTRODUCTION

In their magnificent book ‘*Archaeology from above’*, the Italian archaeologists Albanese, Domenici, Ferrero and Maggi (2010) provide many photographs of stone structures built in many places in the world in ancient times. These range from megalithic structures to Greek and Roman temples, as well as large temples and monuments in Latin America and the Far East. The size, scope and shape of many of these buildings and structures are impressive and inspire huge admiration for what human beings were able to achieve without our present-day array of power tools, equipment, hoisting ability and know-how. It raises the question what would have been the best conditions under which construction of these monuments in ancient times could have taken place.

Reading through several articles in *National Geographic Magazine* about remarkable buildings and monuments constructed from stone in various parts of the world, in places where one would not have thought that people in that particular time or location would have been able to build them, there were a number of factors which these sites had in common. Following on from this discovery, the thought dawned that we have in fact a description dating from antiquity, which provides us with a whole range of factors which all contribute to an ideal situation for the construction of a large building or monument. The Bible provides us with just such an example, namely the temple built by King Solomon in Jerusalem. The accounts of its construction, found mostly in the books of I Kings and I Chronicles, provide us with some interesting insights as well as detailed descriptions regarding the optimal conditions for construction, which will be described and analysed in what follows. There does not seem to be another such extensive written account available about the construction of a temple, dating to antiquity, which makes it quite unique!

It is not the intention to be drawn into a debate in this context regarding authorship or time in which the books referred to were written. The texts will be analysed on their own merit from a practical perspective, and not from a redactional point of view. This analysis in turn can possibly provide a framework by means of which other large construction projects in ancient times can be analysed. The articles from *National Geographic Magazine,* which led to the insights that there seemed to be a number of ideal conditions for the construction of large monumental buildings in antiquity will be used as case studies in Chapter Six, to determine whether the framework is applicable in many different contexts. Besides these, other case studies based on other sources, will be added as well. The question to be answered is whether the criteria derived from the biblical account of the construction of Solomon's temple are indeed forming a framework that can be applied to all other construction projects, and whether there are certain criteria that are more prominent than others.

## 5.2 OPTIMAL CONDITIONS FOR THE CONSTRUCTION OF LARGE BUILDINGS IN ANTIQUITY

### 5.2.1 A situation of peace

Amazingly, one of the first aspects of importance in the accounts of the construction of the temple in Jerusalem is the situation of peace prevalent in the land. King David, who had wanted to build the temple, was prevented from doing so because he was a man of war (I Chr 28:2-3). He had been told by Nathan the prophet to leave the building of the temple to his son Solomon (II Sam 7:12-13). After David's death in 965 BC (Kolb 1986:113), King Hiram of Tyre sent envoys to Solomon after his accession to the throne. Solomon responded to this gesture by writing Hiram a letter. Before he even mentioned in this letter that he needs wood for the construction of the temple, he stated that David could not build the temple because of the wars waged against him and then added: 'But now the Lord my God has given me peace on every side, and there is no adversary or disaster. I intend, therefore, to build a temple for the Name of the Lord my God…' (I Ki 5:4-5a).

According to the biblical narrative, Solomon had inherited this situation of peace as a result of the efforts of his father's predecessor King Saul, who had fought against enemies, such as Nahash the Ammonite (I Sam 11:1-11), and extensively against the

Philistines (I Sam 14; 17; 29). In this effort he had been assisted by his son Jonathan and initially also by David. The latter continued fighting against various enemies both before and after he had succeeded Saul. David defeated the Amalekites (I Sam 30:1-20), the Jebusites (II Sam 5:6-8), the Philistines (II Sam 8:1), the Moabites (II Sam 8:2), Hadadezer the king of Zobah (II Sam 8:3-4), the Arameans of Damascus (II Sam 8:5-6) and the Ammonites at Rabbah (II Sam 12:29-31). Even when he was older, David still went out to do battle, but almost got killed by the Philistines. After this event his men did not want him to go out into battle with them any longer as it had become too dangerous for him (II Sam 21:15-17).

A situation of peace, an absence of adversary or disaster meant that all available resources, manpower and attention could be given to the huge undertaking of building the temple. There was nothing to disturb the task at hand, so it could all proceed without interruptions. This was the absolutely ideal time to undertake a project of this magnitude. No men had to go to war, no metals were needed to make weapons, no food supplies had to be diverted to feed an army, and no mental energy was needed to devise strategies to win a war or to deal with an emergency.

This entire situation as described above stands in stark contrast to the time several hundreds of years later when the temple in Jerusalem had to be rebuilt. According to the book of Ezra there was opposition from those living in Judah at the time, to the effort of the exiles who had returned from Babylon to rebuild the temple (Ezr 4:4-5). The Prophet Haggai had to admonish the exiles to get started with the rebuilding of the temple as there seemed to be a reluctance to do so, due to the fact that the conditions were not optimal (Hg 1:1-11).

The rebuilding of the walls of Jerusalem after the Babylonian Exile took place under even more opposition and hostility, to the point that Nehemiah and his builders had to build with their swords strapped to their sides (Neh 4:18). It was a dire situation indeed, as the destruction layer in Jerusalem, which had been caused by burning after the Babylonians had conquered the city, reached in some of the remains of buildings to their first story ceilings (Stern 2001:310). It makes the fact that the people succeeded in rebuilding the walls even more remarkable.

Another example of building in a time of peace is found in the time of Queen Hatshepsut of Egypt. When she came to power in about 1479 BC, her predecessors had been involved in waging war at the dawn of the New Kingdom (Brown 2009:97). Hatshepsut ended the wars and under her rule there was a time of peace and recovery. Temples damaged during the earlier conflicts were restored. She had new temples built, especially the temple at Deir el Bahri (Brown 2009:100; 103). Trade contacts were renewed, and precious materials such as cedar wood from Lebanon, turquoise from the Sinai and gold, ivory, myrrh trees, spices and many other commodities were brought from Punt (Brown 2009:100). The location of Punt is still a topic of debate, and opinions vary from a place along Africa's Red Sea coast (Brown 2009:101) to as far south as present-day Mozambique (see discussion in 4.2.5).

### 5.2.2 A common purpose

A second important aspect in the construction of a large building in antiquity was the need for a common purpose or ideology. This was necessary to get all those who were needed to cooperate in the undertaking to do so with unity and enthusiasm, and this was often motivated by a religious conviction. According to the biblical record in I Chronicles 28:1, King David, in a speech before his death, admonished a large assembly of his officials to stand united in their dedication to the building of the temple. David had called together all the officials of Israel: the officers over the tribes, the commanders of the divisions in service of the King, the commanders of thousands and of hundreds, the officials in charge of all the property and livestock, the palace officials, the mighty men and all the brave warriors (I Chr 28:1). The first point he mentioned at this gathering was the construction of the temple (I Chr 28:2-3). He then affirmed his kingship and its continuity in Solomon (vs 4-7) as well as the fact that they all needed to remain faithful to God (v 8). After this he admonished Solomon to serve the Lord and then handed him the plans for the temple construction.

In I Chronicles 29 David encouraged everyone present to help Solomon in the task of building the temple and mentioned the materials which he had already gathered for especially the decorations (vv 2-5). In closing he called on the leaders to also contribute to the store of precious materials for the construction, which they did quite lavishly, by donating gold, silver, bronze and iron as well as precious stones (I Chr 29:6-8). This gesture was much appreciated by the ordinary people (vs 9). So, David tried to get everything in place for the one project that he had not been able to accomplish during his lifetime, which was very close to his heart, and that was the construction of the temple. From the above description one can conclude that the leading authorities had bought into the project and were supported by the population. Many had contributed and as such there was a common purpose to get the project underway.

Malacrino (2010:7) also provides an interesting insight into the construction of buildings with stone. He refers to the fact that the Mycenaean culture built with stone, and that large blocks of up to 4 meters were used for the wall near the Lion Gate at Mycenae in Greece. This was in the late 13$^{th}$ century BC (Alexander 1999:65). After the Mycenaean culture had disappeared (in about the 12$^{th}$ century BC; Alexander 1999:67) and their building skills and technologies with it, there was a time during which only clay, wood and other plant materials were used for the construction of modestly sized houses during the Geometric period (Malacrino 2010:7). When the Greek city states started to develop during the transition from the 8$^{th}$ to the 7th century BC, once again stone became the prime building material for the construction of outer walls of buildings (Malacrino 2010:7). In my understanding this implies that the construction methods during the Geometric period could be achieved by a family group, to construct a dwelling for their own use, whereas the construction of larger stone buildings and walls for a city (a *polis*) required the cooperation of a larger group of people. A common purpose was a necessity to build a large structure.

### 5.2.3 Sufficient manpower for the quarrying, dressing and transport of the materials

The next important requirement for the building of a large monumental building such as a temple or a pyramid in antiquity was labour. In order to quarry large blocks of stone, dress them in the required dimensions, transport them and put them in the correct position at the construction site, thousands of labourers were needed. As the work was heavy, not to say back-breaking, workers were not exactly lining up for the available construction jobs to build the temple in Solomon’s time, so he conscripted labourers from all Israel (I Ki 5:13). Of these labourers, forced to work for Solomon under the ‘corvée’ system, according to the biblical record, 30,000 men were assigned to work in Lebanon to cut wood, and they were sent in shifts of 10,000 per month, so that they spent one month in Lebanon and two months at home. Furthermore 70,000 men were appointed to be carriers, and 80,000 men as stonecutters in the hills (I Ki

5:15). Over them 3,300 men were appointed to be foremen who were to supervise the project and direct the workmen (I Ki 5:16). A further interesting point is added regarding the workmen in II Chronicles 2. Here we read that Solomon took a census of all the aliens living in Israel, which was a total tally of 153,600 and they were assigned to be the 70,000 carriers and 80,000 stonecutters with 3,600 foremen to keep them working (II Chr 2:17-18). We may draw the conclusion that the temple was mostly built by the aliens who were used as forced or in fact, slave labour. It is also called 'slave labour' in I Kings 9:21b[21]. There is only the difference in numbers of 3,300 (I Ki 5:16) or 3,600 (II Chr 2:18) supervisors, but a footnote under I Kings 5 in the New International Version of the Bible indicates that some Septuagint manuscripts state 3,600 in this text. In my opinion the 30,000 labourers conscripted from Israel to cut wood in Lebanon had the relatively easier job.

Bible scholars do not agree on whether these numbers are credible or exaggerated. Mulder accepts the numbers, indicating that in comparison with the number of labourers, which the pharaohs used for the construction of the pyramids, the numbers mentioned in the biblical account should not be considered extremely high (Mulder 1987:187). Over against this Volkmar Fritz contends that both the numbers of the labourers as well as those of the supervisors are vastly exaggerated. He states that based on the density and extent of Iron Age settlements in the time of the Monarchy, the population density in circa 1,000 BC was about 150,000 adults in the land west of the Jordan. Only just before the Assyrian invasion, did the population increase to about 400,000 (Fritz 2003:64). If one adds up the 30,000 workers to cut wood in Lebanon, and the 70,000 carriers and 80,000 stonecutters as well as the 3,300 supervisors, the total number exceeds the total population density of 150,000 in circa 1,000 BC. A personal estimate would be that probably two zero's should be taken off each number to get to a realistic number of workers involved in the construction of the temple for the simple reason that too many people working in a quarry or on a construction site would be more of a hindrance than that they would make a positive contribution.

[21] This is in the New International Version. The Amplified Bible states: a forced levy of slaves. The New American Standard Bible states: forced laborers (*sic)*, and the Good News Bible simply states 'slaves'. In Die Bybel, Nuwe Vertaling, in Afrikaans, the word, '*dwangarbeid*' is used.

As a comparison, research into who built the pyramids at Giza in Egypt has revealed that these were built by a highly organised work force, consisting of crews of workers, which were ordinary Egyptians. Some of these workers were conscripts on a rotating basis and others were full-time employees (Morell 2001:81). Mark Lehner, the lead archaeologist at the Giza excavations is of the opinion that the workers were deeply religious and that they believed that by building the tomb for their king, they were assuring his rebirth, as well as their own and that of Egypt overall. This is what motivated them to work extremely hard and their teams would compete with one another (Morell 2001:88). Each crew was responsible for a particular part of the pyramid complex, and in turn was divided in four or five smaller units. These are called *phyles* by Egyptologists (the word *phyles* is used in the plural in this context, from the Greek word for 'tribe'). These *phyles* each had a name, such as 'Great One', or 'Green One', and in turn were broken up into smaller units with names like 'Endurance' and 'Perfection' (Morell 2001:88-89).

The workmanship of the Solomonic temple must have been very precise, as all the blocks for the construction of the temple were dressed at the quarry and no sound of hammer, chisel, or any other tool was heard at the temple site (I Ki 6:7). (See Figure 3-13 regarding the method of quarrying of blocks in Jerusalem, further information about the quarries will be provided in 5.2.8.2). At this point scholars do not agree either. One of the commentaries consulted, states that all that was profane was kept away from the temple as far as possible (Edelkoort 1977:28). Fritz (2003:71) however, is quite explicit with his statement that the stones for the building were finished at the quarry and then put into place at the construction site. This was the normal course of events with hewn stones, which were manufactured and delivered according to a standardized measure in order to be put together without any further work. These hewn stones were reserved for use in royal building projects, due to the intensive labour to produce these stones (Fritz 2003:71). Ritmeyer expresses the same opinion as Fritz (Ritmeyer 2006:282). The Bible in fact states several times that the stone was dressed. Besides in I Kings 6:7, also in I Kings 5:17 mention is made of the removal of blocks of quality stone to provide a foundation of dressed stone for the temple and verse 18 adds that the timber and stone for the building of the temple were cut and prepared. That the stone was dressed away from the temple site must also have required very careful transport, as no damage resulting from the transport could be repaired by re-shaping any building-block on site. As stone has a tendency to chip very easily (Malacrino 2010:106) when it is transported without sufficient care, as it is hard, but also brittle, this was a major feat.

### 5.2.4 An administrative or organisational system to mobilise manpower

A further important requirement for the building effort would be an administrative or organisational system to mobilise workers for the construction effort and to keep them working. In the preceding section (see 5.2.3), it was already mentioned that there were supervisors over the labourers. In I Kings 5:14b it is stated that Adoniram was in charge of the forced labour. The administrative system had already been set up under King David, as can be deduced from II Samuel 8:15-18, where several names of his high officials are mentioned. This system was further extended by King Solomon, who mostly retained David's chief officials, but who also appointed district governors over specific areas to supply provisions for the king and the royal household. In this way each area had to provide supplies for a specific month (I Ki 4:1-19).

The existence of this system must have also made it very easy to comply with the wish of King Hiram of Tyre, who asked to be paid for his services in assisting in the building of the temple, by means of food supplies for his royal household (I Ki 5:9b). That these supplies were considerable can be read in I Kings 5:11, where it is stated that Solomon provided Hiram with 20,000 cors of wheat (about 4,400 kilolitres) and 20,000 baths of pressed olive oil (about 440 kilolitres).[22] Fritz is however of the opinion that 20,000 cors of wheat equalled 800 tons and 20 cors of fine oil was the equivalent of 8,000 liters of extra virgin olive oil (Fritz 2003:61). This had to be provided year after year (I Ki 5:10-11), and it took 7 years to build the temple (I Ki 6:38) and a further 13 years to build Solomon's palace, a total of 20 years to complete it all (I Ki 9:10). After the completion of the temple as well as the royal palace, Solomon also still gave Hiram 20 towns in Galilee as further payment for the cedar and pine wood, and moreover the 120 talents of gold he had received from Hiram earlier (1 Ki 9:11, 14). Hiram was very disappointed with the towns and called the area the Land of Cabul, meaning: 'good-for-nothing' (I Ki 9:13). This area has been identified near the present-day Arab village Kabul, and is called Hurvat Rosh Zayit. It was excavated in 6 excavation seasons

[22] The modern quantities mentioned here are quoted from the footnotes in the New International Version.

starting in 1983, whereby the remains of a Phoenician fort were found, as well as artefacts and many amphorae for the storage of olive oil, wheat and wine (Gal 1993:38-44). Hiram may have complained bitterly, but according to Aubet the trade agreement between Hiram and Solomon was very beneficial for Tyre as it provided access to the trade routes leading to the Euphrates, Syria, Mesopotamia and Arabia as well as access to the Red Sea at Ezion-Geber (Aubet 1993:35-36).

### 5.2.5 Sufficient food supplies

Besides the food supplies which had to be paid to King Hiram for his services, there also needed to be food for the labourers who constructed the temple. It is no

t clear from the biblical text whether the workers received food for their labour, or whether they needed to bring their own food supplies. Even so, there had to be a surplus of food in the land to allow for so many people to be involved in the construction of the temple and to be no longer involved in producing food through agriculture.

The above-mentioned research conducted in the area surrounding the pyramids of Giza (see 5.2.3), has revealed that there was an entire city nearby, where food was prepared for the labourers who constructed the pyramids (Morell 2001:89; Lehner 1997:236-237). As the labourers had to keep up a fairly high-paced work speed, there would not have been time for them to prepare their own food. Moreover, the work was so strenuous, that it would not have progressed well on empty stomachs. Apparently, the era of the Old Kingdom in Egypt was a time of fertile land producing abundant crops, making the construction of the pyramids possible (Morell 2001:97). In fact, there were specific estates that contributed produce to the construction site of a pyramid (Lehner 1997:228). The find of bell-shaped pottery bread moulds and remains of catfish and schal (*Synodontis)* dating to the time of Menkaure, the last of the Pharaoh's for whom a pyramid was built at Giza, have led to the conclusion that the workers lived on a diet of bread and fish (Lehner 1997:236-237).

Another example dates to the time of the so-called Black Pharaoh's, who ruled Egypt as the 25th or Nubian Dynasty from circa 770-656 BC (Draper 2008:45). In the time of Pharaoh Taharqa[23], who ruled for 26 years from 690 BC, the Nile swelled from rains

[23] He is the same as the ruler called Tirhakah in Hezekiah's time, mentioned in II Kings 19:9 and Isaiah 37:9.

and flooded the valleys in the sixth year of his reign, but the water did not sweep away any villages, only all the snakes and rats. Afterwards there was a spectacular grain harvest. This enabled Taharqa to launch a massive building campaign in the two holy capitals of Thebes and Napata. In Thebes he added a portico of 10 massive pillars to the temple of Amun (Blyth 2006:197), and in Napata he built two temples near the holy mountain of Jebel Barkal (Draper 2008:53, 58). This will be further elaborated on in one of the case studies in Chapter Six.

### 5.2.6 Availability of materials for construction

The next item on the list of necessities for the construction of a large monumental building is the material to build it with. In order to produce sizeable blocks for the construction of the temple, a solid and fair-sized stone deposit was needed. Fortunately for King Solomon, Jerusalem had sizeable limestone deposits nearby of good quality, as the mountains around the city consist of Turonian and Cenomanian limestone in horizontal layering. These layers vary in thickness from about 18 inches (45 centimeters) to 5 feet (1.50 meters) thick (Ritmeyer 1989:46), and are even of different quality. Five different types can be distinguished namely *nari, mizzi yahudi, mizzi hilu, mizzi ahmar* and *meleke*. This last type is soft and granular underground, but hardens on exposure to the open air and is an ideal building material (Ritmeyer 2006:132). *Mizzi hilu* (meaning: sweet limestone) was used where the material had to withstand high stress levels, such as columns and capitals (Ritmeyer 2006:132). The material *mizzi yahudi* is very wear resistant and was used for thresholds and door sockets (Ritmeyer 2006:133). No specifics for the use of *mizzi ahmar* are mentioned by Ritmeyer. The use of *nari* (meaning: firestone) is interesting, as this material is very light-weight and is often used for vaults and arches in smaller buildings (Ritmeyer 2006:132). The quarries operated under royal supervision, as only royal building projects required hewn stones. Normally foundations were made from undressed stones (Fritz 2003:64). The king ordered large blocks of quality stone to be removed from the quarry (I Ki 5:17). How this was done, was explained in Chapter Three.

Of this whitish cream-coloured lime stone, the temple was constructed.[24] The relatively close proximity of the material to the construction site must have certainly been a bonus, as a long transport route was avoided.

Other materials had already been stockpiled by King David. Some of these had been looted from defeated enemies, such as the great quantity of bronze which he took from Hadadezer, king of Zobah (I Chr 18:8). Furthermore, there was silver and gold from Edom, Moab, the Ammonites, the Philistines and Amalek (I Chr 18:11). David also had provided iron to make nails for the doors, cedar logs from Tyre and Sidon, and had had stone quarried and dressed beforehand (I Chr 22:2-4). Besides all this, there also was material for decorative purposes such as onyx, turquoise, stones of various colours, fine stone and marble and a large amount of gold from Ophir,[25] as well as silver, which were his personal treasures (I Chr 29:2-4). This latter array of articles had probably been obtained by means of trade, and this is the next important aspect of the requirements for the construction of a large monumental building.

### 5.2.7 Trade

The materials which were not available locally, and which had not been obtained by defeating enemies and then looting their store of available goods, needed to be obtained by means of trade. This is also an important factor in the construction of a large monument, which had almost escaped attention due to the fact that the trade transaction which took place between King Solomon and King Hiram of Tyre was on a royal level and was based on barter trade. For the Phoenicians, trade was a royal prerogative and they traded in trading-partnerships called *hbr* or *hubŭr* with other royal houses such as that of Israel as well as Egypt (Aubet 1993:92). This trade agreement between equal partners was considered a covenant (Fritz 2003:61).

It has already been mentioned that Solomon wrote to Hiram for further supplies of cedar (I Ki 5:6), to which (interestingly) Hiram replied that he would send cedar and pine (I Ki 5:8). The Bible commentary consulted assumes that Solomon had ordered

[24] It is now called ‘Jerusalem Stone’ and it is still the prescribed material for all construction of façades in Jerusalem to this day. This information was given to me by my late father, Johan H. Buddingh, who imported Jerusalem stone from Israel for re-sale in the Netherlands up to his death in 2006.

[25] There is uncertainty as to the location of Ophir, where according to the biblical record a combined expedition of King Hiram of Tyre and King Solomon went to trade (I Kings 9:26-29). I believe that Professor Meir Bar Ilan of Bar Ilan University in Israel is correct, when he contends that Ophir was located somewhere in present day India (Bar Ilan 2015:125-137).

the pine as well (Edelkoort 1977:26), but there does not seem to be anything in the text to substantiate this assumption. It is much more likely, that the less valuable pine was offered with the intention that it should be used in places where it would not be visible, so as to not waste precious cedar, which by this time had become expensive due to it having become scarcer. Cedar trees had already been felled since at least 3,000 BC, when the oldest recorded shipment left the Levantine coast for Egypt (Aubet 1993:146). From the story of Wen Amun[26], dating to circa 1,070 BC, we know that cedar wood had become expensive (Aubet 1993:296-302). Solomon built the temple after his accession to the throne in circa 965 BC (Kolb 1986:286). Another possibility is that Hiram mentioned the pine, sometimes also translated as cypresses, to be used as panelling as well as for the floors, as it was so much easier to cut (Fritz 2003:61). According to Ritmeyer (2006:286) the floor of the temple was made of fir or cypress wood.

Another interesting aspect of the text is that Solomon did not ask Hiram for a quote for the cost first, but stated: ‘I will pay you for your men whatever wages you set’ (I Ki 5:6). Hiram in turn got the men of Gebal (= Byblos) to cut and prepare the timber and was apparently the middle-man in the entire transaction (I Ki 5:18), which may have included a mark-up for himself. Besides the trade between them, Solomon and Hiram also organised their combined trade expedition to Ophir (I Ki 9:26-28), which is another example of *hubŭr* (trading partnership), from which they obtained 420 talents of gold. It is unlikely that they just loaded gold on board of their ships there. They must have sent goods to Ophir, which they exchanged for the gold, according to Professor Bar-Ilan (2015:125-137).

The exchange of goods through trade often also is accompanied by an exchange of ideas, technology and design. This may explain why the design of Solomon’s temple was similar to a temple of Northern Syrian origin, and not a locally designed building such as the broad-room temple, which has been excavated at Arad (see Figure 5-1), dating to the 10$^{th}$ to 8$^{th}$ century BC (Scheffler 2000:58).

[26] Wen Amun was sent from Egypt to go and buy cedar for a sacred barge for Amun-Re and met with all kinds of misfortune on his voyage (Aubet 1993:296-302).

**Figure 5-1: The excavated remains of the broad room temple at Arad (Scheepers & Scheffler 2000:290).**

The similarities between the temple at Emar in Northern Syria (see Figure 5-3) and the Jerusalem Temple (see Figure 5-2) are that they both consist of a long, straight building with a porch, behind which is the Main Hall in the temple in Emar and the Holy place in the Jerusalem temple. At the back of the temple in Emar was a platform, and the Holy of Holies was a separate room at the back of the Jerusalem temple. The difference is that there was an altar inside the Emar temple and that the Jerusalem temple had the altar located outside the building, with only a small incense altar inside it (Ritmeyer 2006:287). From the image on the right-hand side of Figure 5-3, one can see that the temple of Arad had a rather cluttered appearance, which Solomon possibly did not want to replicate. The Jerusalem temple (see Figure 5-2) had straight, clean lines, which may have appealed as a more unique and impressive design.

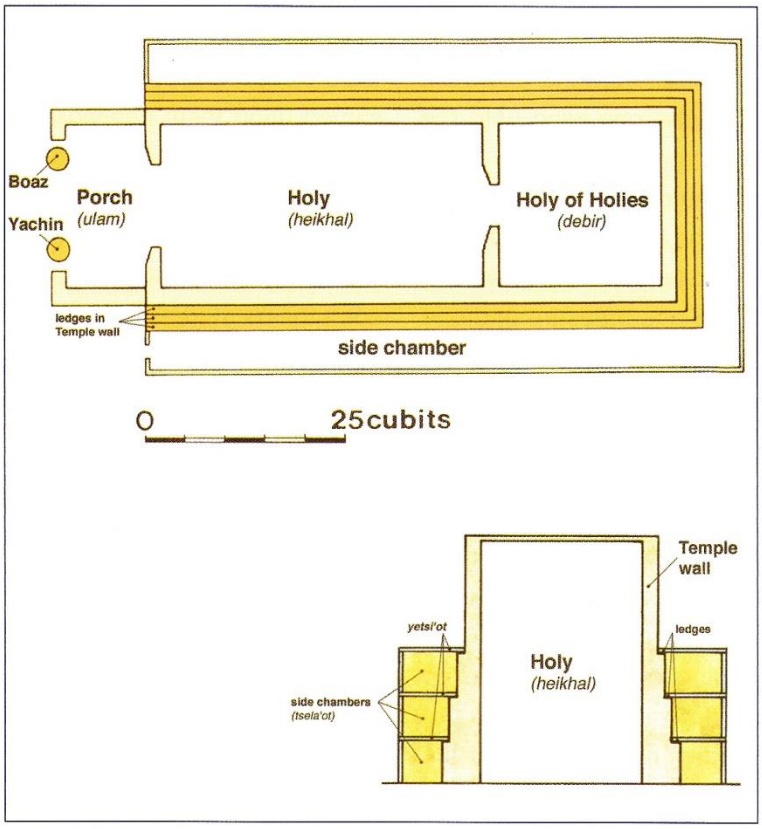



**Figure 5-2: Plan of Solomon's temple and E-W section (Ritmeyer 2006:284).**

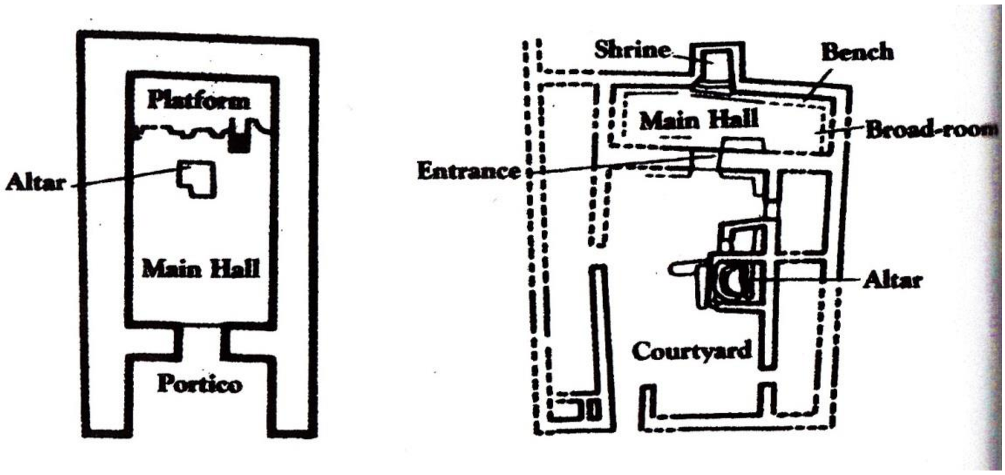



**Figure 5-3: Plans of temples to compare with Solomon's: from Emar in Northern Syria on the left, and Arad in Southern Israel on the right (Scheffler 2000:58).**

Whether in fact Solomon’s temple was based on the temple at Emar as Scheffler (2000:58) is of the opinion, or whether it was based on the design of the temple of Melqart in Tyre, which also had two large pillars at the entrance (Edey 1976:87), is an open question. Hiram is credited with the construction of the temple of Melqart, which became famous for its two large pillars of gold and emerald (Aubet 1993:36). Unfortunately, there is no further information available about Melqart's temple, such as a floor plan, as this temple was destroyed and no excavations of its remains have taken place due to the fact that these are buried under present day Tyre. The only excavation that has taken place at Tyre is the sounding by Patricia Bikai, which was limited in its scope (Aubet 1993:28). The Jerusalem temple may have also been designed according to the plan of the earlier tabernacle as described in Exodus 26.

#### *5.2.7.1 The stone temple model*

Of further interest may be the discovery of a stone temple model during excavations at Khirbet Qeiyafa in 2011, dating to the 10th century BC (see Figure 5-4). What is special about it, is that it is a stone temple model, whereas usually the temple models which have been found so far, are made of clay (Garfinkel & Mumcuoglu 2016:ix). This particular one was elaborately carved of soft limestone (Garfinkel & Mumcuoglu 2016:38) by an expert stonemason, which is believed to be an indication of the importance that was attributed to it in antiquity (Garfinkel & Mumcuoglu 2016:ix). The front of this temple model has a recessed opening (Garfinkel & Mumcuoglu 2016:41), and the researchers believe that the First Temple in Jerusalem also may have had a recessed door and recessed window frames (Garfinkel & Mumcuoglu 2016:128).

This type of doorframe is known from Mesopotamia, where the oldest example is found in Tepe Gawra, dating to 4500 BC, as well as many other examples in different places dating to different eras from the 4th to the 1st millennium BC (Garfinkel & Mumcuoglu 2016:46). Therefore, this design feature came from much further afield than the temple in Emar mentioned by Scheffler (2000:58). What is not clear is whether the recessed door and window frames were just purely aesthetic or whether there was a purpose for this design, for instance to allow for more light to fall into the sanctuary. This especially when the door was open for certain occasions such as a festival or celebration and the statue of the godhead would be visible to the public (Garfinkel & Mumcuoglu 2016:101). (This recessed front reminds me of a modern large camera lens, which also has concentric recessed rings).

**Figure 5-4: Stone temple model excavated at Khirbet Qeiyafa with recessed frames and triple roof beams (Garfinkel & Mumcuoglu 2016:43).**

Another unusual feature of this temple model is that it has four carved protruding rectangles at the top, as part of an original row of seven, with three protrusions now restored (See again Figure 5-4). The four original rectangles, carefully carved in three slices, symbolise the ends of sets of three wooden roofbeams, which supported the roof (Garfinkel & Mumcuoglu 2016:58). This type of roofbeam construction is known from Greek Classical architecture and is called 'triglyph'. The best-known example where this is also present is at the Parthenon on the Acropolis in Athens (Garfinkel & Mumcuoglu 2016:58-59). The triglyph decoration on the temple model found at Khirbet Qeiyafa however, dating to the $10^{th}$ century BC, predates the same decoration in Classical Greek architecture by approximately 500 years (Garfinkel & Mumcuoglu 2016:58). So not only was the design of Solomon's temple in Jerusalem influenced by design elements from elsewhere in the Near East, but architectural phenomena from Solomon's temple in the Near East, influenced architectural design in later times and places, in this case the Classical architecture in Athens, Greece (Garfinkel & Mumcuoglu 2016:58).

### *5.2.7.2 The debate whether David and Solomon existed at all*

In the context of the find mentioned above, it is also interesting to mention that there is a heated debate among Israeli archaeologists about whether Solomon can be credited with the construction of the Jerusalem temple and whether David and Solomon have existed at all. The argument is mostly between the archaeologists Doctor Eilat Mazar, who has excavated extensively in Jerusalem and Professor Israel Finkelstein of Tel Aviv University (Draper 2010:72-73). Mazar believes that she has unearthed the palace of King David in Jerusalem, and Finkelstein argues that Jerusalem in the time of King David was only a 'hill country village' and that David himself was no more than an upstart and leader of a band of rebels (Draper 2010:73). Mazar is not the only one who disagrees with Finkelstein and his 'low chronology' interpretation, as also Professor William Dever of the University of Arizona in the USA wholeheartedly disagrees with him about his dating of archaeological finds (Dever 2003:2-3). Garfinkel and Mumcuoglu (2016:3) also disagree with Finkelstein about this so-called 'minimalist approach' and are of the opinion that David and Solomon did exist. They state that not only did their excavations at Khirbet Qeiyafa show the existence of the Kingdom of Judah, due to specific features present in the city, such as casemate walls, and the find of the stone temple model (Garfinkel & Mumcuolglu 2016:4), but also mention the find of the *Tel Dan inscription* in 1993, which mentions a 'king of the house of David' (Garfinkel & Mumcuoglu 2016:3).

Despite this, the debate still rages on. This became clear to me personally last year. At an international workshop about the Phoenicians, which I attended at the Johannes Gutenberg Universität in Mainz, Germany, from 12-14 December 2018, a younger colleague of Finkelstein, Doctor Omer Sergi, also of Tel Aviv University, gave a talk on the Phoenicians and the Old Testament sources. He was also of the opinion that King Solomon's role in the biblical account is exaggerated, and that his image was modelled on that of Jeroboam II of the northern kingdom of Israel (Omer Sergi, speaking at the Mainz international workshop on the Phoenicians, 13 December 2018). So, Finkelstein's influence and arguments are still permeating the debate about the importance of David and Solomon in Israel in the 10$^{th}$ and 9$^{th}$ century BC. It is however not the intention to find an answer to the question of whether David and Solomon existed, as that falls outside the scope of this thesis.

The find of the stone temple model in Khirbet Qeiyafa (see Figure 5-4) however, is squarely attributed by the archaeologists Garfinkel and Mumcuoglu to the time of David and Solomon, namely around 1000 BC (Garfinkel & Mumcuoglu 2016:10).

### 5.2.8 Appropriate and sufficient technology

#### *5.2.8.1 Construction technology*

It is of course wonderful to want to build a monumental building, but there needs to be sufficient technology to be able to achieve this. David and Solomon were fortunate that the Phoenicians had this know-how, both for the construction as well as for the decoration of the temple. Their craftsmen may have provided the design, but definitely provided the workmanship (Montefiore 2011:32-33). The Bible states: The craftsmen of Solomon and Hiram and the men of Gebal cut and prepared the timber and stone for the building of the temple (I Ki 5:18). For the large decorative elements of the temple such as the bronze pillars and capitals as well as the other bronze work, a specialist craftsman named Hiram was brought from Tyre. He was of mixed descent, as his mother was Israelite and his father Tyrian (I Ki 7:13-46). Archaeology has shown that Phoenician building techniques spread beyond their own realm (Fritz 2003:65). In the time of David and Solomon both Bronze and Iron technology was available, which aided in achieving the desired result of a well-built temple.

Not all building enterprises in antiquity were equally fortunate though. The builders of Göbekli Tepe, who constructed a temple with T-shaped stone pillars and walls of stacked field stones from about 9,600 BC in what is present day Turkey, probably had major problems getting their pillars to stand up. According to modern day researchers in all likelihood they had to have used wooden posts to support them (Mann 2011:41-48). Technology of course is also a matter of experience and only by trial and error is experience gained. The site of Göbekli Tepe will be elaborated on further in the first case study in Chapter Six.

#### *5.2.8.2 Transport technology*

The blocks which had been quarried and then shaped into the required dimensions needed to be transported to the building site. For this a form of transport technology was required. Before we get to the actual methods of transport, a few different locations for the quarries, from which stone has been quarried in Jerusalem, will be described. These date to different times, but are grouped together here for convenience.

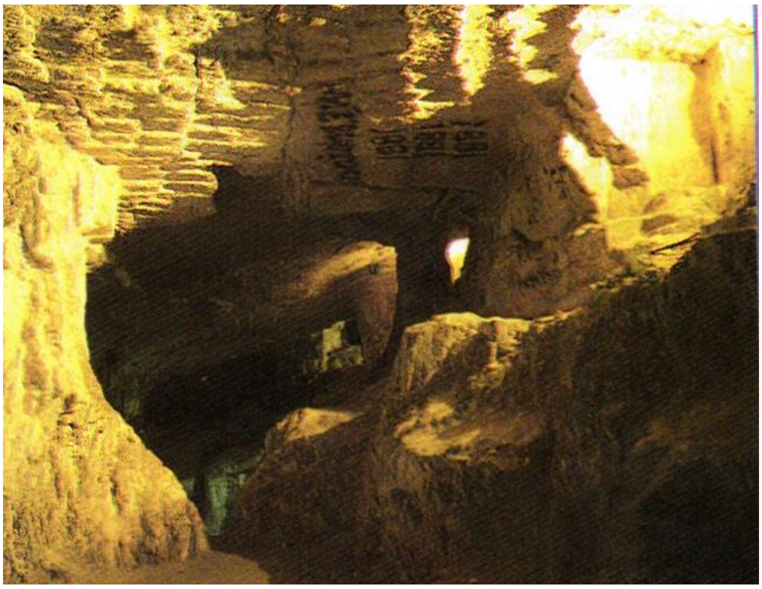


**Figure 5-5: The so-called Solomon's Quarries underneath the Damascus Gate of the Old City. Tradition has it that this is where Solomon extracted the stone for the temple (Ritmeyer 2006:286).**

According to Ritmeyer (2006:286) tradition has it that the stones for Solomon's Temple came from the so-called Solomon's Quarries located underneath the Damascus Gate of the Old City[27] (see Figure 5-5). On the top half of the picture the striations of the quarrying process are still visible. Ritmeyer states with more certainty that the limestone for the construction of the Second Temple came from an area about a mile away from the Temple Mount, near what is now known as the Russian Compound, which is located north-west of the Old City (Ritmeyer 2006:134)[28].

[27] If this was indeed the case, it would also account for the absence of noise during the construction of the temple, as all the blocks were shaped to size underground.

[28] This compound came into being when European inhabitants of the city started building outside the city wall in the mid 1880's, with the Russians taking the lead. They built a number of institutions with the support and encouragement of the Tsar, and the area of which they took possession thus got the name of the Russian Compound (Ben Dov 1990:33).

A 12.50-meter long limestone column is still visible there (see Figure 5-6), which was left attached to the bedrock, when it was discovered by the builders that it could not be used because it was defective due to a crack in the middle (Ritmeyer 2006:134, 136; Stein 1981:43).

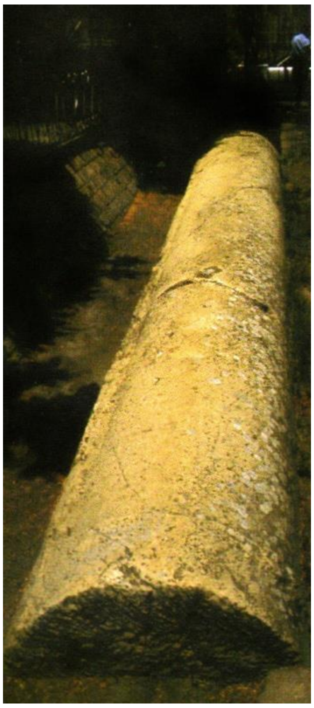


**Figure 5-6: Large column found in situ in the Russian Compound (Ritmeyer 2006:136).**

Another area in Jerusalem where stone was quarried in antiquity was on the north side of the Transversal valley, as far north as the present-day Church of the Holy Sepulchre (See Figure 5-7). Some of these quarries were in the open air, while others were underground caverns, which supplied the high quality *meleke* stone (Gibson 2009:120; see 5.2.6). These quarries date to the 7$^{th}$ or 8$^{th}$ century BC, which is the time of the late Judean monarchy (Bahat 1986:28). That means that the material for Solomon's Temple did not originate from these quarries, but the exploitation of these quarries coincides with the rule of King Joash who ruled from circa 840-801 BC, when extensive repairs of the Temple were necessary (Ritmeyer 2006:298-299).

In the time of King Hezekiah, who ruled from circa 725-697 BC, the Temple had to be restored again and the Temple Mount was extended as well (Ritmeyer 2006:303-304).

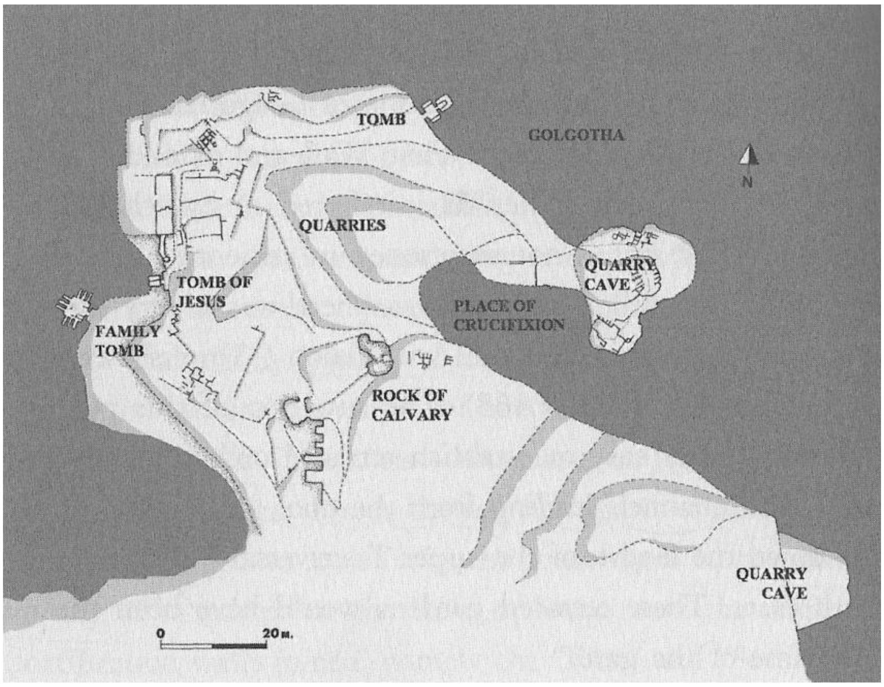



**Figure 5-7: Map of the rocky areas and quarries in the area of the Church of the Holy Sepulchre (Gibson 2009:120).**

The underground quarries at the site of Solomon's Quarries (as stated in the above, these are located near the Damascus Gate), were laid out in such a way, that they had a main corridor, which sloped gently upward towards the exit, so that it was possible to move the blocks, which had been prepared underground, on sledges or rollers out of there (Ben Dov 1990:263; see Figure 5-8).

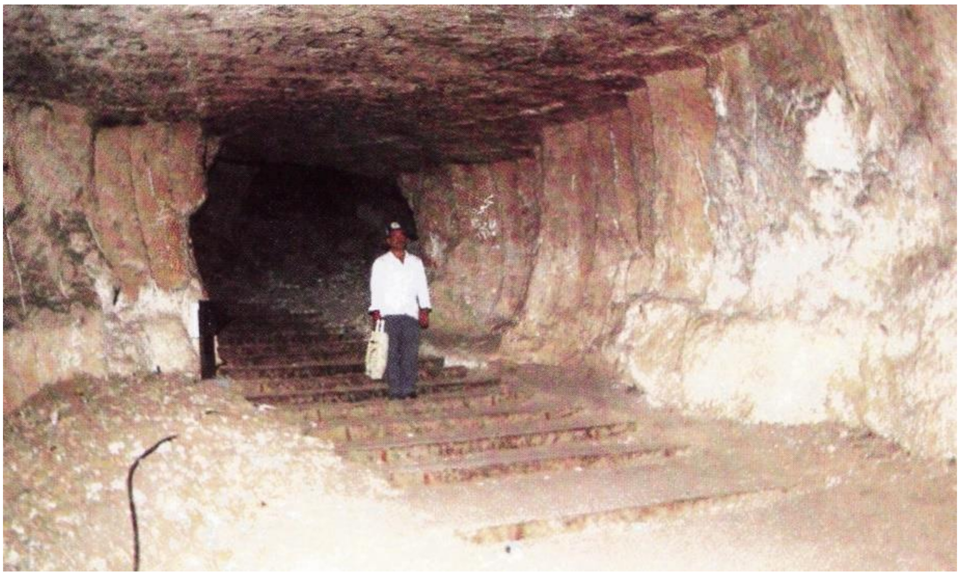


**Figure 5-8: Solomon's quarries with gently sloping corridor (Ben Dov 1990:263).**

Then there is still another possibility, namely that the stone for construction was quarried right on the Temple Mount. Ritmeyer is of the opinion that some of the cisterns, which are now all underneath the Temple Mount, started out as quarries and that after extraction of a lot of stone, these quarries became water cisterns after they had been plastered (Ritmeyer 2006:226-227; also Jacobson 2000:136). All the water cisterns underneath the Temple Mount were investigated and put on a map by Charles Warren between 1867 and 1870 (Ritmeyer 2006:220-221). The interior of one of these cisterns, known as the *'Great Sea'* was painted by William Simpson in 1872 (Ritmeyer 2006:224), and Simpson wrote about this cistern, that it had 44 very worn steps and that he could not understand what had been the purpose of these steps, as the water was drawn from the cistern through shaft openings in the ceiling, and was not transported up the steps (Ritmeyer 2006:227). Ritmeyer believes that the steps were used to haul blocks upwards when this cistern was still a quarry (2006:227). Quarrying right at the site of the Temple Mount would have saved a lot of transport effort.

Some additional information regarding the area of the Russian Compound is that it is situated 125 feet higher than the Temple Mount (Ritmeyer 1989:47), so gravity could be used to lower the blocks. This was usually done over specially constructed sloping paths. This process in turn necessitated ropes, straps or frames to prevent the blocks from moving too fast. We know from the remains of the platform on which the Second Temple stood, that some of the blocks were very large (Ritmeyer 2006:61), so this would have required a large amount of manpower. It is possible that the builders of the First Temple used rollers, which is an ancient method of moving blocks and which is assumed to have been used already at Göbekli Tepe (see Figure 5-9), but that would have only moved the blocks along a fairly level surface (Mann 2011:44).

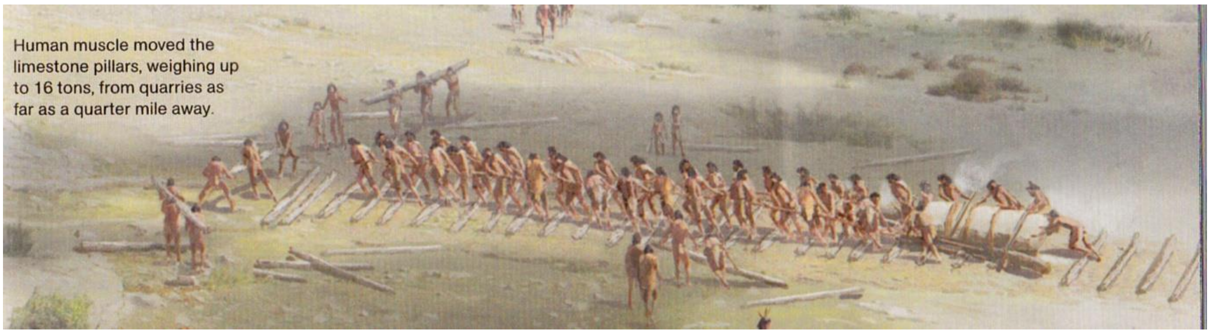



**Figure 5-9: Moving a block with the help of rollers along a fairly level surface (Mann 2011:44).**

To the higher levels of construction, the blocks may have been moved on sledges, pulled upwards with ropes on ramps (Ben Dov 1990:83, see Figure 3-31), as was also done during the construction of the pyramids in Egypt (Morell 2001:81).

For the re-construction of the Temple Mount under King Herod, Ritmeyer (2006:137) is of the opinion that the largest blocks of for instance the south-western corner of the Herodian Temple platform were moved there over the level fill which was used to fill in the space between the original Temple platform and the enlarged Herodian Temple platform. The ashlars were put into place from the bottom, then the fill would be brought in and levelled, which would have provided a level surface over which the next level of ashlars could be brought and put into place, after which fill would be upped again and so on (Ritmeyer 2006:137). It is also possible that the very large blocks were rounded after quarrying, so that they could be rolled to where they needed to be. Once they had arrived at their destination, they were squared again, by removing the rounded sides, effectively making the block smaller (Stein 1981:42-44; as discussed in section 3.4.3.4).

*5.2.8.3 Tools*

In order to quarry and dress the stone blocks, tools were needed. (See for a discussion of the development of tools sections 2.6.1 to 2.6.4). That there were definitely tools available in King Solomon’s time is clear from I Kings 6:7, where it is mentioned that no hammer, chisel or other tool was heard, because all the blocks were dressed at the quarry (see 5.2.3). Moreover, reference is made to the use of a saw to trim blocks in I Kings 7:9. We can deduct from these two references that there were tools with which the work was done. Ritmeyer used the text of the King James Version of I Kings 6:7 implying that the work was done with iron tools (Ritmeyer 2006:282). A comparison of different Bible translations[29] showed, that most translations refer to iron tools, only the New International Version does not. We may therefore assume that iron tools were used in the construction of Solomon’s Temple, also because by this time the Iron Age was well under way. If the Israelites had not had iron tools, the Phoenicians as major traders in iron, would have supplied them as part of their involvement in the construction project. Moreover, mention is made in the biblical account of a large

[29] Bible translations consulted were: New American Standard Bible, The Amplified Bible, New International Version, Good News Bible, Nederlandse Bijbelvertaling 1951, De Nieuwe Bijbelvertaling 2004, Die Nuwe Bybelvertaling 1983.

amount of iron for the door-nails (I Chr 23:3). In fact, the availability of iron tools was a technological innovation, which increased the likelihood of success of this building enterprise.

Copper tools were used in the construction of the pyramids, as copper chisels were found during the excavation near the Giza pyramids (Morell 2001:83). It is not clear from which time onwards bronze was used as material for stone working tools. Lehner (1997:210) is of the opinion that bronze tools were probably not used in Egypt before the Middle Kingdom, which started ca. 2040 BC (Lehner 1997:8), so this implies that no bronze tools were available to build the pyramids in ca. 2550 BC. Mannoni (1985:142) contains an image of a bronze chisel from an Egyptian tomb, dating to the 15$^{th}$ century BC (see Figure 2-13), so by that time there were bronze tools available.

## 5.3 SEASONS, WEATHER AND SAFETY

### 5.3.1 Seasons and weather

One aspect not mentioned in the biblical account of the construction of Solomon's Temple is the influence of seasons and weather. In the milder climate of the Mediterranean, harsh winter weather is not likely to be a big problem, but in other parts of the world this most certainly is the case. In his book '*Stone Tools and Society'*, Mark Edmonds mentions a few times a bit disparagingly that the quarrying of flint for the production of tools was only a seasonal event, and was not done year-round (Edmonds 1995:61, 117). He may think that it should be a year-round event, but in my opinion, he is mistaken, as the summer season would have been the right time for quarrying, with more light, no snow, less rain and no frost in the ground. In the context of our present day and age in which everything is operating throughout the year, Edmonds' comment is an understandable one, but in the context of the past it is incorrect in my opinion. A similar remark regarding the limited season in which shipping was possible in the Mediterranean was made in a book about ancient ships (Casson 1971:271). What I am trying to make clear is that we often lose sight these days of the fact, that there used to be a seasonal change in people's activities.

Let me use the example of the activities in our own stonemason company in the Netherlands, which also were subject to seasonal influences. Stocks of materials used to be bought in autumn, so that it was in the yard when needed and the company could supply even when quarries were closed or roads impassable due to snow and ice to transport the material. One winter we lost a load of tiles, ordered at short notice from Italy, when the truck it was transported in, jack-knifed on the Autobahn in Germany on a bridge which had become frosted over with moisture rising up from the river. In the quarrying of stone, the seasons play a considerable role, especially in the colder latitudes, but elsewhere as well[30].

That flint was quarried seasonally had to do with the fact that it is too cold in winter to quarry and that it was much better to quarry the raw flint in the summer when there was also more and longer daylight. In the same way stone quarries operated and still operate today. If a quarry is in the mountains, where there is snow in winter, or even heavy rain, it becomes impossible to extract the material. When visiting a quarry of dark red slate in Switzerland in the early 1980's, the owner commented that the quarry could only be exploited in summer, as it was covered in snow in the winter, and that if we wanted to buy any material from him, we had better do so sooner rather than later. To give another example: here in South Africa the granite quarries in the Rustenburg area cannot produce any material when there is a lot of rain, as it becomes impossible to transport blocks out of the quarry over the muddy paths through the surrounding bush. Having worked as a quality control officer here in South Africa for a Dutch company in the late 1980's, which imported granite grave stones from Rustenburg, the scarcity of blocks of granite during the rainy season was almost an annually recurring matter.

There are also examples from antiquity, for instance the one I encountered regarding the building of the Second Temple under Herod with respect to rain. Meir Ben Dov quotes Josephus who informs us that in the 11 years that it took to build the Temple, it only rained in Jerusalem at night, so as to not interfere with the construction work (Ben Dov 1986:46). Ben Dov also states that this is confirmed by a Talmudic legend which refers to the same phenomenon that at daybreak the wind would blow rain and clouds away and there would be another sunny day so that the people could do their work (Ben-Dov quotes the *Jerusalem Talmud*, Berachot 1:8, and the *Babylonian Talmud,* Ta'anit 23:71 as his sources). When mentioning this remarkable fact in an

[30] In this respect I speak from personal experience gained when buying stone over a period of four years for the family business.

article about the excavations below the Temple Mount, Ben-Dov also added that in the 14 years that the excavations lasted there, the excavation teams on average only lost about five work days per year because of rain and snow, because it mostly rained at night (Ben Dov 1986:45).

The fact that Solomon's Quarries in Jerusalem were located underground (see Figure 5-8), meant that they were always accessible, regardless of seasons or weather conditions (Jones 2017:9).

To provide another example: in Egypt in antiquity the change of seasons would probably not have had much influence on the quarrying of material, because of the absence of snow and very cold weather, as well as the very limited amount of rainfall, but there the annual flooding of the Nile may well have had an influence on the transport of material. In order to transport very large stone pillars or obelisks, the barge used for this purpose would have to be lowered by ballast stones, for which deep water would be required. The transport barge would be brought into a narrow canal connected to the Nile for this purpose, to prevent it being washed away by the increased current caused by the high-water level in the Nile itself (Lehner 1997:202). It is believed that low flooding levels of the Nile were to blame for the discontinuation of transport of basalt from Widan el-Faras to the Giza plateau towards the end of the Old Kingdom era (Bloxam 2005:25).

### 5.3.2 Safety

Besides the above-mentioned points there is still another issue of importance in the construction of large monumental buildings and that is safety. That stone-working can be a dangerous undertaking is referred to in Ecclesiastes 10:9 it says: 'Whoever quarries stones may be injured by them; whoever splits logs may be endangered by them.' As split logs were used in the process of quarrying in Jerusalem, both these verses are applicable to quarrying stone. And indeed, quarrying is dangerous business. Straps to haul blocks can break and when such a heavy block takes on a path of its own (blocks could be up to 20 tons in weight), anything in its way gets crushed due to its sheer weight and size.

That this is not an exaggeration can be attested to by the following example: at the excavation site at Giza near the Pyramids in Egypt a skeleton was found of a worker, whose arm had been badly injured (Morell 2001:98). The arm was found to have been amputated below the elbow, but despite that it was clear from the skeleton, that the arm had healed. In the same way the leg of an official had been amputated, but both men had lived for many years after their accidents, according to physical anthropologist Azza Mohamed Sarry El-Din, who investigated these excavated skeletons (Morell 2001:98). She confirmed that workers who were pushing stones of this size around were likely to get hurt. Sarry El-Din is of the opinion that there was medical care available for the workers in those days. There must have been something like a clinic for them there, so that their injuries could be taken care of (Morell 2001:98). This is also confirmed by Anne Austin of Stanford University, who has been studying remains of workers in Deir el-Medina. From this research she has drawn the conclusion that medical care was available for those involved in the building of the tombs in the Valley of the Kings (Austin 2015:24). Deir el-Medina was a village in the desert, where the workers were housed who built the tombs in the Valley of the Kings and the Valley of the Queens, and which was in use from circa 1520 to 1069 BC (Mark 2017:1). It was extensively excavated between 1922 and 1951 by Bernard Bruyère and his team, and provided a wealth of information about the workers and their lives, especially so because they left thousands of ostraca, written records on potsherds and limestone flakes (Lesko & Lesko 1999:39).

The study mentioned above of the skeletal remains by Sarry El-Din has also revealed so far that nearly all the workers suffered from arthritis, in the form of badly compressed lumbar vertebrae, which can be expected of a manual workforce, which had to push large pieces of stone or pull statues on sleds. Surprisingly also many women were involved in the construction of the pyramids, and their skeletons also showed damage to the neck vertebrae, which is indicative of carrying heavy loads on the head from a young age, besides the damage to the lumbar vertebrae (Morell 2001:97).

Recent excavations at the sandstone quarries at Gebel-el-Silsila by Doctor Maria Nilsson and John Ward of the University of Lund in Sweden, have also brought information to light about the physical condition of the workers there, whose remains have been excavated (https://www.lunduniversity.lu.se/article/twelve-new-tombs-discovered-in-gebel-el-silsila-egypt). The Nilsson and Ward team discovered the following: the human remains found at the site were of healthy individuals. There was very little evidence of malnutrition or infection. But what they did find was fractures of the long bones, as well as increased muscle attachments in these skeletal remains. These findings indicate that there were occupational hazards, which were the result of the extremely labour-intensive situation in which the workers found themselves. But they also found that many of the injuries were largely healed and believed this to be the result of effective medical care (https://www.lunduniversity.lu.se/article/twelve-new-tombs-discovered-in-gebel-el-silsila-egypt).

Other injuries, which cannot be detected by physical anthropology, because they were not bone injuries, could be caused by chipping stone. One of the great risks was that a small chip would get into the labourer's eye. Chips that are being chiselled off a larger piece of stone can fly in any direction and eyes are particularly vulnerable to this kind of injury. The two stonemasons who worked for our company when I was young, and who were still using hammers and chisels, both wore glasses and would always caution people entering their work area to remain at a safe distance. At the end of the day all the chips would be swept up and they would be collected from the entire floor of the workshop.

Another risk factor for the eyes in the process of working stone is blindness, especially when a very white material is being used. In order to work the material, whether is it being quarried, or dressed into the required shape, sufficient light is required. In ancient times this would mostly be done in the daytime and the only available suitable light to work by, would be sunlight. Moreover, stone would already be worked in the quarry, and if this was an open quarry there usually was no shelter. As many materials contain quartz and other particles, which reflect light, long-term work with white or light-coloured materials could result in blindness, due to the reflected light affecting the eyes. The article by Lesko and Lesko (1999:44) about the workers' village at Deir-el-Medina also mentions accounts on ostraca of eye-infections and temporary blindness. These conditions were exacerbated by the dry and dusty conditions in the workplace, and were frequent complaints. Furthermore, the continuous noise of the hammering most likely caused deafness in the labourers in the long term as well.

Sandstone entails the risk that silica particles are dislodged and will become airborne. The stonemasons working the material breathe in these particles, which will settle in the extremities of the lungs and cannot be removed in any way, not even by coughing.

Eventually the lungs are so loaded with the silica particles, that the stonemason starts suffering from Silicosis, and struggles to breathe, leading to a premature death (http://www.silicosis.com/symptoms/index.php). The knowledge about the dangers of Silicosis was repeatedly emphasized to me from a young age. Even though the Netherlands does not have any stone of any kind, it adopted legislation after World War II, which forbade the use of sandstone, except for use in restoration of buildings and then only under very strict safety conditions. This legislation did much to improve the image of the stonemason sector, as many stonemasons had started to suffer from Silicosis, after working sandstone imported from Germany over many years. About this aspect of stone working, Lesko and Lesko (1999:44) also comment that the fine limestone dust damaged the lungs and sinuses of the workers in Deir el-Medina. In South Africa many miners also suffer from Silicosis after working in mines for many years and breathing in the dust caused by the breaking of rock. A recent High Court verdict in a class action court case against gold mining companies in Johannesburg has once again highlighted the scourge of this disease (Mtongana 2016:1).

Another kind of danger, as mentioned on the Deir el-Medina ostraca, were the presence of scorpions and snakes (Lesko & Lesko 1999:44).

## 5.4 CONCLUSION

The construction of large monumental buildings in antiquity was not just a matter of materials and labour. As can be noted from the above there was a whole series of requirements to be met in order to have the best possible situation for the construction of such a large monument. It is remarkable how much detail the biblical account of the construction of the temple provides for this analysis. In Solomon’s time all the elements for an ideal situation were definitely in place, so that despite the fact that he may have lacked experience in the construction of a large monumental building, he succeeded with ease. A large part of the successful completion of the project was owed to the construction skills of the Phoenicians. Furthermore, the success of the project also required the concerted effort of a large group of people over an extended time, the availability of materials at close proximity, as well as continued good harvests to support the construction effort and a situation of peace and favourable weather.

A number of examples from other construction sites have already been mentioned in the above, and in the next chapter a more detailed analysis will be made of other large construction projects in different places and different times with different materials whereby this whole series of requirements will be used as a framework to analyse these other construction projects as a form of template to determine whether the same criteria as established in this chapter also apply to those projects, or whether other monumental buildings were constructed under worse, similar or possibly even better circumstances.

# CHAPTER SIX

## CASE STUDIES BASED ON THE FACTORS DERIVED FROM THE DESCRIPTION OF THE CONSTRUCTION OF SOLOMON'S TEMPLE IN JERUSALEM

### 6.1 INTRODUCTION

Quite a number of common factors initially observed in various articles in *National Geographic Magazine* (Brown 2009; Draper 2008; Mann 2011; Smith 2014) about different sites where monumental buildings were constructed at different times in antiquity, led to the insight that the description in the Bible of the building of Solomon's temple in Jerusalem, probably presented a template or framework of many factors for the most ideal situation under which construction of a large building or monument could take place. The information contained in those articles, will be analysed below in a number of case studies, to determine whether the majority of factors found in the account of the construction of the first Jerusalem temple were indeed present in the other places where these large buildings were constructed. Besides these, an article and books from other sources about the construction of some large buildings in antiquity will be used as further case studies. These are not based on information published by *National Geographic Magazine*, and thus can form a counterbalance to see if the same principles have been observed to apply elsewhere. The intention of this research is to find out whether the factors that are found in Solomon's account of the construction of the first temple, can also be applied to the other construction projects that will be analysed in the various case studies. In other words: do Solomon's factors apply and are the factors that are mentioned in I Kings 5, indeed the right ones that can be applied in general to construction projects in antiquity?

The sites that I have selected, are not all found in the biblical world, but have been chosen because they represent different times, are found in different locations and were built by different types of populations. As no other very large buildings were constructed in ancient Israel before Solomon's temple, that we know about, use needs to be made of other and older buildings such as at Göbekli Tepe to establish if the factors derived from the account in I Kings 5 can be applied universally. Besides that, the use of different types of stone materials was a determining factor in the choice of the sites. The site of Göbekli Tepe in present-day Turkey was chosen, because it represents the oldest temple built of large pillars of limestone in the world, which has been discovered up till now, and was built by hunter-gatherers, who did not yet have metal tools at their disposal (Mann 2011:39). Even though this site is not found in the biblical world, it is part of the so-called Fertile Crescent to which Israel also belongs (Mann 2011:42).

The site of the Orkney Islands located to the north of Scotland was selected, because of the use of a fine sandstone, which was used split in layers and not quarried in blocks (Smith 2014:32), of which no example in the biblical world has been found. The population that built it was agrarian in nature and also did not yet have metal tools available (Smith 2014:31, 35).

The case study on the Black Pharaoh's was included because they were the last Pharaohs who commissioned a significant addition to the temple of Karnak after having re-established peace in the whole of Egypt (Draper 2008:53). They are slightly connected to the biblical world, as they shared a common enemy, namely the Assyrians, with King Hezekiah of Judah, who they tried to help (see II Ki 19:9 and Is 37:9). The materials used for the addition to the temple at Karnak were limestone and sandstone. It also provided an opportunity to include the achievements of black Africans with respect to the construction of large monuments.

The construction of the Parthenon in Athens was used as a case study, because the two wars against the Persians had a major influence on the progress of the building enterprise, and the delay in getting the project completed, led to a considerable change in the design of the temple (Carpenter 1970:37). The material used for construction was marble, and the connection to the biblical world is that the apostle Paul visited Athens, as described in Acts 17:16-34, and must have seen the Parthenon in all its splendour. It was built by an urban and mercantile population.

The reconstruction of the Temple Mount in Jerusalem under King Herod was included because it brought the study back to the temple in Jerusalem and also to New Testament biblical times. Besides that, it is an example from the Roman Era, which brings it to the end of the technical aspects of stone working as described in the earlier chapters of this study. It was built by an urban population, for use by pilgrims. As was the case with Solomon's temple, the reconstruction of the Temple Mount was built with the local limestone.

The reason the case studies have been included in this thesis is to show that building large stone monuments is not just a matter of hewing stone blocks and putting these together to make a building. Economic, political, environmental, organisational and a whole number of other factors also play a role to make construction possible. These factors will be analysed in what follows, and as already stated in the above, are based on the information provided to us in the biblical account of the construction of the Solomonic temple in Jerusalem. The case studies might not give us a better understanding of the biblical text, but the biblical text and the criteria which have been distilled from I King 5, may help us to analyse the factors surrounding the construction of the other sites better. The intention is to understand whether the factors in King Solomon's account are the right ones. Are these factors indeed the most important factors in the construction of any large temple or monument? In other words, how authentic were the aspects of the construction of the First Temple, and was the account of I King 5 correct in what it attributes to King Solomon?

The factors that were established in 5.2 are:

- A situation of peace
- A common purpose
- The availability of enough manpower
- An administrative or organisational system to organise manpower
- Sufficient supplies of food
- Availability of materials
- Trade
- Construction technology
- Transport technology
- Tools
- Seasons and weather
- Safety

These will be analysed in what follows.

## 6.2 CASE STUDIES

### 6.2.1 Case Study 1: Göbekli Tepe

#### *6.2.1.1 Introduction*

The site of Göbekli Tepe is situated near the town of Şanliurfa in present day south-eastern Turkey, and its material culture is that of the Pre-Pottery Neolithic (PPN) period of the Near East (Schmidt 2011:917). It contains the oldest known temple, in fact the oldest known example of monumental architecture presently known, and dates to circa 9,600 BC (Mann 2011:39). The structure consists of rings of standing T-shaped pillars of limestone, with circular walls of stacked field stones of the same material in between the pillars (see reconstruction in Figures 2-6 and 6-1; use is made of the images produced by National Geographic, as the images in the chapter by Schmidt were vary feint, and were impossible to scan, due to the thickness of the handbook). There are probably about 20 sets of these pillared rings on this site, which have not all been excavated yet (Mann 2011:41). Some of the pillars are decorated with animal figures in bas-relief, and the largest pillars are sixteen to eighteen feet high and weigh from seven to ten tons with the largest weighing close to sixteen tons (Curry 2008:1; Mann 2011:41). The complex was constructed by people living in small bands as hunter-gatherers (Schmidt 2011:918), as there is no village or sign of permanent habitation near the site (Schmidt 2011:919). This is most unusual, as scientists until recently believed that the construction of temples and towers only took place after hunter-gatherers had started to live as farmers in villages (Mann 2011:49; Curry 2008:2). It is not known whether these people are related to any other or later inhabitants of this region.

These villages of farmers were believed to have become technologically more sophisticated, and their leaders, such as kings and priests then started directing their subjects to undertake large scale building projects. However, the structures found at Göbekli Tepe have put this hypothesis into doubt (Mann 2011:39-40). The leader of the excavation at Göbekli Tepe, Klaus Schmidt argues the opposite, namely that 'the extensive, coordinated effort to build the monoliths laid the groundwork for the development of complex societies' (in Curry 2008:2). In this case study the various criteria established in 5.2 will be used to investigate whether these apply to the builders of Göbekli Tepe when they were building their large structures.

#### *6.2.1.2 A situation of peace*

In order to build their circular temples, the various groups of hunter-gatherers that were living in south-eastern Turkey at that time, must have been in a state of peace with each other in order to co-operate in such a large building project. Nothing is known of any kind of war in that era. This is also deducted from the fact that the first fort in this general area was only built much later, namely in the 6th millennium BC and that no great upheavals or migrations took place in the Neolithic up to about 3000 BC (Zangger 2001:234).

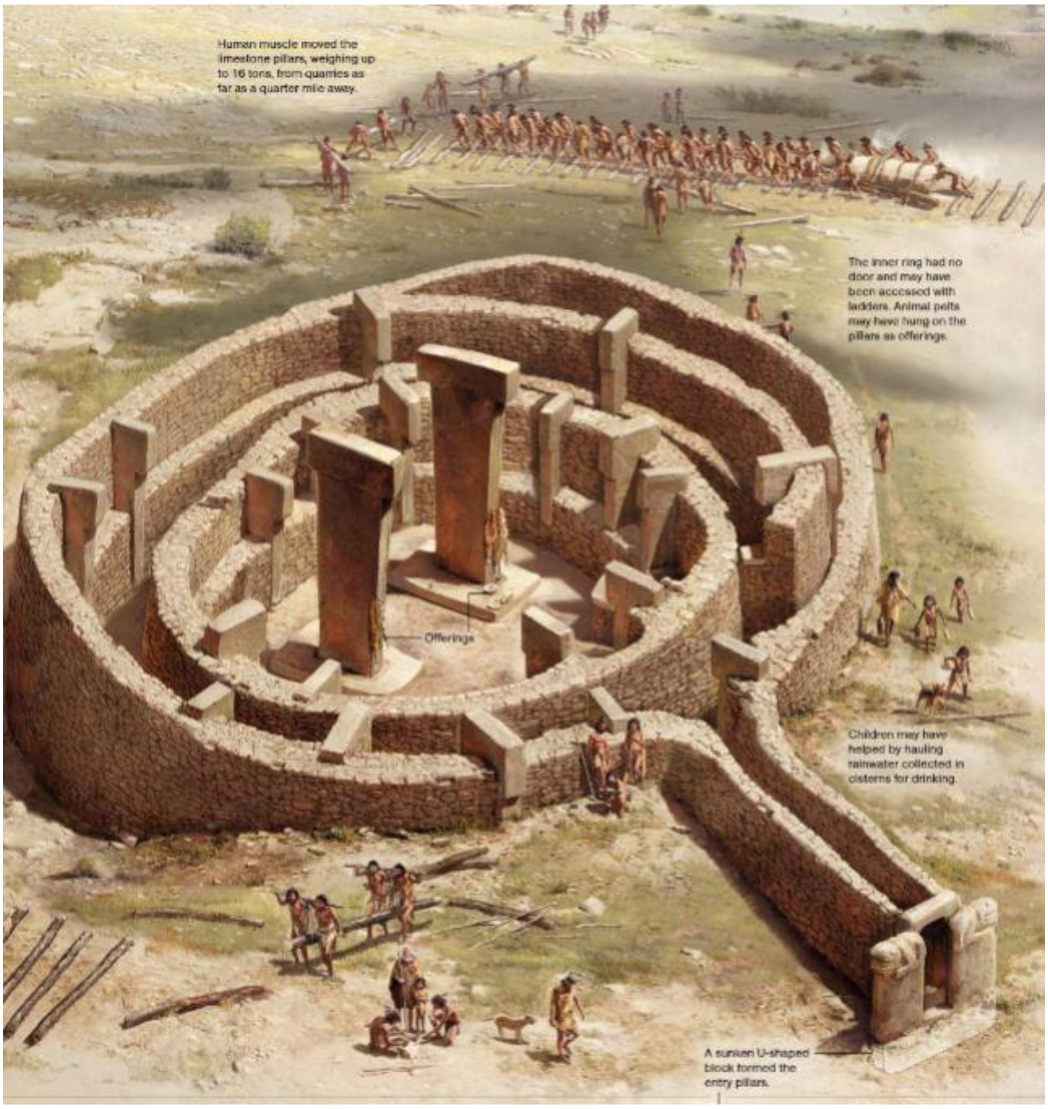



**Figure 6-1: Reconstructed image of the building of a circular temple at Göbekli Tepe, part of a larger complex which was constructed from 9,600 BC onwards (Mann 2011:44).**

#### *6.2.1.3 A common purpose*

Without a common purpose it must have been impossible for the hunter-gatherer groups to build the entire complex. The presence of a single strong leader seems unlikely (Mann 2011:48), but Klaus Schmidt is of the opinion that there must have been a complex, hierarchical social organisation, as well as a division of labour to bring about the craftsmanship to construct and maintain a site like this (Schmidt 2011:930).

#### *6.2.1.4 The availability of enough manpower*

Quite a few hunter-gatherer groups involving large numbers of people must have come together from afar (Mann 2011:44) and have worked together in order to construct a complex of this magnitude, especially in view of the size of the largest pillars (as stated, 16 to 18 feet and weighing 10 to 16 tons). No signs have been found by the excavators that there were groups of foreigners or slaves who were pressed into forced labour. Rather, feasting is presumed to have been the reason for the gathering of hundreds of individuals at the site (Schmidt 2011:930; Curry 2017:44).

As a comparison it can be mentioned that also at Stonehenge feasting may have been the main focus, but that this site is much younger than Göbekli Tepe, dating to 4,500 years ago. Prof. Mike Parker Pearson, who is professor of British Later Prehistory at University College London, and his fellow researchers there, have been coming to the conclusion that Stonehenge was the gathering place for annual rituals of the summer and winter solstice, as well as for the dead, in which feasting was an important aspect. The crowds that gathered there for that purpose would then also work on the construction of the site. This according to a documentary entitled, ‘Stonehenge decoded’, produced by National Geographic Television Incorporated, which was broadcast on television in South Africa on 16 September 2017, Channel 181.

The most recent research about Stonehenge has revealed through DNA testing of Neolithic human remains, that the builders descended from populations which had originated in Anatolia. They had migrated from Anatolia over time via two routes, one via the valley of the Danube and the other group via the Mediterranean coasts and by island hopping. The latter had reached Britain in about 4,000 BC, where they had introduced the building of megalithic monuments (Rincon 2019:1).

#### *6.2.1.5 An administrative or organisational system to organise manpower*

There must have been organisers and overseers for this complex endeavour, but so far no evidence of a social hierarchy, such as a living area for richer people, no tombs filled with grave goods for an elite, and no signs of some people having better diets than others, have been found as no villages have been found near the site (Mann 2011:48). Schmidt states that because of the amount of time, craftsmanship, manpower and energy devoted to the construction of this site, there must have been a hierarchical social organisation and a division of labour to organise the large numbers of people needed to build the structure (Schmidt 2011:930). Even though Schmidt does not provide a reason for his opinion, a recent presentation by Professor-Emeritus David Lewis-Williams of the University of the Witwatersrand in Johannesburg (at the Annual Symposium organised by the South African Archaeological Society Northern Branch at Delta Park in Johannesburg on 25 August 2018), can shed some light on this aspect. In his power-point presentation Professor Lewis-Williams showed that some of the rings at Göbekli Tepe had a single designated stone seat inside the ring with vertical stone elements on its sides, whereas all other seating was on a circular bench, which formed part of the stacked stone walls between the standing pillars. So, there was a seat of honour for just one person there[31].

#### *6.2.1.6 Sufficient food supplies*

As a result of the end of the Ice Age in about 9,600 BC, the climate had become warmer and wetter. This in turn brought about the growth of more vegetation on which wild game could feed (Mann 2011:41). Thousands of gazelle and auroch bones were found at the site, as well as wild ass and wild pig (Schmidt 2000:47), remains of the animals brought in from faraway hunts, to feed the workers, whose diet also consisted of plants that were gathered (Curry 2008:2; Mann 2011:48). A number of people were tasked with hunting and gathering food, while others were busy with the construction of the temples. There must have been food in abundance, but strangely enough no remains of mess kitchens or cooking fires have been found (Mann 2011:48). One of the puzzling aspects of the site is that there is no source of water nearby at present,

[31] Professor Lewis-Williams also informed me at the above-mentioned symposium that Klaus Schmidt unfortunately had passed away recently.

(the nearest source is about 5 kilometers away) and it is not sure whether water could have been found closer by during the time of construction of the circles (Mann 2011:48)

More recent research suggests that there was a totally different reason for the construction of Göbekli Tepe and that is that hunter-gatherers brewed beer there from the wild grasses (Curry 2017:44). Large barrel and trough shaped vessels were found in some of the smaller enclosures, the largest of which could hold 40 gallons of liquid and residues of oxalate were found in these vessels. The presence of oxalate could be indicative of the brewing of beer with grains (Curry 2017:39, 44). Moreover, the presence and early domestication of an ur-wheat called *einkorn* only a few miles away from Göbekli Tepe (Mann 2011:46, 57), may be pointing to the brewing of beer. It is thought that the hunter-gatherers congregated at Göbekli Tepe and were rewarded for their efforts of building the religious site with beer and meat from the hunted wild animals.

As already stated, it is now thought that the main reason for the domestication of grains may have been the brewing of beer instead of for making bread (Curry 2017:44). And Göbekli Tepe is not the only site where workers were provided with alcoholic drink, as the builders of the pyramids in Egypt also were provided with beer made from a mixture of wheat and barley, which was produced in industrial quantities by the state as early as 3,150 BC (Curry 2017:49; Morell 2001:90; Lehner 1997:237).

#### *6.2.1.7 Availability of materials for construction*

The pillars were hewn out of limestone (see Table 2-2), not such a very hard material, which was found in the surrounding hills, by means of flint tools (see 2.6.2). The workers would hew a T-shaped pillar by making use of the trench method (see Figure 3-8; Mann 2011:55), and then hauled it to the building site over a distance of up to a quarter mile, probably on wooden rollers (see Figure 5-9; Schmidt 2011:922; Curry 2008:2; Mann 2011:44, 54). The remains of a partially quarried pillar that had cracked, are still present at the quarrying site (Schmidt 2011:922; Mann 2011:55; see Figure 3-7). The pillars were shaped in a more refined manner on the building site (Mann 2011:44).

#### *6.2.1.8 Trade*

Research at the site so far has not found any trace of trade contacts, but the fact that the builders had supplies of flint and were able to work this material into tools (Mann 2011:41), may have made trade possible, for instance in exchange for food. As this site belongs to the Pre-Pottery Neolithic period, and no pottery has been found there (Schmidt 2011:917), it is unfortunately not possible to give an indication of the places they traded with.

#### *6.2.1.9 Construction technology*

The circles were made by erecting limestone pillars, shaped like capital T's. These were in size about five times as wide as they were deep. They were placed an arm span apart and were interconnected by low stone walls made of stacked field stones. Two taller pillars were placed in the middle, mounted in shallow grooves in the floor (see Figure 6-1; Schmidt 2011:922; Mann 2011:41). The engineering skills used were such, that the builders probably needed to have propped up the central pillars by means of wooden posts during the construction process (Mann 2011:41). The pillars were decorated with bas-relief images of animals (see Figure 6-2), as well as stylised humans, executed with remarkable artistic skill (Schmidt 2011:921; Mann 2011:48).

The images were most likely engraved with burins, which are prehistoric flint tools with a bevelled point, used for engraving (Merriam Webster 1977:148), which were found at the site (Schmidt 2011:918).

Over time the people at Göbekli Tepe added a new, smaller ring inside the earlier ring and after a few decades filled the entire ring with debris, after which a new ring of pillars was constructed. Strangely enough their building skills deteriorated over time, and the later circles are technically and artistically less sophisticated, for which no reason has as yet been determined (Mann 2011:48). If indeed the populations migrated westward out of Anatolia, as mentioned in 6.2.1.4, and started building large monuments elsewhere, this may account for the fact that the building skills at Göbekli Tepe deteriorated, because there were fewer people available to build at the site. A further point of interest is that the aurochs and deer, on which they depended for food, moved northward and westward as the ice disappeared (Spinney 2012:135), and the hunter-gatherer groups may have followed them in that direction. That may also account for the fact that by about 8,200 BC the building effort at Göbekli Tepe ceased completely. As already stated, a remarkable fact is that the people themselves would bury the pillars and fill a ring in with debris, and then would build a new ring again (Schmidt 2011:921; Mann 2011:48). The filling of one enclosure had a volume of at least 300 cubic meters (Schmidt 2011:921).

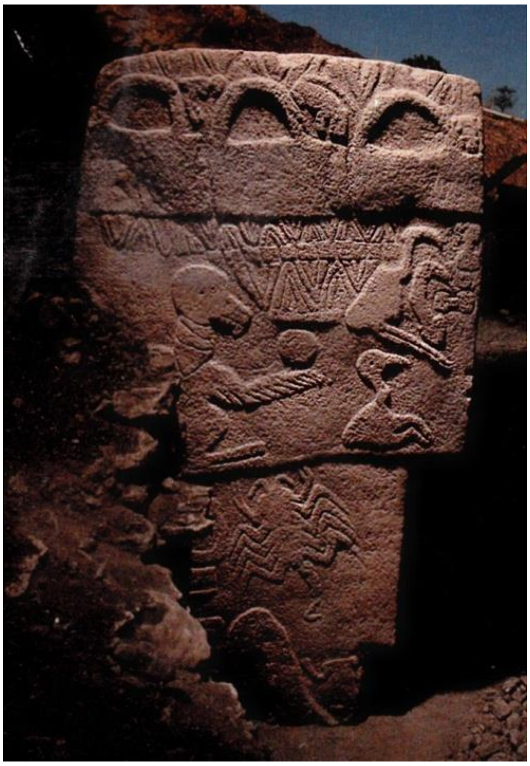


**Figure 6-2: Bas-reliefs of vultures, scorpions and other creatures on the T-shaped pillars at Göbekli Tepe (Mann 2011:54).**

#### *6.2.1.10 Transport technology*

The limestone pillars were hewn directly out of the bedrock and are assumed to have been transported by means of wooden rollers (see 3.3.2, and Figure 3-19; Mann 2011:44). Even though the site is rather barren at the present time with very little vegetation, the wetter weather around the time of construction may have supported more abundant tree growth in the area (Mann 2011:55). Cutting down the trees during the construction period may have also caused its present barrenness. The transport of these massive pillars is believed to have taken a huge, concerted effort (Schmidt 2011:921).

#### *6.2.1.11 Tools*

The builders at Göbekli Tepe most definitely had tools available. Klaus Schmidt, the archaeologist leading the excavation, reported that the site was littered with the greatest quantity of ancient flint tools (see 2.6.2.1), that he had ever seen. There were stone hammers and blades (Curry 2008:2), flint knives, choppers and projectile points (Mann 2011:41) and arrowheads, burins, end-scrapers, scrapers as well as notched and denticulated tools (Schmidt 2011:918). The raw flint originated from nearby valleys (Mann 2011:41), as there are no flint sources on the limestone plateau (Schmidt 2000:51). There also were a few tools of obsidian (see 2.6.2.2), but the majority was made of high-quality dark-coloured flint (Schmidt 2000:51; Schmidt 2011:919). As flint with a hardness of 5 is harder than limestone, which ranges in hardness from 3 to 4.5 (see 2.6.2), the tools were quite sufficient to get the job done.

Thin tree trunks were used as rollers for transport (see 3.3.2). The branches of the trees also had a purpose and served as levers (see Figure 3-11 and 3-12), both to lift the pillar out of the bed-rock, once it had been cut into shape, as well as to lift it enough to push the rollers underneath it (Mann 2011:44). Moreover, Schmidt (in Mann 2011:44) is of the opinion that wooden posts were used as supports for the largest pillars during construction, but were subsequently removed.

#### *6.2.1.12 Seasons and weather*

Whether seasons and weather had any influence on the construction of the site is not so easy to determine. We do know that the climate was wetter than at present (Mann 2011:40), so rain may have caused delays. At present it is very hot in summer there and in winter there is much rain, so the excavations have taken place in spring and in autumn (Curry 2008:2). Whether this pattern was the same at the time of construction is hard to tell. The mound of Göbekli Tepe is located at 785 meters above sea level, and is the highest point (Schmidt 2011:917). The quarry sites for the pillars are located in the surrounding hills and as this is not such a high elevation, it is not likely that severe winter weather would have caused much delay. Rain may have been a problem, as rain-soaked terrain would have made transport very difficult, if not impossible.

#### 6.2.1.13 Safety

Safety issues, such as flying chips and injuries during transport may certainly have occurred, but as no skeletal remains have been found at or near the site it is not possible to draw any conclusions in this regard.

#### 6.2.1.14 Conclusion

By applying the framework of the factors established in 5.2, we can conclude that quite a number of the conditions for the construction of a large monument were met at Göbekli Tepe. Even though the presence of an administrative or organisational system cannot be established conclusively, the builders must have been quite disciplined in their efforts to build the ring-shaped temples there and to have kept this up from circa 9,600 BC till 8,200 BC, which is a great accomplishment, especially when taking into account what basic kind of tools they had at their disposal.

### 6.2.2 Case Study 2: Orkney Islands

#### 6.2.2.1 Introduction

Even though the Orkney Islands are not part of the ancient Near East, as they are located to the north of Scotland, the Neolithic structures that were built there from about 3,200 BC onwards, form part of a remarkable religious complex, which is older than Stonehenge and which dates to about 2,500 BC. The example of the Orkney Islands has been chosen for analysis, because the material that was used to build the various structures there, is fine sandstone which occurs in layered form (see 2.2.2; Figure 2-1), and was used split in layers, of which no other example has been found, which can be analysed in the ancient Near East. Other factors that influenced the choice, were the remoteness of this site, its location on an island, and the fact that the builders lived in an agrarian society. Whereas Göbekli Tepe in the previous case study was built by hunter-gatherers, the religious complex in the Orkney Islands was constructed by farmers and herdsmen (Smith 2014:27).

The complex consists of several parts which initially were considered to be individual monuments, located in an open ritual landscape (Card 2013:15). The Stones of Stenness and the Ring of Brodgar are stone circles dating to 3,200 BC (Smith 2014:27) and circa 2,500 BC respectively (Smith 2014:50-51). These are located in a straight line from each other at the far ends of the site (Card 2010:14). The village of Skara Brae dates to circa 3,100 BC (Smith 2014:34), the enormous chambered tomb at Maes Howe is more than 4,500 years old (Smith 2014:32). The Ness of Brodgar site, which was a sprawling religious complex, dates to between 3,300 and 2,300 BC and was in use for circa 1,000 years (Card 2013:16). The entire Ness of Brodgar is a narrow peninsula between the Loch of Stenness and the Loch of Harray, and forms a connection between the Ring of Brodgar and the Stones of Stenness (Card 2010:14). Both of these monuments are visible from the Ness of Brodgar site and the same is true of the tomb of Maes Howe, as well as two single standing stones, the Watch Stone and the Barnhouse Stone (Card 2010:14). On the middle of this narrow peninsula (see Figure 6-3) the latest excavation is taking place, which has yielded some amazing results.


**Figure 6-3: Map of Ness of Brodgar site with monuments surrounding it (https://nessofbrodgar.co.uk).**

The site of Skara Brae is not indicated on this map, but lies in a straight line from the Ness of Brodgar site to the north-west on the coast at the Bay of Skail (https://www.maphill.com/united-kingdom/scotland/orkney-islands/detailed-maps/road-map/). The Stones of Stenness and the Ring of Brodgar have been known for millennia, but the village of Skara Brae was only discovered as a result of a severe gale in 1850 (Oliver 2009:25), which removed some sand dunes along the Bay of Skail (Smith 2014:34). The Stone Age village, which was excavated there, consisted of a number of well-built homes, which were equipped with stone hearths, beds and cupboards (see Figure 6-4).

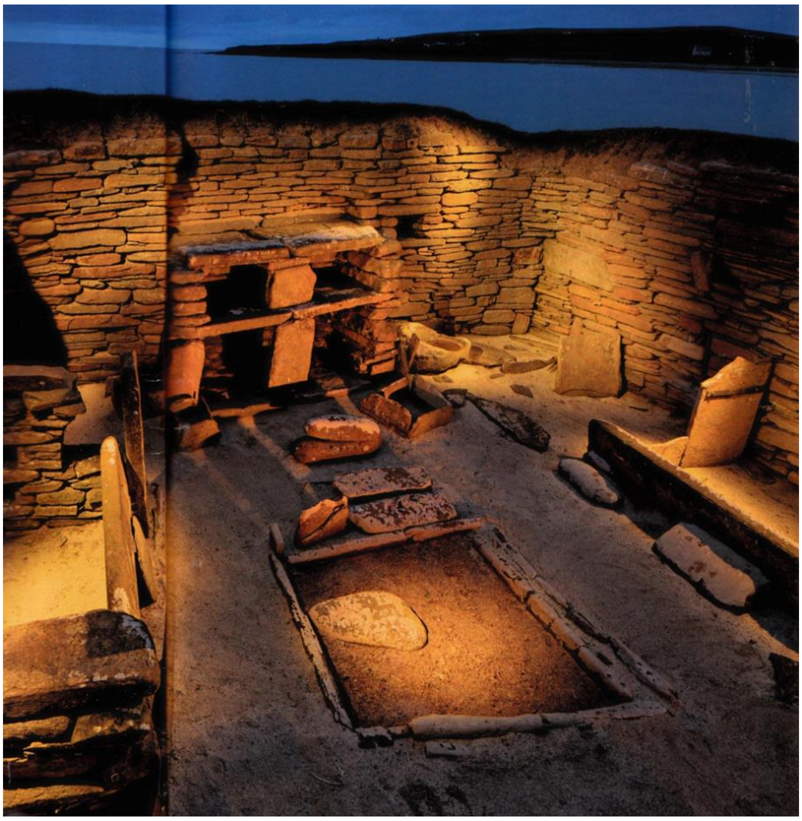


**Figure 6-4: Part of the interior of a well-built Stone Age home in Skara Brae on the Orkney Islands (Smith 2014:29).**

The houses were located closely together, interlinked by covered passages (Smith 2014:34). A thick layer of compacted waste was piled onto the outside of the houses to insulate them against the harsh winters (Oliver 2009:25-26).

At the south side of the bridge of Brodgar another Neolithic settlement was discovered and excavated in the 1980's by Colin Richards and was called the Barnhouse settlement. The houses of this settlement were also built of drystone, and were equipped with stone-slab beds, hearths, dressers and drains as well (Card 2010:14-15). This village dated to about 3,200 to 2,800 BC, so mostly to the same era as the ritual sites (Card 2013:15).

The circular tomb complex at Maes Howe has also been known to exist for millennia. It is a chambered tomb of which the 10-meter long entry passage is aligned to receive the rays of the setting sun on the eve of the winter solstice, so that the inner chamber is illuminated on the shortest day of the year (Smith 2014:32). It consists of a central chamber with three associated side chambers, and was used for multiple burials (Card 2010:15). The central chamber's roof is a high corbelled vault of 4.5 meters high and the two walls of the entrance passage were constructed of monolithic slabs (Card 2010:15).

The most recently found part of the entire complex, the Ness of Brodgar, was only discovered in 2002 after a survey (Card 2010:16; Smith 2014:34). It has been the subject of ongoing excavations since, in the summer months of July and August under the leadership of Nick Card (Card 2018a:44), and was found to have been surrounded by a massive wall (see Figure 6-5), on both sides of the complex. So far only about 10% of the Ness has been excavated, and there is the expectation that there is still so much more to discover. The site is deeply stratified and is a multiphase complex, which so far is unparalleled in this part of Europe (Card 2018b:21). It was initially thought that the site contained a few successive phases, but this turned out to be incorrect, as the development, which took place over generations, was 'fluid and organic', to quote the senior project manager Nick Card (Card 2013:16).

It is believed to have been a ritual center for seasonal rituals, feasts and trade, and consisted of a walled compound containing several large freestanding buildings, which had been constructed with sophisticated building techniques. These consisted of the use of opposed stone piers, to delineate internal space, and not all of the same configuration in each respective building (Card 2013:16). The buildings also contained carved stonework and coloured façades, and were connected by means of paved walkways (Card 2013:17; Smith 2014:32). The walling is of very high quality, whereby the builders made use of the natural fracture of the local stone, which produces flat vertical surfaces to stack well finished walls (Card 2013:17). Some of the walls were up to 4 meters thick (Card 2013:19). X-Ray Fluorescence (XRF) analysis of the coloured stone work in several buildings has shown that this was brought about by a rich iron content, probably haematite and/or ochre (Card 2013:17). The roofs were made of carefully trimmed rectangular stone slates (Card 2013:18; Smith 2014:32, 37). There was a standing stone in the center of the complex (Card 2018b:22), which was aligned with the spring and autumn equinoxes.

**Figure 6-5: Overview of the Ness of Brodgar site (Image by Hugo Anderson Whymark; https://www.nessofbrodgar.co.uk).**

The complex was in use for at least 1,000 years (Smith 2014:36), and from about 2,400 BC it was noticeable that the site was going down (Card 2018a:44), after which it was decommissioned and partially destroyed in circa 2,300 BC for reasons still unknown, by the local people themselves (Smith 2014:49). More than 400 cattle were slaughtered for the event, which would have been sufficient to feed thousands of people (Smith 2014:49). The remains of these cattle were placed around the monumental Structure 10, which was the last major building on the site. These cattle were very large, measuring 1.8-meter tall at the shoulder, and bones were also found at various places across the entire site (https://www.nessofbrodgar.co.uk/neolithic-bull-putting-in-appearance-at-county-show/).[32] Nick Card is of the opinion that this was no ordinary settlement, in view of the scale and the complexity of the buildings, as well as the large wall, which surrounded it (Card 2018a:45). There also is a lack of food processing evidence. This was a place for feasting and celebration (Card 2018a:45).

It is interesting that both this ritual center, as well as the successive temple circles at Göbekli Tepe of the previous case study, were decommissioned by the very people who built and used these complexes (Schmidt 2011:921). Considering what was written in 6.2.1.4 about the recent DNA research, which showed a link between the megalith builders in Britain and their Anatolian origins, the site on the Orkney Islands is probably one of the furthest areas that was reached by these migrating builders. The decommissioning of the site may have been part of normal sequence of events pursued by these builders. More can be read about the excavation and images are available at: https://www.nessofbrodgar.co.uk, which is the official website of the dig.

An analysis of the factors conducive for the construction of large monuments as established in Chapter Five (see 5.2), applied to this site, brings us to the following conclusions:

#### *6.2.2.2 A situation of peace*

From the fact that there was extensive trade between the islands and the mainland, it can be deducted that there must have been a prevailing situation of peace in the Orkney Islands (Smith 2014:46). Also, the houses found at Skara Brae and at the Barnhouse settlement, show that these were well-built and snug, containing hearths, beds and cupboards (Oliver 2009:25-26; Card 2010:15). The people who lived there, were secure in their dwellings and led a refined life (Smith 2014:28-29). There is even evidence that there was a channel with running water passing by each house (Oliver 2009:26).

Carved stonework, which consists of more than 80 separate panels of finely incised Geometric art (Card 2010:19), coloured façades, slate roofs (of all these aspects

[32] The information about the cattle was given on the Ness of Brodgar website in connection with the display of a cut-out image of the cattle's size, at the county show in Kirkwall on 9/10 August 2019, where information about the Ness of Brodgar excavation was also on display.

images are available on the website https://www.nessofbrodgar.co.uk)[33] and paved walkways at the site of the Ness of Brodgar, are all an indication that there was a situation of peace, which enabled the builders to build without interruption or threat. There was even time to decorate (Smith 2014:32).

At the end of the 2019 excavation season, the conclusion was reached that, 'the history of the Ness was being characterised by compulsive building, rebuilding, alteration and improvement. The place seems never to have stood still or been finished in any real sense' (https://www.nessofbrodgar.co.uk/dig-diary-wednesday-august-14-2019/). This too seems to be indicative of a situation of peace.

*6.2.2.3 A common purpose*

Many thousands of tons of the fine-grained local sandstone were quarried, trimmed and dressed (Card 2013:18; Smith 2014:32), and in order to do so there must have been a common purpose among the estimated circa 10,000 inhabitants of the islands to build a complex of this nature (Smith 2014: 48), and to keep it going for 1,000 years (Smith 2014:36).

*6.2.2.4 The availability of enough manpower*

The islanders themselves built the complex, as there were no slaves to fulfil the task. No mention is made by Nick Card, that signs have been found to indicate the existence of a stratified society, with like for instance bigger houses for the rich and smaller houses for the poor. Smith states that there were plenty of willing hands and strong backs to put to the cause of building these monuments (Smith 2014:48).

*6.2.2.5 An administrative or organisational system to organise manpower*

The farmers and herders on the Orkney Islands in all likelihood made up a more cohesive and close-knit society than the hunter-gatherers who built Göbekli Tepe, which were analysed in the previous case study (see 6.2.1), as they were a settled population and to an extent confined to these islands. As such it was probably easier to organise the construction of the various sites. No trace of a ruling or priestly class has been found.

[33]As all images are copyrighted, I do not dare to use more of them than I have already inserted.

#### *6.2.2.6 Sufficient food supplies*

Due to the mild climate as a result of the Atlantic Gulf Stream and the fertile soil, there was an abundance of agricultural wealth (Smith 2014:31). The farming soils were some of the richest in Britain (Smith 2014:47) and Orkney's farmers were among the first in Europe to deliberately manure their fields in order to improve their crops (Smith 2014:49). Cattle, sheep, goats and possibly red deer were brought from the mainland by skin boats and enjoyed rich grazing (Smith 2014:49). Cattle were of major importance at the Ness of Brodgar complex, where many bone-remains have been found, especially at structure 10 (Card 2013:17). Besides that, pottery evidence shows that beef and dairy made up a large part of the Ness of Brodgar diet (Card 2018a:45).

#### *6.2.2.7 Availability of materials for construction*

For the construction of all the elements of the entire larger complex, the local layered, fine-grained sandstone (see Table 2-2) was used. Thousands of tons were quarried on the island, trimmed and dressed with impeccable skill (Card 2013:18; Smith 2014:32). Material was obtained from various quarries on the island, at Harray, Orphir, Sandwich and Stenness (private communication Nick Card, 30 August 2019). Unfortunately, no images of the quarries are available, but Figures 6-6 and 6-7 show the layered nature of the sandstone.

Also coarse-grained red and yellow sandstone was sourced several kilometres from the site, and these coloured sandstones were found in some important places in Structure 10. Of further interest is that the surfaces of these particular pieces of stone had been pick-dressed (Card 2013:18).

Some of the roofs of buildings at the Ness of Brodgar were covered with overlapping slabs of stone as a slate-like covering. This is the case with Structure 8 and also the Structures 1 and 12 may have had this covering (Card 2013:18). Stone covering of roofs is an extravagance, in view of the fact that in that age roofs were normally covered with sods, hides or thatch (Smith 2014:32).

**Figure 6-6: Image showing the layered nature of the sandstone materials on the Orkney Islands (Image: Sigurd Towrie; https://www.nessofbrodgar.co.uk).**

**Figure 6-7: A more close-up image of the layered sandstone that was used on the Orkney Islands (Image: Sigurd Towrie; https://www.nessofbrodgar.co.uk).**

As sandstone is a fairly soft material, there was no difficulty working these with flint tools. For the purpose of decorating the buildings with colourful designs, there were pigments such as ochre, hematite and galena, which were ground. An area where these pigments were prepared was found in a corner of Structure 10 during the excavations in 2011 (Card 2013:17; Smith 2014:46).

*6.2.2.8 Trade*

Despite their very northerly location, there was extensive trade between the islands and the mainland (Smith 2014:46). In fact, Orkney was an important maritime hub, from which many places could be reached (Smith 2014:47). Items originating from far afield have been found during excavations, such as volcanic glass from the Isle of Arran located on the west side of Scotland and flints from the east coast of England of high quality (Card 2013:17). The islands produced distinctive coloured and grooved pottery, of which remains have been found throughout Neolithic Britain (Smith 2014:46). In fact, Grooved Ware pottery with a very wide range of designs was found at the site, representing almost all types found at different sites across the Orkney Islands (Card 2010:19).

*6.2.2.9 Construction technology*

As the sandstone was of a layered variety (see also Figure 6-7), it was not quarried in blocks, but in slabs, by splitting the layers with wooden wedges and hammerstones (private communication Nick Card, 1 September 2019). The smaller pieces of stone were stacked to construct walls (Wernick 1974:99), and larger slabs served as shelves for cupboards and as beds in the houses of Skara Brae (Smith 2014:28-29; see Figure 6-3), and at Barnhouse (Card 2010:15). Large slabs of up to 4 meters long laid on edge were used to support orthostats (which are upright standing stones), used to clad the interior (Card 2018a:47). The tallest slabs were used as the upright standing stones of the Ring of Brodgar and the Stones of Stenness (Smith 2014:26), as well as for the construction of the tomb at Maes Howe (Smith 2014:40-41). How the standing stones were erected is not referred to in the articles consulted, but the explanation may be the one shown in the programme ‘Stonehenge decoded’ about the construction of Stonehenge, which was mentioned in 6.2.1.4. The stone for the pillar would be brought on rollers to the site where it was to be positioned, and where a hole had been dug already. Then ropes would be slung around the top of the stone, which would be pulled upright, whereby the foot of the stone would slide into the hole. Once it was standing upright, the hole would be filled with soil to keep the stone standing up.

### *6.2.2.10 Transport technology*

The material was transported over a distance of several miles (Smith 2014:32), but no indication is given by Smith of how this was achieved. As there were no solid blocks to transport, but only larger and smaller slabs, these must have been much easier to move to the building sites due to their lighter weight (in comparison with blocks) and smaller dimensions. Also, due to the fact that sandstone has a lower specific gravity of 1.75 to 1.95, than for instance granite at 2.75 (Shadmon 1996:20; see 2.5), the material was lighter and therefore probably easier to transport as well. Maybe the cattle that were present on the islands (Smith 2014:49) were used to transport the stones, the smaller pieces loaded on their backs, or piled on litters to be dragged, and the larger slabs may have been dragged. This is still being investigated after the discovery of 'drag marks' on slabs at the excavation site, which Director Nick Card believes to be relating to either the quarrying or transportation of these stone slabs (https://www.nessofbrodgar.co.uk/dig-diary-monday-august-19-2019/). The use of wooden rollers to transport the slabs is a possibility (see Figure 3-19), although the islands do not have trees due to their northerly latitude, but driftwood has been used extensively from ancient times right through to the historic period (Fenton 1997:11). Another possibility is that a track of seaweed was used to slide the slabs over. This was tried out experimentally for the BBC2 TV documentary 'Britain's ancient capital' (private communication Nick Card, 30 August 2019).

### *6.2.2.11 Tools*

The excavations at the site have yielded countless artefacts, among which polished stone axes, mace-heads and flint (see 2.6.2.1), knives (Card 2010:19; Smith 2014:35) as well as high-quality flints from across the archipelago and beyond (Smith 2014:46), and pitchstone, which is a volcanic glass from the island of Arran (Card 2010:19), so the builders did have tools available. In order to extract the stone from the quarries, it is believed that wedges and hammerstones were used (private communication Nick Card, 1 September 2019). I hold it possible that the larger slabs were extracted by inserting long wooden poles in the openings made with the wedges and hammerstones, and that they were loosened by means of levering (see Figures 3-11 and 3-12).

*6.2.2.12 Seasons and weather*

The mild climate resulting from the Atlantic Gulf Stream made for pleasant summers (Smith 2014:31), but the winters were harsh, as can be deducted from the manner in which the houses at Skara Brae were constructed, all snugly huddled together with narrow walkways between them (Wernick 1974:101), and insulated from the cold by a layer of compacted waste (Oliver 2009:25-26). From this we may deduct that the work to quarry the material as well as the construction of the various sites probably was mostly done during the months of clement weather.

*6.2.2.13 Safety*

As no physical remains of the builders have been found, no conclusion can be drawn on whether there were any safety issues. From personal experience it can be stated that a split layered material is prone to have sharp edges and can cause skin cuts when handled. In the absence of heavy solid blocks of material, really serious injuries caused by hauling blocks would have been less likely to occur.

*6.2.2.14 Conclusion*

From this analysis the conclusion may be drawn that the template of factors, as developed for the building of the Jerusalem temple under King Solomon, based on the biblical account in I Kings 5, was already applicable in Neolithic times on the Orkney Islands and that the combination of factors were mostly the exact ones required for the construction of large monuments. The only factor that does not seem to be very prominent is the existence of a strong administrative and organisational system. As for safety issues, there is no information available for this site.

### 6.2.3 Case Study 3: The Black Pharaohs of Egypt and the additions to the temple at Karnak

*6.2.3.1 Introduction*

It is not a very well-known fact that among the various dynasties of Pharaohs who ruled over Egypt, there also was a period when several black Pharaohs reigned. This already began when the Nubian King Kashta (circa 770-circa 747 BC; Wilkinson 2005:123) pushed into the south of Upper Egypt and extended his rule northwards till Aswan, where he left a stela (Blyth 2006:192). An overview of the reign of these black Pharaohs will be given first, after which their additions to the temple complex in Karnak will be discussed and mention will be made of some other places where they built monumental temples.

The African civilisation of the Nubian kings had already flourished along the upper reaches of the Nile for 2,500 years, dating back to the time of the First Egyptian dynasty. By the Sixth dynasty diplomatic, cultural and economic relations between the Egyptian court at Memphis and what was termed 'the land of Yam' were customary (Bonnet & Valbelle 2005:11).

The son of Kashta, Piye (or Piankhy), extended his father's rule further northwards into Upper Egypt till Thebes, and claimed kingship there, even though Takeloth III still ruled over the Delta (Blyth 2006:192). While Piye was ruling over Upper Egypt and also had already ruled as king over Nubia for 20 years, he invaded Lower Egypt in 730 BC (Draper 2008:38). At that time Egypt was torn apart by feuding war-lords. King Piye and his well-trained men sailed northwards on the Nile River and within a year had subdued all the warlords. This included the most powerful one, Tefnakht, who controlled the delta (Wilkinson 2005:187; Draper 2008:38; Bonnet & Valbelle 2005:13). Piye then packed up his war booty and sailed back to Nubia. He did not consolidate his conquests, but left his sister Amenirdis as God's Wife of Amun-elect to hold power in Karnak, where Shepenwepet, the sister of Takeloth III was still the official God's Wife of Amun (Blyth 2006:192: Wilkinson 2005:187). Piye died in Nubia at the end of his reign in 715 BC (Draper 2008:38). When exactly or where he became Pharaoh, is not clear, but with him the 25th dynasty began, which saw Egypt ruled for three-quarters of a century by a series of Nubian kings. They reunified Egypt, creating an empire that stretched from the present-day Khartoum all the way to the Mediterranean Sea (Draper 2008:39). During this period, they built many monuments which still inhabit the landscape, such as the numerous pyramids in the Sudan (Draper 2008:39), as well as made extensive additions to the temple at Karnak (Draper 2008:53, 58; Blyth 2006:197-200).

After the Nubian King Piye's death, his brother Shabaka succeeded him (Draper 2008:44). He put his foes to work building dikes to protect Egyptian villages from Nile floods (Draper 2008:44). Thebes and the temple of Karnak at Luxor were the scene of lavish building projects (Draper 2008:44). Shabaka restored the 'golden' porch, built by Tuthmosis IV of the 18th dynasty, by covering it with gold plating again (Blyth 2006:194), and built a Treasury and a House of Gold at Karnak (Blyth 2006:194). Shabaka's rule lasted for fourteen years, after which he was succeeded by his nephew Shabitku, another son of Piye (Blyth 2006:195). During the reign of Shabitku, the Assyrians became a threat from the north and in 701 BC, when the Assyrians marched into Judah, the Nubians decided to intervene. Shabitku sent his younger brother Taharqa to deal with this threat (Blyth 2006:195). It resulted in the battle of Eltekeh, which the Assyrians claimed to have won (Draper 2008:48). Nevertheless, Taharqa survived. He is referred to in the Bible as Tirhaka, a son of Piye (Draper 2008:48), and came to the rescue of King Hezekiah of Judah as referred to in II Kings 19:9 and Isaiah 37:9. Taharqa's influence on Egypt was impressive and could not be eradicated (Draper 2008:48-49).

After the death of Shabitku, Taharqa received a crown in Memphis in 690 BC and ruled over the combined empire of Egypt and Nubia for 26 years (Blyth 2006:196). An impressive dark grey granite statue of Taharqa was found during excavations of a cache at Doukki Gel in Nubia in January 2003 (Bonnet & Valbelle 2005:70). His head was covered with a typical Kushite skullcap, decorated with the double uraeus (Bonnet & Valbelle 2005:89), which is the symbol of authority over both Lower and Upper Egypt. That the statue was of Taharqa was clear, as Taharqa's name was inscribed on his belt (Bonnet & Valbelle 2005:91). Even though the statue was found broken into several pieces, now reconstructed it is magnificent and shows a very powerful man (Bonnet & Valbelle 2005:88; see Figure 6-10).

**Figure 6-8: The entrance porch, consisting of ten large columns, which King Taharqa added to the Great Temple of Amun at Karnak (Draper 2008:41).**

Pharaoh Taharqa undertook a most ambitious building programme and the two capitals of Thebes and Napata were the main beneficiaries of this effort (Draper 2008:53). His main achievement was the addition of an entrance porch of ten large columns to the temple of Amun at Karnak (Draper 2008:40-41; Blyth 2006:197). These open-papyrus columns were each 18.87 m high (Blyth 2006:197; see Figures 6-8 and 6-9). The temple of Amun at Karnak was in fact a series of temples, which were built over several centuries by consecutive Pharaohs (Blyth 2006:1). The last Pharaoh before Taharqa, who had made a contribution, was Sheshonk (945-924 BC; Blyth 2006:xxiv), who had added a court of about 9,000 m2 in front of the Second Pylon in Karnak (Blyth 2006:188), but nothing major had been added for 200 years until the addition of the massive porch of Taharqa (690-664 BC; Blyth 2006:xxiv), which was erected in this courtyard of Sheshonk, in front of the Second Pylon (Blyth 2006:197).

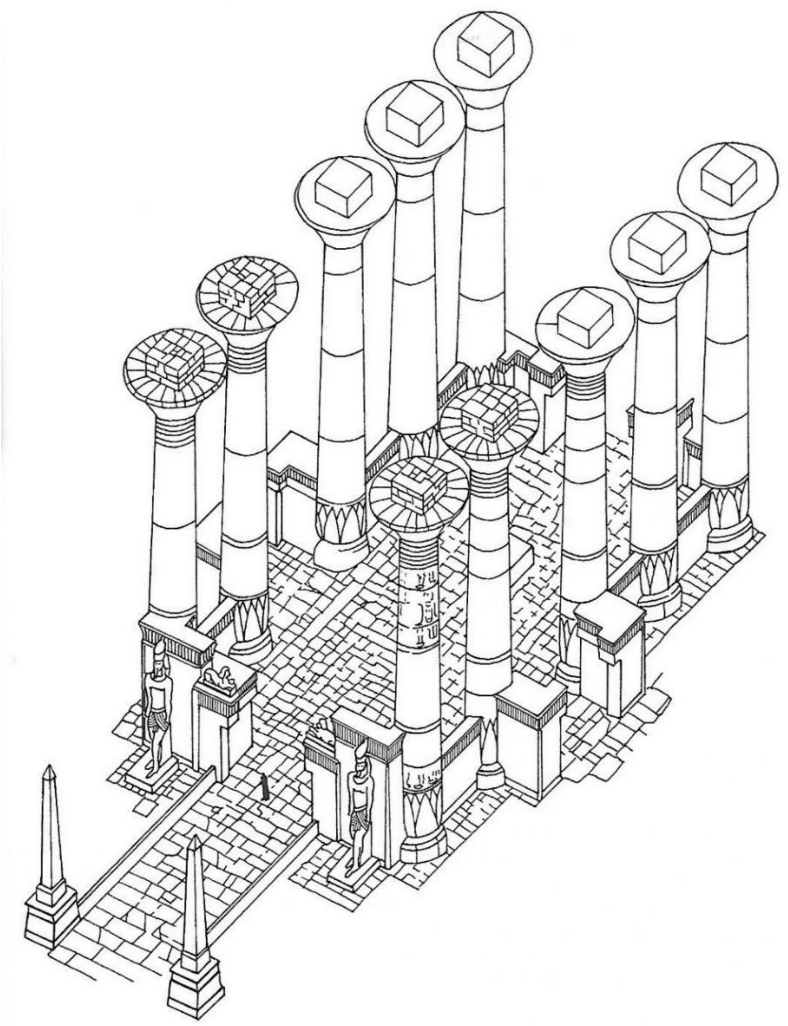


**Figure 6-9: Artist's reconstruction of Taharqa's porch (Blyth 2006:199).**

It is sometimes also called 'the kiosk of Taharqa', but this is incorrect, as a kiosk would have been roofed. With a width of 16.25 meters, it was impossible to roof this porch, even with timber (Blyth 2006:197). It has been speculated that this open structure may have served for solar rites in the open air (Blyth 2006:197). It was paved with red granite and the columns were built of small limestone blocks (Blyth 2006:197). These blocks had to be held together with a mortar, and this is visible on the small remains of the pillars in Figure 6-8. What this mortar consisted of I have not been able to establish. The porch also contained an alabaster block in the center, which is believed to be an altar, and which predated Taharqa (Blyth 2006:197).

Besides this large porch at the temple of Amun in Karnak, it is interesting to mention that Taharqa also added smaller porches to the main entrances of other temples, which were part of the Karnak temple complex, namely those of Montu, Khonsu, Mut and the Eastern temple of Amun-Re-Horakhte (Blyth 2006:200).

Taharqa also built another building, of which not much is left above ground, but of which interesting rooms underground have been excavated, called ‘The Edifice of the Lake’ (Blyth 2006:202). It was located near the Sacred Lake, and was built upon a platform of sandstone blocks, measuring 29 x 25 m. This building was in all likelihood part of a cult of water (Blyth 2006:202-203). It may be concluded that Taharqa went on a veritable building spree at Karnak.

As the ruler over both Upper and Lower Egypt as well as Nubia, Taharqa did not only endow the temple complex at Karnak with new structures, but also his native Nubia. At Jebel Barkal near Napata in Nubia a temple was built which was dedicated to the goddess Mut, the consort of Amun (Draper 2008:50-51; Bonnet & Valbelle 2005:53). This entire building programme was made possible by a number of factors, and will be analysed below with the use of the template as determined in section 5.2.

#### *6.2.3.2 A situation of peace*

Due to the intervention by King Piye in Lower Egypt to subdue the bickering warlords (see 6.2.3.1) and the efforts by his successors Shabaka, Shabitku and Taharqa to rout the Assyrians, lasting peace was restored to the entire region (Draper 2008:53; Wilkinson 2005:186, 226, 237). The efforts of these Nubian kings reunified a tattered Egypt (Draper 2008:38). This made it possible to undertake the extensive building programme as outlined in the above.

#### *6.2.3.3 A common purpose*

The intervention by King Piye to free Egypt of its warlords had not just been his own initiative, but had been at the behest of the priests at the temple of Karnak. Due to the fracturing of Egyptian society, the devotion to Amun had become rather diminished. The priests looked south to find help in restoring order in Egypt and asked King Piye for help. Due to the fact that in earlier times Nubians had been educated in Thebes and had taken over the spiritual and cultural customs of Egypt, they had preserved Egypt’s spiritual traditions better than Egypt itself at that time (Draper 2008:44).

This powerful alliance of the military power of King Piye and his successors, with the spiritual power vested in the priests of the temple of Amun at Karnak, created a common purpose to undertake the lavish building programme, which entailed projects in various places, in the entire combined empire (Draper 2008:44). Another important factor was the fact that Pharaoh Taharqa was a devout worshipper of Amun, and wanted to add a spectacular addition to the temple of Amun at Karnak (Blyth 2006:196).

#### *6.2.3.4 The availability of enough manpower*

The Egyptian civilisation was structured from early days onward in such a way that the Pharaoh was at the pinnacle of society as both god and king. He in turn was supported by high officers, to whom his authority was delegated, and underneath this level, a vast bureaucracy functioned which could order workers and peasants to do their bidding (Casson 1966:12). This hierarchy functioned more or less throughout the entire Egyptian era, and had its origins in the efforts to tame the Nile by building dikes, canals and irrigation projects to reclaim more arable land (Casson 1966:12). This system was extended to undertake the massive building projects throughout Egypt (Casson 1966:13). During the months that the Nile was in flood, it was impossible to till the fields, and this was the time that labourers would be drafted to come and work on construction projects (Casson 1966:14). Egypt basically knew three seasons: 'Inundation', which was the time of flood, from about June to September and this was when the workers were required to work on the Pharaoh's building projects (Casson 1966:31). Then 'Emergence of the fields from the water', which started in October and went on till February, leaving the fields moist for cultivation, so this is when planting took place. After this there was the season of 'Drought', from February till June, during which the harvest was brought in and threshed and then the cycle started again (Casson 1966:31).

Besides these general workers, there also existed a class of more specialised workers, such as masons, carpenters and artisans, as well as specialists such as sculptors, painters and cabinet makers, who could apply the finishing touches to a temple (Casson 1966:14). From this we may conclude that there was an elaborate system by which enough manpower could be called up.

#### *6.2.3.5 An administrative or organisational system to organise manpower*

As has already been discussed under the previous heading, there was an administrative or organisational system to organise manpower, and this also existed in the time of the Nubian Pharaohs. For instance, King Piye could order an army under his command to sail for Lower Egypt to restore order, so this indicates that there was an organised and trained army. In fact, he ordered his commanders to: ‘Harness the best steeds of your stable’ (Draper 2008:38). The fact that his brother and successor Shabaka organised the building of dikes to protect Egyptian villages against the Nile flooding, indicates that there was an organisational structure to achieve this (Draper 2008:44). In fact, we saw in the previous section that the building of dikes was the origin of organising manpower (Casson 1966:12). This function was extremely important because it could make the difference between abundance of food or famine (Casson 1966:31), and the fact that there was renewed effort to rebuild dikes under the Black Pharaohs, indicates that this had been neglected in the preceding period. We see here a restoration of good governance, which made the building projects possible, because manpower could be made available, which did not have to be used to repair flood damage, or for which there were no food supplies. Besides this all, the priests at Karnak must have had an organisational and administrative system in order to maintain the temple complex at Karnak. They were the ones who had called on the Nubian Kings in 730 BC to come and restore order in Egypt (Draper 2008:44).

#### *6.2.3.6 Sufficient supplies of food*

As already referred to in section 6.2.3.1, under the rule of Pharaoh Taharqa there was abundant rain and flooding, which brought about a bumper harvest. Especially in year six of his reign there was a catastrophic flood. Despite the damage that was caused, Taharqa recorded the event on a number of stelae, one of which is in the temple of Kawa in Nubia (Blyth 2006:196). On this stela Taharqa announced that the flood ‘had caused the cultivation to be good’, that it had ‘slain the rats and snakes’, ‘kept away the devouring of locusts’ and had given Egypt ‘an incalculable harvest’ (Blyth 2006:196). The reason that the villages did not flood as a result, was because Taharqa’s uncle Shabaka had had dikes built around the villages to protect them from potential flooding (Draper 2008:44, 53). Taharqa had the height of this flood also recorded upon the west face of the quay at Karnak’s entrance. Besides this, four other

Nile flood levels were recorded here by Taharqa during his reign (Blyth 2006:196). The annual flooding of the Nile brought a layer of silt, called 'black land' by the Egyptians, which provided fertility to produce crops. A good level of flooding made sure that more land could be planted to produce crops (Casson 1966:31). With all the good floods in Taharqa's time, there were plentiful harvests, so there were sufficient food supplies to feed the workers who built additions to the temple at Karnak, as well as for all other building projects. How many people would have to be fed is not so easy to determine. Dodson (2003:10) is of the opinion that the ancient population of Egypt was not very large. He states that in the time of the New Kingdom, from the 16$^{th}$ to the 11$^{th}$ centuries BC, the population amounted to about two million people, and possibly to about 5 million in Roman times (Dodson 2003:10). That means that in the time of the Nubian Pharaohs there probably were about 3 million mouths to feed, which is still a considerable number.

#### *6.2.3.7 Availability of materials for construction*

From the account in 6.2.3.1 it has become clear that a number of different materials were used for the various additions to the temple at Karnak. They originated from different places.

In Upper Egypt there was red/pink granite at Aswan (Wilkinson 2005:236; Malacrino 2010:28; see 3.2.5.2), which was used by Shabaka to erect a statue of himself at Karnak, depicting him wearing the Kushite crown of the double uraeus, which was an indication of his legitimacy as Lord of the Two Lands (Draper 2008:44). This red/pink granite was also used for the paving of Taharqa's porch (Blyth 2006:197).

Then there was black gabbro, a type of granite, in Nubia, which was used to build a multitude of pyramids in the desert near Meroë (Draper 2008:56-57). The same material was also used for statues up to ten feet high of Nubian kings, which were recently found, buried at Doukki Gel outside the Nubian capital at Kerma (see Figure 6-10; Bonnet & Valbelle 2005:27; Draper 2008:42-43).

**Figure 6-10: Part of the broken statue of Pharaoh Taharqa (Bonnet & Valbelle 2006:89).**

Moreover, there was limestone, quarried from the cliffs bordering the floodplains of the Nile (Wilkinson 2005:236), which was used to build the pillars of Taharqa's porch as well as the temple for the goddess Mut at Jebel Barkal (Draper 2008:50-51). Limestone was also used to repair the temple walls at Karnak after the massive flood (Blyth 2006:196).

In the south of Upper Egypt, the geology changes and there, sandstone is found along the banks of the Nile (Wilkinson 2005:236). This was the material used for the foundation platform of the Edifice of the Lake, and it most likely originated from the massive sandstone quarries at Gebel-el-Silsila, which were located on both banks of the river Nile, about 65 km north of Aswan between Edfu and Kom Ombo, (Kucharek 2012:2; https://artsandculture.google.com/entity/m06sj9l), where the river is very narrow (http://isida-project.org/egypt_april_2017/aswan_silsila_en.htm; Wilkinson 2014:69).

Alabaster, as used for the altar block in Taharqa's porch, was found in various places in Egypt, such as at Hatnub (see 3.3.5), as well as in El Qawatir near el Minya, Wadi Barshawi, Wadi el-Zebeida near Amarna and near Wadi el-Asyut (De Nuccio & Ungaro 2002:241).

So, in fact quite a number of different materials were used.

### *6.2.3.8 Trade*

Nubia already had an established trade network long before King Piye entered Egypt to rid it of its strife. The Nubians traded in gold, ebony and ivory (Draper 2008:40). Under Pharaoh Taharqa there also was trade with the Levant, which saw a steady supply of juniper and cedar arriving in Egypt for use in the various building projects (Draper 2008:58).

### *6.2.3.9 Construction technology*

As stone had already been quarried and used in Egypt for the construction of monuments for millennia, it is probably correct to assume that there was still knowledge of technology for the construction of Taharqa's porch and other structures at Karnak. As already mentioned in 6.2.3.4 there existed a class of specialised workers in Egypt for the construction of various buildings. Besides that, a densely occupied urban center also already existed at Kerma near the Nile's Third Cataract, which has been excavated by the Swiss archaeologist Charles Bonnet, and according to him it had its own construction customs (in Draper 2008:40). So, both in Upper and Lower Egypt there was know-how of construction technology.

By the time of Taharqa's rule (from 690-664 BC; Blyth 2006:xxvi) there definitely were iron tools available elsewhere in the Middle East, which would have made the work easier than with copper or bronze tools. Iron tools would have worked with ease for the limestone, sandstone and alabaster, which are softer materials. What is intriguing is that the paving in Taharqa's porch was of pink/red granite, which means that the workers must have sawn this hard material into small slabs. That must have involved rather strenuous work. One wonders if diamond dust was used as an abrasive, together with saw-blades (see 4.2.6.4). Of which material these saw blades were made is not sure. The reason is, that even though there were some imported iron goods in Egypt, iron tools were scarce there. This was due to the fact that it was difficult for the Egyptians to develop iron-smelting themselves, as there was a chronic shortage of wood to make charcoal, which was needed for the smelting process (Shillington 1995:39). As a result of this, most tools were still made of bronze. This situation lasted till the invasion by the Assyrians in 670 BC, who easily defeated the

Egyptian army, as the Assyrians had iron weapons (Shillington 1995:39). This forced the last of the Nubian rulers of the twenty-fifth dynasty to withdraw back to Nubia, where in later times they developed an African Iron Age by moving south to Meroe, where there was both iron ore as well as hardwood to make charcoal, which was needed for the smelting of iron (Shillington 1995:40).

In the light of the above-mentioned considerations, it is very well possible that all the stone working at Karnak up to the time of Pharaoh Taharqa was done with bronze tools (see 2.6.3), which makes it an even more impressive achievement.

*6.2.3.10 Transport technology*

In Egypt there had been transport of items made of stone by means of ships down the Nile since the pyramids were built (Lehner 1997:202), as well as in the time of Queen Hatshepsut (Blyth 2006:54), and Pharaoh Seti I (Blyth 2006:152), and this most likely continued in King Piye's time and beyond, with the Nile as the main transport artery, so transport was available. The red/pink granite paving of the porch of Taharqa (Blyth 2006:197) most likely originated at Aswan, which was located up-river from Thebes (De Nuccio & Ungaro 2002:264), and river transport by ship would have been the easiest method to be used.

When quarries were located further away from the Nile, roads and ramps were used to bring the quarried material to the river for further transport (Bloxam 2005:25). What kind of vehicle was used for this transport is not certain, and archaeology has not been able to provide a definite answer on whether the transport was done with sledges or carts (Bloxam 2005:25).

The sandstone quarries at Gebel-el-Silsila are right on the banks of the river Nile and transport from there (http://isida-project.org/Egypt_april_2017/aswan_silsila_en.htm), would also have been easy over water. The Temple at Karnak was situated close to the banks of the Nile and had its own quay (Blyth 2006:210), which would have made off-loading of the stone materials quite easy.

*6.2.3.11 Tools*

As already discussed in 6.2.3.9, the presence of iron technology in Egypt may have been scarce in the time of the 25$^{th}$, Nubian dynasty, but there must still have been stonemason tools available, such as chisels (of bronze), hammers, measuring tools, sanding stones, etcetera, due to the fact that tools had been used in Egypt for the construction of buildings and monuments since at least the time of the construction of the pyramids. It is possible that the above-mentioned trade with the Levant (see 6.2.3.8) to obtain cedar and juniper may have been accompanied by trade in iron tools (see 2.6.4), as the Phoenicians were the traders in iron par excellence (Aubet 1993:61-62, 73). Unfortunately, no tools seem to have been found during excavations at Karnak, but I do not find that surprising, as stonemason tools were not difficult to transport and were most likely taken from one site to the next where work was to be done by the stonemasons themselves, or by the organising authorities.

*6.2.3.12 Seasons and weather*

The annual flooding of the Nile may have affected the construction of the various monuments, and necessitated repairs after flood damage (Blyth 2006:196), but the resulting deeper water of the Nile may also have been instrumental in the loading of heavy stone elements, as ships needed to be lowered with ballast in order to bring heavy blocks of stone on board (Lehner 1997:202; see 3.3.6.1).

*6.2.3.14 Safety*

As no remains of bodies have been found at Karnak so far (and it would have been unlikely that bodies of workers would have been buried in the temple complex), nothing can be stated with any certainty about the safety of the workers while they were building Taharqa's porch. The erecting of the tall pillars no doubt must have been a dangerous enterprise and inhaling stone dust of especially sandstone and granite during quarrying and cutting/sawing may have affected the workers' lungs negatively (see 5.3.2). By this time the workers' village at Deir-el-Medina on the west bank of the Nile was no longer occupied, as this was only used to house workers during the 18$^{th}$ to the 20$^{th}$ dynasties', from about 1550 BC to 1069 BC (Mark 2017:1). We therefore cannot use the research done by Anne Austin (see 5.3.2) on the workers' remains (Austin 2015:24, 26), to draw any conclusions about the health of the workers who worked during the 25$^{th}$ dynasty of the Black Pharaohs.

*6.2.3.14 Conclusion*

It is interesting to note that also in this example the rules as established in section 5.2 mostly seem to apply. Peace was established by a succession of Nubian Kings and eventual Pharaohs, of whom the last one, Taharqa, subsequently undertook to extend the temple at Karnak, as well as to build monuments and temples elsewhere in his realm. The flooding of the Nile was abundant a number of times and this produced lavish harvests, which provided enough food for the builders. It enabled them to add a substantial addition to the temple at Karnak as well as smaller buildings and porches. There was trade up and down the Nile and beyond, and a variety of stone materials were available within a reasonable distance from the temple at Karnak. There must have been adequate tools to work the materials with, the materials were transported over the river Nile on ships and there were labourers to do the work.

From a personal point of view, I find the time of the Nubian Pharaohs absolutely fascinating and believe that their influence over and contribution to Egypt as a country is not widely enough known, but most definitely should be. Besides re-establishing peace in the entire land, they also re-instituted good governance to fulfil the essential tasks of repairing and maintaining the dikes, thus harnessing the annual flooding of the Nile for the benefit of the population. The Black Pharaohs probably needed to restore the administrative system after they had come to power, to first repair the dikes and then to achieve what they did in the area of construction of a number of monuments.

### 6.2.4 Case Study 4: Construction of the Parthenon in Athens

*6.2.4.1 Introduction*

The Parthenon on the Acropolis in Athens is one of the most well-known and iconic buildings in the world. At first sight the remains of what was once a splendid temple dedicated to the goddess Athena, seem to represent a building of perfect dimensions. Quite the opposite is in fact the case, as the design for this temple underwent quite drastic changes while it was being constructed. This was the result of a number of dramatic events and political changes, as well as changes in style. Many aspects surrounding the construction of this temple came in pairs. There were two wars, two politicians, two architects, two materials and two building plans, to name but a few.

There are several reasons for including the site in this study. One of these is that use was made of marble as the material of which the Parthenon was constructed. Another reason is that there were alternating periods of war and peace, which had a large influence on the configuration of the temple, a third reason is that a different time period is represented and a fourth reason is that there was a fair amount of information available about the site and the construction process.

The initial stages of construction took place after the first war against the Persians in 490 BC, and for the platform on which the temple was to be built, the local limestone from Mount Hymettus was used. The eventual temple itself was built of marble from Mount Pentelikon (or Pentelic). Successive periods of war and peace succeeded each other and had an influence on the eventual construction process. The delays caused a major change in the building plan. This will be explained further in what follows. An analysis of the construction of this temple, with the use of the various aspects as established in 5.2. will follow below.

#### *6.2.4.2 A situation of peace*

The construction of the Parthenon was a direct result of the war waged by a group of Greek city-states to defend themselves against the invading Persians under Darius I. (This Darius I, or the Great, is the same ruler who confirmed the authorisation of the reconstruction of the temple in Jerusalem after the Babylonian exile and he is mentioned frequently in the Old Testament, for instance in Ezra 5:6, 6:1; 6:13, Nehemiah 12:22. Also in Daniel chapters 5 and 6, as well as in Haggai 1:1, and Zechariah 1:1; https://www.newworldencyclopedia.org/entry/Darius_I_of_Persia).

After the Battle of Marathon was won in 490 BC, it was decided in Athens that a temple to the city-goddess Athena Parthenos was going to be built (Carpenter 1970:28; Alexander 2000:127). In order to do so a large and high platform was constructed to build the new temple on the highest elevation of the Acropolis, and the steps leading up to this platform were put in place. The funds required to build the temple came from ‘the spoils of Marathon’, (as Carpenter quotes Demosthenes XXII, 13) and there may also have been contributions from private sources, as well as from public funds (Carpenter 1970:29).

Construction of the temple had just started, during the approximately 10 year-period of peace which followed the first war against the Persians, when in 480 BC the Persians returned under Xerxes, the son and successor of Darius I (Alexander 2000:126; Edey 1976:49), and the Greeks needed to defend themselves once again. The Persians besieged Athens and stormed the Acropolis, which was destroyed by fire (Carpenter 1970:31). From discarded column drums, which have been found incorporated into the fortification wall of the Acropolis, it has been deducted that part of one row of bottom drums for the temple pillars had already been set out before the second Persian attack, and that these were discarded after the attack (Carpenter 1970:30). The reason for this is generally believed to be that they went through the fire and ended up calcined[34] as a result (Carpenter 1970:31). Therefore, they were probably no longer considered strong enough to serve as bottom drums for the columns to be erected. Carpenter himself is of the opinion however, that there was not enough wood near the bottom drums for them to have been put through fire, but believes that they were damaged with mallets and sledge-hammers by the invading Persians (Carpenter 1970:33; see Figure 6-11).

As an aside, these discarded column drums also can teach us something about the construction of Greek temples from a stonemason's perspective. The bottom drums of the columns already had about 5 centimeters of fluting on the lower edge of the drums. This was to guide where later the final fluting of the columns would have to take place and it was carefully divided into twenty flutes (see the lower edge of the top drum in the right-hand corner of Figure 6-11; Carpenter 1970:30).

[34] The word 'to calcine' is a verb indicating the heating of inorganic materials to a high temperature to effect changes such as oxidization or pulverization (Merriam Webster 1977:156). In the case of the column drums, they had not disintegrated, but if they had been burned, they were probably no longer safe to use.

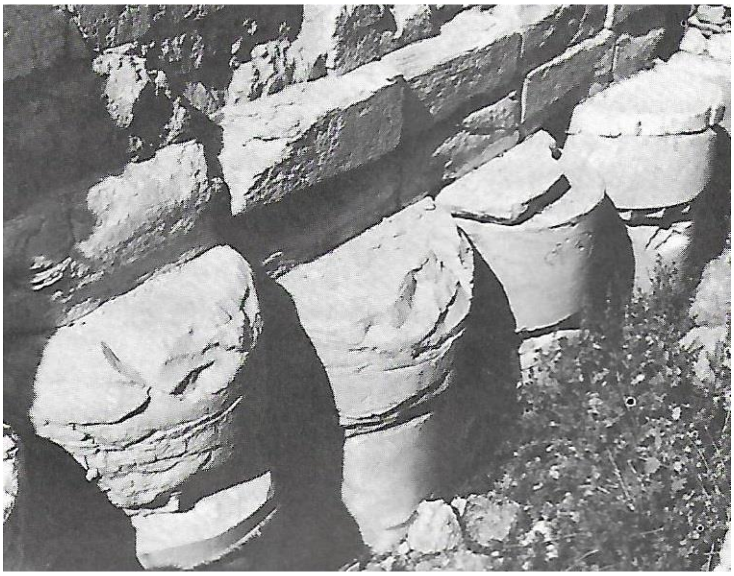


**Figure 6-11: Discarded bottom drums as part of a fortification wall (Carpenter 1970:30).**

The word ‘flute’ in this context means the following: ‘a rounded groove, specifically one of the vertical parallel grooves on a classical architectural column’. The word ‘fluting’ means the application of a series of these flutes on a column (both words, Merriam Webster 1977:443). The building process of a column worked as follows: the drums to build a column would be stacked on top of one another without being finished off, until sufficient height was reached. The drums had wooden *empolions* or centring pins between them so that they could be rotated in position (Phoca & Valavanis 1999:111, see Figure 3-38). Once all the columns had been built in this way, and the superstructure of the temple, the *architraves*, *metopes* and roof etcetera had been put into place, the final dressing was applied to the columns by the fluting process (Carpenter 1970:30). In my understanding these vertical grooves enhanced the sense of height of the columns and also covered up the horizontal seams between the drums. This process of fluting the columns was the final step in completing the construction of the temple (Carpenter 1970:30).[35]

[35] It was initially my impression that fluting was an exclusive Greek idea, but the Egyptians also already applied vertical lines on their pillars either by applying grooves (Stierlin 1995:77), or by making eight-sided or sixteen-sided columns (Stierlin 1995:84). Some pillars were left smooth (Stierlin 1995:80), or would be decorated with hieroglyphs (Stierlin 1995:2). In that respect there was more variety in the decoration of their pillars than with the Greek building conventions.

But before this point was reached, much still had to happen to bring about the construction of the Parthenon and the final fluting of the columns.

After the Persians had been defeated once again, the inhabitants of Athens (who had fled the city before the attack), upon their return first had to rebuild their houses and repair and extend the city walls (Carpenter 1970:35). This apparently was done in great haste and with whatever stone material that they could lay hands on (Carpenter 1970:36). The construction of the Parthenon took a back seat and only resumed later. The most likely reason was a lack of funds, but this got solved, once the Delian league had been formed in 478 BC (Carpenter 1970:75). This alliance was intended to provide protection against a future attack by the Persians and also against pirates, and required the member states to pay for Athens to provide naval protection. These funds were held at the island of Delos in the temple there, hence the name Delian league.[36] A part of these funds was used to build the Parthenon and eventually the funds from Delos were moved to Athens (Carpenter 1970:76).

Carpenter is of the opinion that the temple construction resumed in about 460 BC with Kallikrates as the architect and under the political leadership of Kimon (Carpenter 1970:37, 49). When Pericles succeeded Kimon after his death in 449 BC however, another architect, Iktinos, took over as master-builder in 447 BC and he changed the entire building plan (Carpenter 1970:37). The older design of 6 pillars on the narrow sides and 16 on the long sides of the temple was changed to 8 pillars on the narrow sides and 17 on the long sides. The temple platform also needed to be expanded for this adjustment in size (Carpenter 1970:49; see Figure 6-12).

[36] The first time I became aware of this was at the AENES lecture given by Doctor Martine de Marre of Unisa on 16 March 2017.

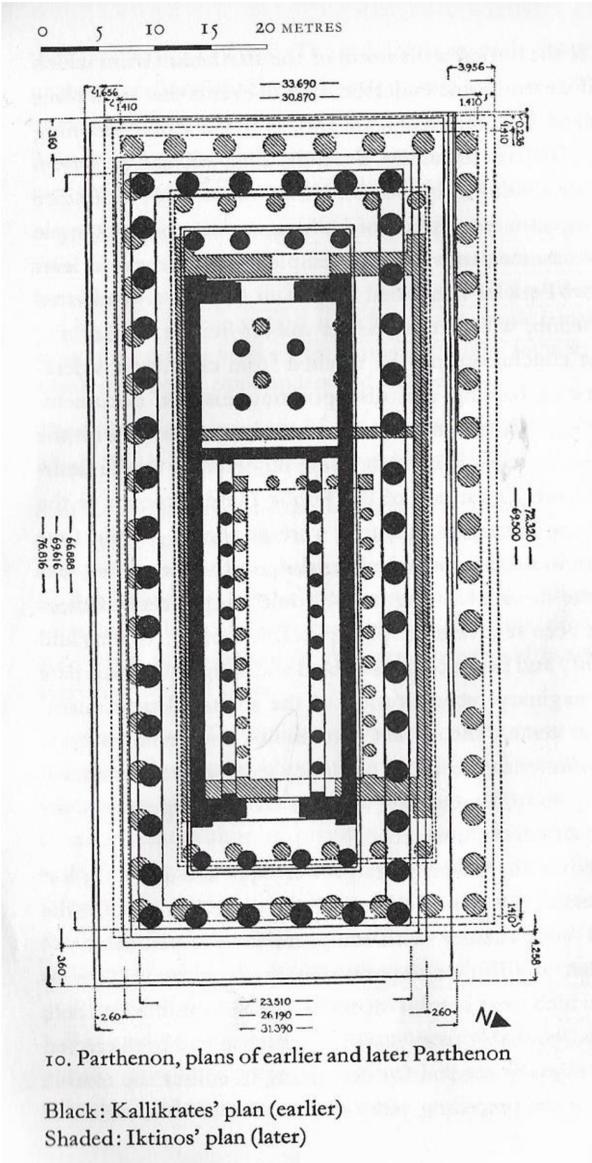



**Figure 6-12: Plans of the earlier and later Parthenon (Carpenter 1970:38).**

Part of the reason for this may have been that a bigger temple was necessary to accommodate the massive 40-foot statue of Athena (Carpenter 1970:80) which the sculptor Pheidias, who was a friend of Pericles, was designing (Carpenter 1970:50).

The plan to enlarge the temple was however not without problems on the east side of the temple platform, so Iktinos solved this by moving the entire temple as far to the west as possible and by moving the pillars slightly more closely together, so that they would all fit onto the existing platform (Carpenter 1970:53). Moving the pillars meant that they all had to be taken apart in their drum sections and be re-stacked (Carpenter 1970:47). The altered plan could have been executed with thinner pillars, but as considerable labour had already gone into the manufacture of the existing pillars, Iktinos simply retained them (Carpenter 1970:47). Moreover, the decorated *metopes*[37] which had already been made, were retained, which accounts for the difference in style between these, depicting the contest of Lapith and Centaurs, and the *metopes* of a later date (Carpenter 1970:58-59).

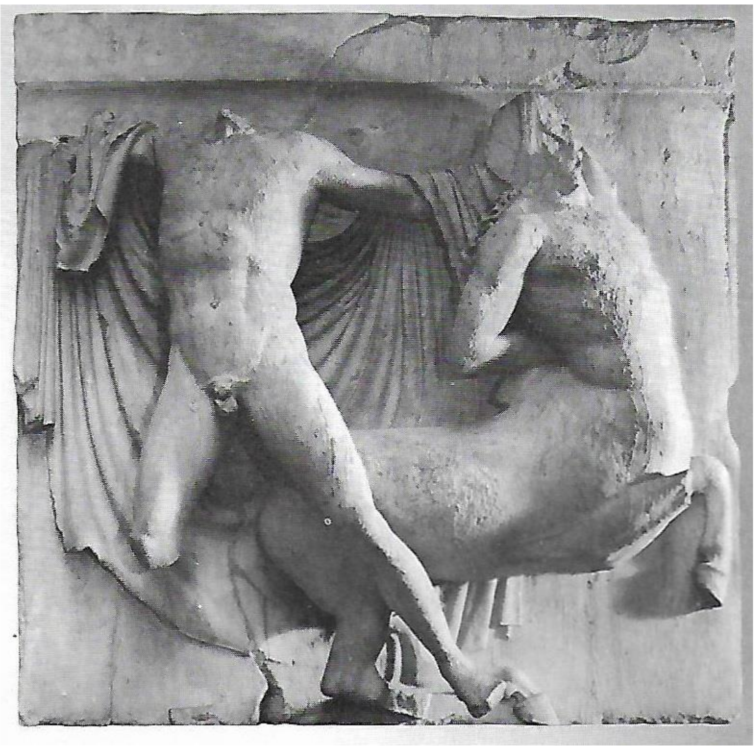


**Figure 6-13: *Metope* which was cut down to size (Carpenter 1970:57).**

As these *metopes* did no longer fit properly, due to the changed distance between the pillars, they were reduced in size (see Figure 6-13 and 6-14), and were placed at the least frequently visited and least well visible southern flank of the Parthenon (Carpenter 1970:64). It is quite noticeable on Figures 6-13 and 6-14 that the sides of both these *metopes* are damaged. In Figure 6-13 the hand of the male figure on the left seems to be missing and there is a big chunk missing from the edge on the right-hand side above the horse's knee. In Figure 6-14 the centaur has lost his tail, and is missing a large part of his arm, the top left-hand corner is missing and the entire right-hand edge is serrated, indicative of the edge having been hammered off without any care. These *metopes* were not made of the marble from Mount Pentelikon, but of

[37] A *metope* is an approximately square slab, located between *triglyphs* in the frieze of the Doric order of Greek architecture. It may be decorated with relief carving, or left plain. A *triglyph* is a block with vertical bands and groves, which separates the *metopes* of a Doric frieze (Carpenter 1970:182-183). *Metopes* and *triglyphs* alternate above the pillars of the temple and under the triangular roof.

Parian marble, from the island of Paros (Malacrino 2010:16; see 3.3.6.3), which must have been brought to Athens by ships.

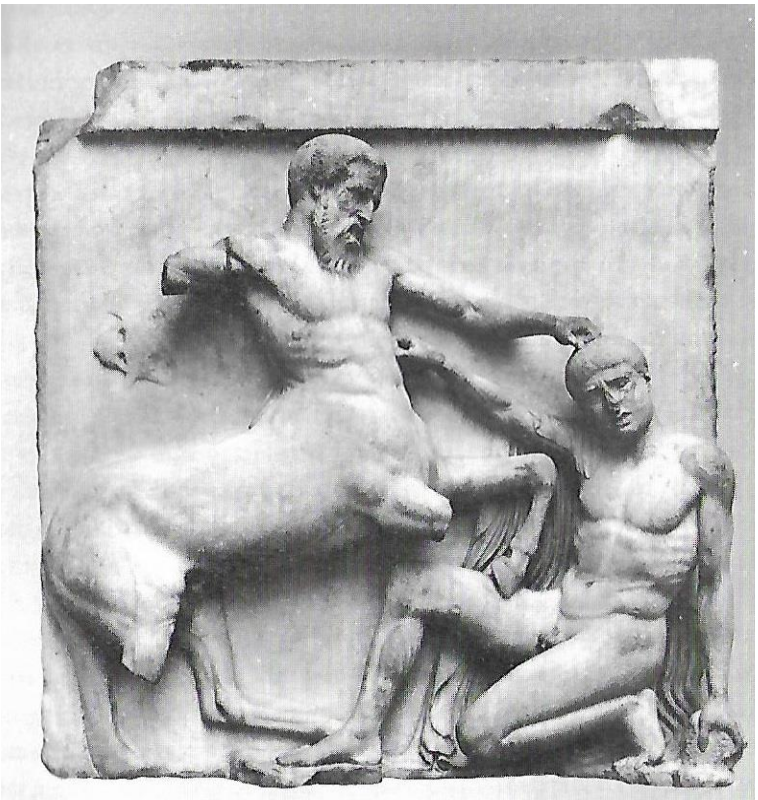


**Figure 6-14: Another damaged older metope (Carpenter 1970:58).**

#### *6.2.4.3 A common purpose*

After the defeat of the Persians at Marathon, an ambitious plan was conceived to build a temple for Athena Parthenos on the Acropolis (Carpenter 1970:29). This was out of gratitude for the routing of the Persians and could be afforded from the spoils of the Battle of Marathon as well as from private resources (Carpenter 1970:29). After the second invasion by the Persians in 480 BC, during which Athens had been sacked and burned, a renewed effort was made to continue with the construction of the temple (Carpenter 1970:37). It is clear that a strong common purpose existed to build the temple for Athena Parthenos, otherwise the effort would have been discontinued after the destruction wrought by the second Persian war.

#### *6.2.4.4 The availability of enough manpower*

Already during the Archaic Age (from circa 750 to circa 500 BC), which preceded the Classical Age (from circa 500 to circa 323 BC), populations had started to rise

(Alexander 2000:118), so manpower was available for the task at hand. Besides that, there was an ambitious employment program of public works to get craftsmen, artisans and unskilled workmen to work on the construction of the Parthenon (Carpenter 1970:79-80).

#### *6.2.4.5 An administrative or organisational system to mobilise manpower*

Athens as a city-state had a developed political system with a city council and was guided in this era by a number of great statesmen such as Themistocles, Kimon and Pericles. Besides them also a number of outstanding, but unnamed, citizens made a contribution (Carpenter 1970:35). Therefore, it should not have been a problem to mobilise manpower to build the Parthenon. The employment program mentioned in the above (see 6.2.4.4) also was put into place by an administrative system.

#### *6.2.4.6 Sufficient food supplies*

In Greece in antiquity food was produced on small farms and the main agricultural products were cereals such as emmer, durum wheat, barley and millet. Furthermore, pulses such as broad beans, lentils and chickpeas were grown. Vines were cultivated for wine, and olives for oil. Fruit, such as figs, pears, apples, pomegranates and vegetables such as cucumber, onions, garlic and salad greens, as well as almonds and walnuts were all produced. Then there was animal husbandry, mainly consisting of sheep, goats, pigs and chickens, as well as some cattle. Cheese was produced from milk, and the sea provided fish and shellfish. Beekeeping produced honey (Cartwright 2016:1).

Occasionally there were crop failures of especially the cereals, but this was alleviated by grain imports from Egypt into Athens, via the harbour at Piraeus, from the 5$^{th}$ century BC. For this, there were special grain-buyers called *sitones* (Cartwright 2016:1).

Athens was a wealthy and bustling city, as well as a main trading port, and in the Agora, which was the main market place, as well as its political center, all kinds of food were for sale (Alexander 2000:126-127), so food supplies for the builders of the Parthenon were not in short supply.

*6.2.4.7 Availability of materials for construction*

The marble for the Parthenon came from Mount Pentelikon (or Pentelic), about 17 kilometers from the city (Malacrino 2010:140; Carpenter 1970:39; see Figure 6-15).

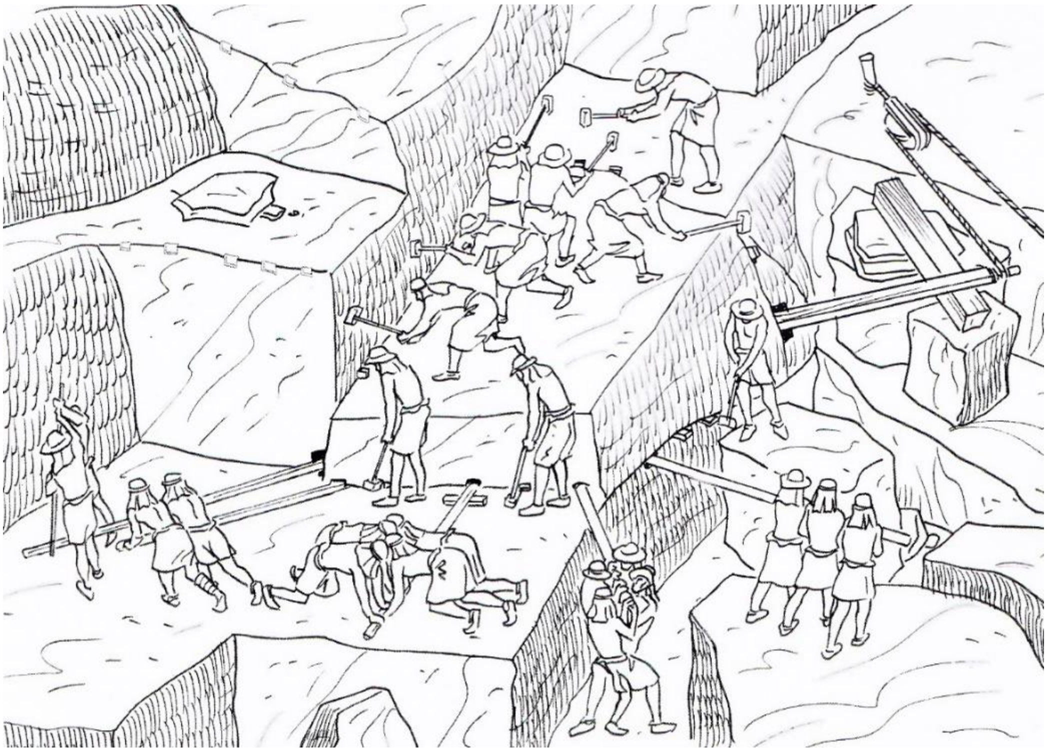


**Figure 6-15: Image of quarrying activities at the Pentelikon marble quarry to dislodge blocks (Malacrino 2010:33).**

It is maybe interesting to analyse here what is shown on Figure 6-15. The workers on top of the block in the center are hammering metal wedges into the marble on the two vertical sides where the block is still attached to the bedrock. The workers on the lower levels are using long wooden poles in some of the wedge holes to try and crack the block loose on the horizontal level. On the right-hand side a pole is used with a rope attached to it and strapped around a pulley to also exert pressure on the block in order to lever it loose from the vertical break that has been made in the marble deposit.

Besides the Pentelikon marble, also grey limestone was used for the Parthenon, from a quarry 3.5 kilometers southeast of Athens, at the base of Mount Hymettos (Malacrino 2010:9). This material was used for the bottom step of the earlier Parthenon, and was at a later stage covered by the second architect Iktinos with steps of Pentelikon marble. This was done as it would have been too complicated to remove the old steps, which would have resulted in the total dismantling of the steps and the colonnade (Carpenter 1970:51).

It is very well possible that the original plan may have entailed that the entire Parthenon should be constructed of the grey limestone from Mount Hymettos, which was found very close to the construction site. This could have been done to save costs, as the use of this material would have incurred fewer transport costs. Fortunately, this did not happen, as the Hymettos limestone would not have lasted as well as the marble from Mount Pentelikon, due to the fact that it was a much softer material (Malacrino 2010:9). That the use of limestone for the construction of the Parthenon would not have allowed it to last as well as it has done, executed in harder marble, can be deduced from what has happened with the temple dedicated to Apollo Epikourios at Bassae in the Peloponnese, also designed by Iktinos, which is now crumbling from within. The reason for this is that the local grey limestone was used for its construction and it just was not hard enough to withstand the wear and tear of time (Alexander 2000:127). Another example of a similar nature is that of the change in use of material for the reconstruction of the temple of Apollo at Delphi. Where the original design called for the use of limestone, this was changed to marble from Paros by the family of the Alcmaeonidae, who were in charge of the construction (Malacrino 2010:16, 18).

The fact that the Parthenon was built of marble is an indication that there were enough funds available for its construction, as the transport from Mount Pentelikon incurred additional cost. The funds generated by the Delian league were probably used for this extra cost.

##### *6.2.4.8 Trade*

Trade had already expanded into the Mediterranean basin before the attacks of the Persians and continued after they had been defeated (Alexander 2000:118). This was aided by the fact that Athens as leader of and on behalf of the Delian League, not only kept the Persians at bay but also patrolled the sea routes to keep them safe and free from pirates, which benefitted trade (Carpenter 1970:75; Alexander 2000:119, and Map supplement 'The Greeks', *National Geographic*, December 1999). Surplus population was sent to settle in foreign lands (Carpenter 1970:79), but may also have contributed to trade with the mother city Athens.

#### *6.2.4.9 Construction technology*

The various sources consulted all seem to be in agreement that there was a large development of technology in the time of the construction of the Parthenon. Therefore, we may assume that construction and technology went hand in hand (Carpenter 1970:49; Malacrino 2010:140; Kotsanas 2017:85-95). It has come to mind that these developments may have also come about by the developments in shipbuilding, with for instance the system of block and tackle possibly having been developed for hoisting sails first and then finding an application in the construction of buildings. As was shown in 3.4.2, a number of cranes were developed for various types of hoisting, such as the monopod crane of Heron for hoisting drum sections for pillars (see Figure 3.33), and the quadpod or scaffold crane for hoisting architraves (see Figure 3-36). These cranes, as well as the other types mentioned in 3.4.2 were very likely to have been used in the construction of the Parthenon.

#### *6.2.4.10 Transport technology*

As the marble for the construction of the temple was obtained from Mount Pentelikon, which, as already mentioned, was 17 km away from the city, there was a whole system to transport the materials from the quarry all the way up the building site at the Acropolis. First the blocks were quarried, as was shown in Figure 6-15, and then hewn to the correct sizes, after which they were eased down the mountainside, tied onto sledges, on a specially constructed slipway with a slope of 30 degrees by means of snubbing ropes (Malacrino 2010:140, Carpenter 1970:49; De Nuccio & Ungaro 2002:184; see Figures 6-16 and 6-17). These ropes were slung around capstans of about 30 centimeters in diameter, located on the side of the slipway to slow the descent of the sledges with the blocks, and levers were used to guide the sledges and keep them on the track (Malacrino 2010:140; Phoca & Valavanis 1999:106; see Figure 6-16).

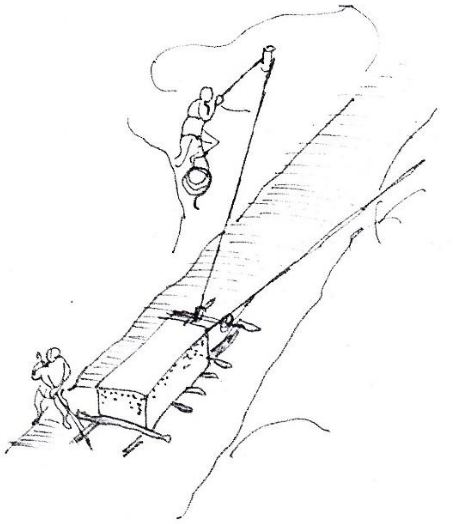


**Figure 6-16: Lowering of a block of marble on the slipway down the mountain (Phoca & Valavanis 1999:106).**

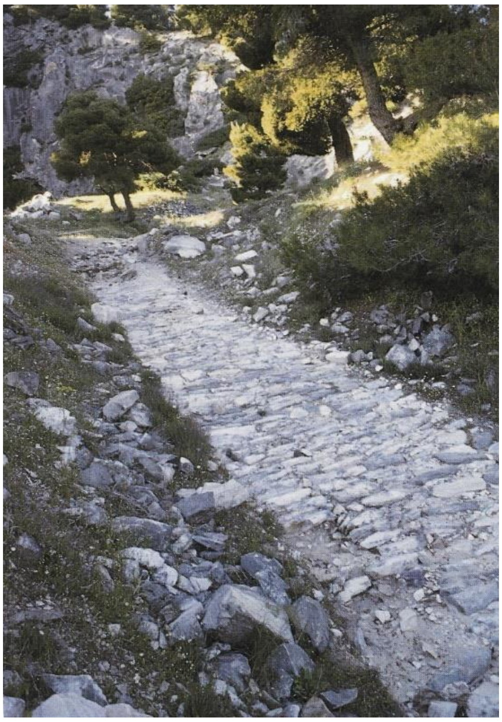


**Figure 6-17: Specially constructed slipway for the lowering of blocks on Mount Pentelikon, Greece (De Nuccio & Ungaro 2002:184).**

Once the sledges had arrived on level ground, the blocks would be loaded on special carts, drawn by teams of oxen for the 17 km trip to the city (Ressler 2014:25). Then there was a special way of pulling the carts up to the building site, by using oxen to pull an empty cart downwards, while the cart with the block of stone would be pulled upward with a rope connected via a winch to the empty cart over a track of laid timbers (Malacrino 2010:140; Carpenter 1970:49). This saved the oxen from slipping while trying to pull a heavily loaded cart upward. Of course, the loading of blocks on a cart was nothing new, but to use the system with the winch was a huge improvement, as the weight of the load was reduced by the use of the winch, as is the case when using pulleys in a block and tackle system (Malacrino 2010:146; Kotsanas 2017:86; see Figure 6-18; and Figure 3-47 for pulleys).

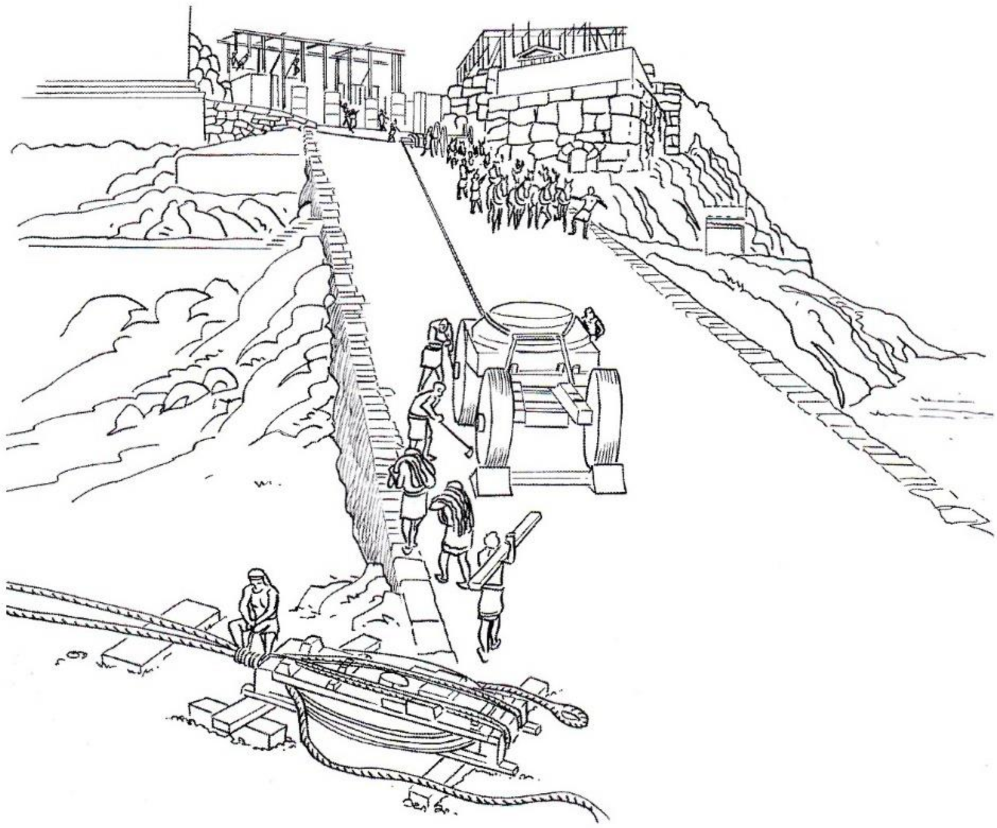


**Figure 6-18: Transport of blocks up to the Acropolis by means of balanced carts (Malacrino 2010:140).**

*6.2.4.11 Tools*

The Parthenon was built after the second attack by the Persians and was completed in about 438 BC (Carpenter 1970:37). At this time the Iron Age was well and truly established, so there must have been iron tools to work with. The literature consulted does not mention what tools were used, but does mention the use of clamps to clamp blocks together (Carpenter 1970:46; see Figure 3-52), which were made of metal, either iron or bronze (Malacrino 2010:108). As stonemason tools did not change much for millennia, the tools used at the Parthenon were simple hammers, chisels, measuring tools (see 2.6), to which the Greeks in the era of construction of the

Parthenon added hoisting cranes, blocks and tackle (see section 3.4.2), as well as the *empolion* to center the drums of pillars (see Figure 3-38).

### *6.2.4.12 Seasons and weather*

Factors such as seasons and weather are poorly represented in the available material. The change of activities in different seasons, often under the influence of changes in weather, were probably accepted as normal in antiquity and did not often warrant any special mention, so references to that are hard to find and need to be inferred from the available information.

Winter rains may have made the transport of blocks on ox-drawn wagons difficult, as roads would have become impassable to use due to mud. Moreover, a wet slipway to lower the blocks would have been very slippery in rainy weather. As can be noted on Figure 6-17, the slipway on Mount Pentelikon was probably made of pieces of marble from the quarry. The sliding of blocks on sledges over these marble pieces would have smoothed them over time, making them slippery in rainy conditions.

The upward slope to reach the building site of the Parthenon, shown in Figure 6-18, would probably also have been affected by the winter rainfall.

### *6.2.4.13 Safety*

No information regarding accidents during the time of construction has been found, but it is very unlikely that the construction of a building of these dimensions over a lengthy period of time would have happened without any accident at all. Lowering blocks on slipways is a risky undertaking. Hewing the drums, blocks, *architraves*, *metopes*, *friezes* and all other building components, as well as the artistic representations on the *metopes* and *friezes* is likely to have resulted in deafness from all the hammering noise among the workers. Inhaled dust probably also was a problem.

### *6.2.4.14 Conclusion*

In the analysis of the construction of the Parthenon, it is so interesting to observe that the two wars fought against the invading Persians had a major effect on the completion of the project. The initial period of peace after the first war was interrupted by the second war against the Persians and the subsequent necessity to rebuild the city of

Athens first, caused major delays in the construction of the older version of the Parthenon. These time delays in the construction process eventually brought about major changes, as the political power passed into other hands and the first architect Kallikrates was taken off the project and was succeeded by the second architect Iktinos. This in turn brought about that the design of the temple was changed. The artwork on the *metopes* differs greatly in style between those of the earlier period of construction and the later ones. The fact that Pheidias could sculpt a massive statue of Athena also meant that it had been possible to quarry a massive block of marble at Mount Pentelikon for that purpose, which indicates an advance in technology, both to dislodge such a massive block as well as to slide it down the slipway safely. Most other factors under consideration are present, such as a common purpose, an administrative system to mobilise manpower as well as enough manpower, sufficient food supplies, trade, adequate technology, which also developed as construction progressed, so here too the framework as established in 5.2 from the description of Solomon's Temple, is seen to apply. The fluctuating situation of war and peace had a major influence.

### 6.2.5 Case Study 5: King Herod's reconstruction of the Temple Mount in Jerusalem

#### *6.2.5.1 Introduction*

In the year 20 BC King Herod the Great launched his ambitious project to restore the Temple in Jerusalem and to enlarge the Temple Mount (Mazar 2002:25). This massive undertaking had become necessary due to the large numbers of pilgrims visiting the Temple during the major religious festivals, many of whom came from the Diaspora. It has been estimated that between 80,000 and 100,000 people would come to Jerusalem for each festival and that the population of the city itself amounted from 150,000 to 200,000 (Ben-Dov 1986:42). A more recent estimate of the population size in Jerusalem at that time states that this was about 30,000 (Lawler 2019:57). Regardless of this difference in numbers however, the influx of pilgrims made it necessary to expand the Temple complex. King Herod the Great is known from biblical sources as the king who reigned when Jesus Christ was born, and who attempted to kill Jesus as a baby (Matt 2:1-22; Luke 1:5).

The Temple built by King Solomon had been destroyed in 586 BC, when the Babylonians overran the Kingdom of Judah, as described in 2 Chronicles 36:19-21 (Ritmeyer 2006:317). Subsequently the Temple had been rebuilt seventy years later under the leadership of Jeshua and Zerubbabel (Ritmeyer 2006:318; Ez 2:2; Ez 3:2, 8). This was the Temple that was still present when King Herod undertook to enlarge the Temple Mount. At that stage the Temple was located on a square Temple Mount with a measurement of about 500 x 500 cubits (Ritmeyer 2006:170-171). How long a cubit really was, is the topic of much debate among scholars, as there was more than one type of cubit in antiquity, and its size may have varied from 450 millimeter to 525 millimeters (Ritmeyer 2006:171). The cubit measuring 525 millimeters was known as the Royal Cubit (Ritmeyer 2006:171), and if we would take that measurement as the yardstick and multiply that by the 500 cubits mentioned, the total length and width of the square Temple Mount would be 262.5 meter by 262.5 meter, which is 68,906 m2. This was not enough to accommodate the massive influx of worshippers, and already in the time of the Hasmoneans[38], who ruled before Herod came to power, an attempt had been made to enlarge the temple complex by adding an extension on the southern side over the whole width of the then Temple Mount (Ritmeyer 2006:206). The size of this extension is now only visible on the eastern wall of the Temple Mount, where a stretch between what is called the 'bend' and the 'seam' shows masonry that differs from the later Herodian masonry, as well as from the earlier masonry further to the north along that wall (Ritmeyer 2006:102-104).

Herod's plan was massive in its scope, as it entailed adding large extensions to the north and south of the Temple Mount and a narrower section along the western side. The enlarged Temple Mount measured 144,000 square meters (Goldhill 2005: 4). The eastern wall was left intact, but simply lengthened both on the northern and the southern end (Ritmeyer 2006:102-103). The original Temple Mount was encased into the larger one, by new, large walls, that were constructed around it. The space between the original Mount and the new outer walls, was filled in with a fill of rubble. As the older Temple Mount was surrounded by lower lying areas around it, namely the area of the Bezeta Valley with a 'fosse' (or drain) in it to the north, the Tyropoeon

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[38] The Hasmoneans were a priestly family who ruled in Jerusalem between the end of the Hellenistic period and the beginning of the rule of Herod. When Herod became king, he married Mariamme, a Hasmonean princess (Mueller 2008:40; 42).

Valley on the western side, and was sloping down to the city of David on the southern side (Ritmeyer 2006:168, 55; see also Figure 6-19), the walls of the new Temple Mount had to be exceedingly high (Ritmeyer 2006:60-61), as well as very strong to hold the fill (Ritmeyer 2006:137). Behind both ends of the southern wall there also were extensive vaults to accommodate the low-lying bedrock underneath the construction, which also was to hold the so-called 'Royal Stoa' on top of it (Ritmeyer 2006:60-61). For the construction of this massive esplanade around the temple building to accommodate the influx of all the pilgrims and local worshippers at the same time, it was necessary to quarry massive blocks of stone (Ritmeyer 2006:61). For this purpose, the local lime stone, which is now known as Jerusalem stone (see 5.2.8.2), was used (Ritmeyer 2006:132, 286).

King Herod obtained the assistance of 1,000 priests to restore and beautify the temple building itself, and that part of the project was completed in 18 months (Ben-Dov 1986:45; Mueller 2008:41). The construction project to enlarge the Temple Mount took much longer, and only started after eight years of preparations. During that period the local limestone was quarried, dressed and transported to the building site and at long last King Herod ordered the construction to go ahead (Ben-Dov 1986:45). The project was far from complete when King Herod died in the year 4 BC (Matt 2:15, 19; Mazar 2002:26), and it continued until the reign of the Procurator Albinus (62-64 AD). According to Josephus, there were 11,000 workers employed at this project (in Mazar 2002:25). Mazar also believes that there were lavish decorations on the outside of the Temple Mount walls, which were of a figurative nature and applied with colour compounds (Mazar 2002:43).

Figure 6-19 at the end of this Case study shows a drawing of the enlarged Temple Mount. The central part of the image shows the Temple and the older Temple platform, and the two large walls visible on the outside of the Temple Mount show the extent to which the whole complex was enlarged.

The reason this site was chosen for analysis, is the sheer magnitude of the project. Besides that, also the fact that it falls within the Roman era, which is the terminus as far as time is concerned of this study, and the technological advances which had been made by this time.

The aspects surrounding the extension of the Temple Mount will be analysed below with the use of the criteria established in 5.2.

*6.2.5.2 A situation of peace*

The long reign of Emperor Augustus was characterised by a lengthy period of peace for the entire Roman empire (Ben-Dov 1986:44). The fact that so many pilgrims were able to travel to Jerusalem for the major festivals during the latter half of the Second Temple period is in itself already an indication that there was a situation of peace prevalent in Jerusalem and surrounding countries. In a situation of war, people do not set out on a long voyage unless it is absolutely necessary, or to get away from the conflict.

King Herod himself also refers to the situation of peace in a speech, which he gave to the leaders of the people to announce the details of his plans. This speech has been preserved by Josephus (*Jewish Antiquities*, XV, II. 382-387), who probably copied it from the court archives (Ben Dov 1986:42). King Herod spoke of a 'long period of peace', which was of course the *Pax Romana*, the 'Roman peace' enforced by the Romans, who did not tolerate any form of revolt (Reid 1997:61). This intolerance of revolt is also referred to in the account in Acts 19 about the riot in Ephesus, especially in Acts 19:40.

*6.2.5.3 A common purpose*

The speech by King Herod, which was mentioned in the previous section, was necessary, because he needed to get the cooperation of the leaders of the Jewish people for this project (Ben-Dov 1986:42). As Herod was in the good graces of the Roman emperors, it was to be expected that the motives for his grandiose plan would be questioned by the Jewish leaders. King Herod needed to tread carefully to not arouse suspicions about his intentions. His speech was well received though, as he obtained massive support for the project (Ben-Dov 1986:42). The one part of the project entailed the restoration and embellishment of the Temple building itself, for which he needed the cooperation of the priests, because of course nobody else than the priests were allowed to enter the sacred precinct. This cooperation he obtained and the 1,000 priests who were willing to be trained to undertake the work, accomplished the task in 18 months (Mueller 2008:41; Ben-Dov 1986:45).

The second part of the project entailed the enlargement of the Temple Mount, for which he needed the permission of the Roman rulers. There is no source which provides proof that Herod applied for permission from the Romans, but also no evidence that Rome interfered either, so somehow King Herod must have been allowed to proceed (Ben-Dov 1986:43).

#### *6.2.5.4 The availability of enough manpower*

As to the availability of manpower, the article by Ben-Dov (1986) contains some interesting information. He starts from the premise that the country was basically agrarian, but that Rome had brought new technologies, such as hydraulic engineering and metal forging. The Jewish people adapted these technologies quickly for agriculture, and used hydraulics technology, which allowed for water to be transported over great distances via aqueducts, for irrigation purposes (Ben-Dov 1986:44). Metal technology brought better agricultural tools and thus brought a higher level of agricultural productivity. As a result of this, fewer hands were needed to work in agriculture. Coupled to this all was a natural population increase as a result of the lasting period of peace, through which there were more working hands available to do the work (Ben-Dov 1986:44). Therefore, the conclusion may be drawn that there was sufficient labour for a large project like this.

#### *6.2.5.5 An administrative or organisational system to mobilise manpower*

There must have been an administrative system to organise manpower both among the religious elite in Jerusalem, as well as at Herod's court. How otherwise would it have been possible for the 1,000 priests to restore the Temple in 18 months, as has already been mentioned in section 6.2.5.3?

King Herod also had an administrative system as without that it would have been impossible for him to achieve the many building and agricultural projects which he undertook. These included, besides the enlargement of the Temple Mount, the harbour at Caesarea, Herodium, Masada, several fortresses throughout the country, three defensive towers in Jerusalem, a palace in Jericho and an extensive agricultural farm in the Jordan Valley (Ben-Dov 1986:43). Moreover, there was the administrative system of the Romans as the supreme rulers in this era.

#### 6.2.5.6 *Sufficient food supplies*

As already mentioned in section 6.2.5.4 there was sufficient food production in the country due to improved irrigation methods and better implements to work with, which allowed many labourers to work at the reconstruction of the Temple Mount. Besides the normal agricultural production by the country's inhabitants, King Herod also had established agricultural farms in the Jordan Valley (Ben-Dov 1986:44), so agricultural production was at an all-time high.

#### 6.2.5.7 *Availability of materials for construction*

As King Solomon had done for the construction of the First Temple in Jerusalem, King Herod also made use of the local limestone for the reconstruction of the Temple Mount (Ritmeyer 2006:132). This is found under and in the mountains around Jerusalem, and King Herod opened up a new quarry to the north of Jerusalem, which was 40 meters higher in elevation than the Temple Mount (see section 5.2.8.2). In this way use could be made of the principle of gravity to transport the blocks down to the building-site along a slope of 2.5 percent (Ritmeyer 2006:134; see Figure 3-20). Moving blocks downwards is of course easier than trying to move them upwards. Moreover, the blocks were moved in over the fill that was used to fill the gap between the walls that surrounded the old Temple Mount and the new walls that were under construction to extend the Mount. This provided a fairly level surface for their transport (Ritmeyer 2006:137; see Figure 3-51).

#### 6.2.5.8 *Trade*

In his speech as recorded by Josephus (see section 6.2.5.3), King Herod stated that 'there continues to be an abundance of wealth and great revenues', which he intended to use for the execution of his plans. This wealth came from a number of sources. One of these was that King Herod controlled the international route of the spice trade. He had expanded his territory to the north and east in order to be able to control this and it provided him with considerable revenue in the form of toll (Ben-Dov 1986:44). Another source of income came from the farms which King Herod had developed in the Jordan Valley. These were located on the north-western side of the Dead Sea and east of the Jordan River. On these royal farms, spices, medicinal plants and dates were cultivated, and especially the dates were of great commercial value, as they served as the main sweetener in those days, because sugar did not yet exist (Ben-Dov 1986:44).

After King Herod died in 4 BC (Mazar 2002:26), prosperity in Judaea declined and his descendants squandered the enormous fortune he had left them (Mueller 2008:58), so the Temple Mount project must have been financed in a different manner, most likely through taxation. Matthew 17:24-27 mentions a two-drachma tax, also called the temple tax, which may have been used to finance the continued work on the Temple Mount. Mazar also mentions that there was high taxation under the Roman Procurators, who ruled in Jerusalem after Herod had died in 4 BC and after his son and successor Archelaus, who ruled for ten years, had been banned by the Roman Emperor Augustus (Mazar 2002:26-27). Due to the enormous scope of the project, it was of course impossible to stop the construction once it had been started, and it had to be completed.

#### *6.2.5.9 Construction technology*

For the reconstruction of the Temple Mount King Herod had all the technological know-how and skills of the Roman Empire at his disposal, ranging from quarrying skills to transport and hoisting skills. That these were in existence is known from the writings of the contemporary Roman architect Vitruvius (Ben-Dov 1990:82). The great technological advances which had been made by this time also allowed for very large limestone blocks to be quarried and used. This had a two-fold advantage, namely that much time was saved by building with these very large blocks (Ben-Dov 1990:84), and that no mortar was needed to cement the blocks together, because the blocks were held together by their sheer weight. That no mortar was needed to cement the blocks also saved an enormous forest of trees, because in those days wood was needed to burn lime in order to produce mortar (Ben-Dov 1990:82, 84). The largest blocks were used at the lowest points on the south-western and south-eastern corners of the Temple Mount extension to produce a solid substructure for the buildings that were to be built on top of the extended platform, such as the Royal Stoa. Besides this, the walls also had to be very strong to hold the weight of the fill that was used to level the area between the outer wall of the original Temple platform and this newly built wall of the enlarged Temple Mount (Ritmeyer 2006:100; 137).

*6.2.5.10 Transport technology*

The blocks needed to enlarge the Temple Mount were quarried in and around Jerusalem, so a long transport route was avoided (see 5.2.8.2). For the transport of the blocks there was a whole array of transport technology available. The smaller blocks may have been transported on sledges or ox-drawn carts, or suspended in a cradle between the wheels of a different type of ox-drawn cart. As a third possibility, the blocks may have been moved on rollers and pulled forward by oxen. All these methods are explained in detail in 3.3.7, accompanied by the images of Figure 3-31. A further transport possibility was the use of very large wooden wheels, whereby the block formed the axle, or the frame designed by Chersiphron, to roll a large cylinder (see Figures 3-30 and 3-31). The very large blocks that were used to build up the south-western corner of the wall, which were too heavy to be transported on rollers, may have been made into cylinders, then rolled to their position, where they were squared again, one side at a time, and rolled or levered into place (see 3.3.7).

*6.2.5.11 Tools*

The fact that iron forging had been improved by the Romans in order to provide their armies with the best equipment (Ben-Dov 1986:44), was also to the advantage of the construction project of the Temple Mount, as there was quality iron available for the tools which were used to quarry and hew stone. Besides iron for chisels and pick-axes, tools such as hammers, measuring equipment and wood for wedges, to loosen the blocks from bedrock (see Figure 3-13), were all available. For the Herodian masonry, use was made of the eight-toothed comb pick (see Figure 2-23) to produce the margins along all four sides of the blocks. This was done to ensure that the stones would fit correctly to each other (Ritmeyer 2006:116).

*6.2.5.12 Seasons and weather*

Regarding the influence of seasons and weather on the reconstruction of the Temple Mount under Herod, there is written information about rainfall. This was already referred to in 5.3.1. Meir Ben Dov (1986:46) quotes the writings of Josephus, who stated that it only rained in Jerusalem at night during the 11 years that were needed to build the Temple, and that as a result of this, there was no interruption of the construction work. According to Ben Dov this is also confirmed by a legend in the

Talmud, (he quotes the *Jerusalem Talmud,* Berachot 1:8 and the *Babylonian Talmud,* Ta' anit 23:71), which gives account of the same phenomenon, namely that wind would blow clouds and rain away early in the morning, so that the people could do their work during yet another sunny day (Ben Dov 1986:46).

Besides this, Ben Dov also states that during the 14 years that archaeological excavations took place below the Temple Mount in modern times, on average only five work days were lost per year due to rain and snow, because it usually rained at night (Ben Dov 1986:45).

Moreover, the blocks were quarried in underground quarries, which also were not subject to the vagaries of the weather. It may therefore be concluded that seasons and weather had very little influence on the progress of the project.

#### *6.2.5.13 Safety*

Nowhere in the literature consulted was anything mentioned about injuries at work, but over the years that this project took to complete, there are likely to have been injuries. As no physical remains of this nature have been found, it is impossible to say with certainty what may have gone wrong. We do know from the writings of Vitruvius that there may have been accidents with hoisting equipment, as he warned that wood of sufficient thickness needed to be used to hoist heavier blocks (Malacrino 2010:146).

#### *6.2.5.14 Conclusion*

In the analysis of the reconstruction of the Temple Mount by King Herod, all the factors established on the basis of the description of the construction of King Solomon's temple, are seen to apply. An administrative system, manpower and sufficient food supplies were all available. The availability of large amounts of the local limestone were a great advantage for the project, as a long transport route was not necessary. The long period of peace, and high levels of technological development were a major boost for the completion of this very ambitious project.

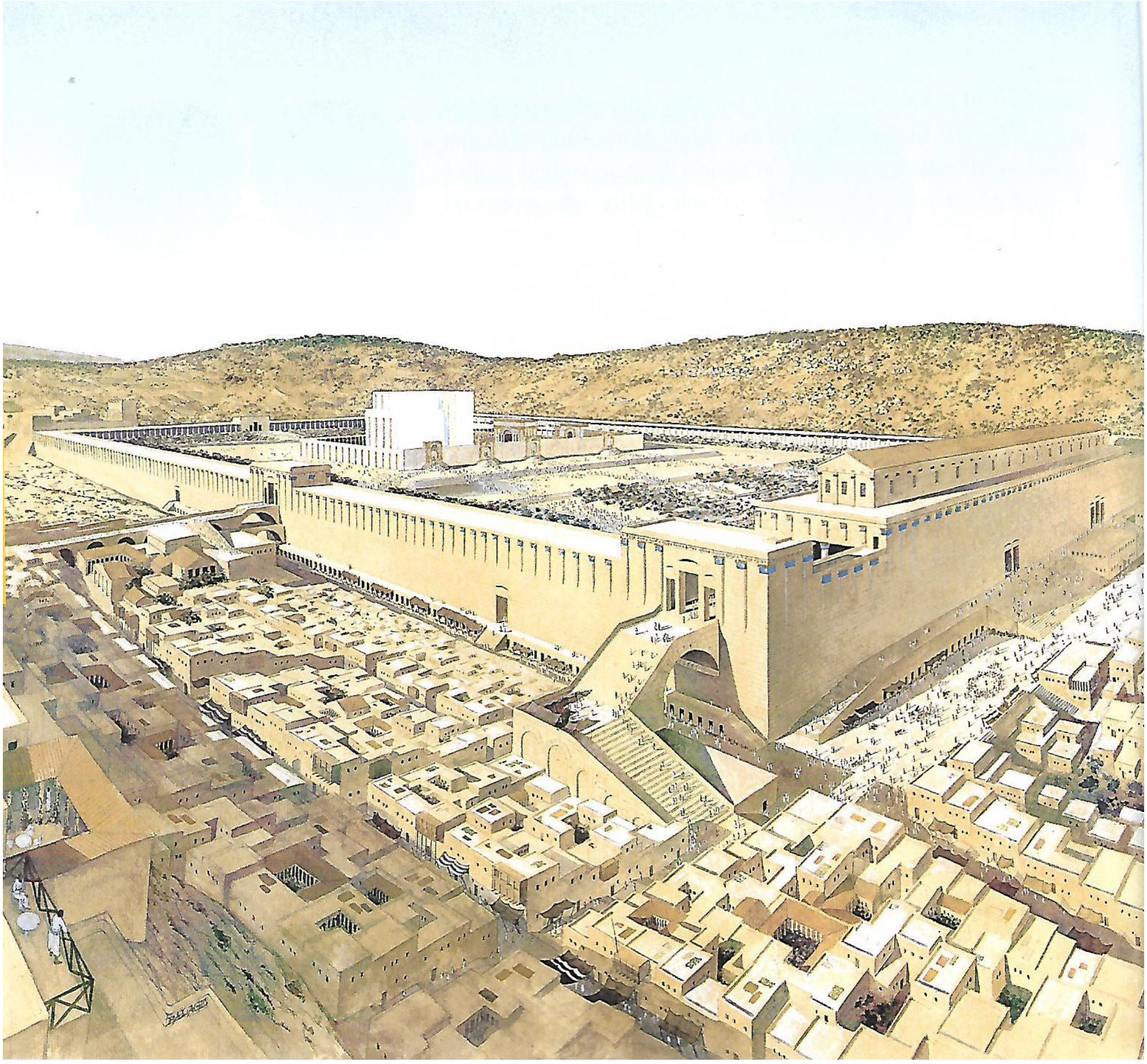

**Figure 6-19: Reconstructed image based on archaeological finds of the enlarged Temple Mount in Jerusalem (Mazar 2002:28).**

What came to mind is the wisdom of King David not to undertake the construction of the original Temple in Jerusalem himself, even though he was quite eager to do so (2 Sam. 7:1-2), but to accept the word of the Lord, which came to him via the prophet Nathan to leave this task to his successor (2 Sam 7:13). David would not have been able to complete the task in his lifetime. This is to be seen in comparison to King Herod who died before the completion of the reconstructed Temple Mount. The fact that his descendants squandered his estate, must have dried up the funds to continue the construction and was very likely the cause of the high taxes levied on the population in that time.

# CHAPTER SEVEN

# CONCLUSION

## 7.1 INTRODUCTION

The purpose of this chapter is to draw a number of conclusions both from the first part of the thesis about the practical aspects of stone working as well as of the second part, regarding the requisite conditions which need to be present in society to allow for the construction of a large temple or monument. Before analysing these two aspects separately though, there are a number of other points to be considered.

### 7.1.1 Methodology

In the first place there is the question of methodology and whether I gained anything by making use of an archaeological approach. The answer is quite simple: without an archaeological approach I would not have been able to find the information and facts that were needed to conduct this study. Also more specifically the Behavioural approach was very useful, especially the Life history model developed by La Motta (see Figure 1-2), as that diagram provides all the points in the construction of a large temple or monument, namely procurement of materials, the manufacturing of the monument or temple with those materials, the use, maintenance and reuse of it and then the cultural deposition, more in particular the abandonment of the site. Reclamation and recycling did not occur as much, though definitely in the case of the Temple Mount in Jerusalem.  Maybe this study is not sufficiently anchored in Biblical Archaeology, and is a mix of Archaeology and Biblical Archaeology, and I will be the first to admit that. The initial set-up of this thesis was to begin by looking at the account of the construction of the First Temple by Solomon in I Kings 5 and I Chronicles 28, followed by the Case Studies and after that to provide the information about stone working, and this simply did not work. It was necessary to give an overview of the various aspects of the development of stone working first, before turning to the account of the construction of Solomon’s Temple and after that the Case Studies.

The reason for making use of finds made by non-biblical Archaeology, is that in order to be able to go back in time to the start of the construction of large monumental buildings or temples, there is no information from the discipline of Biblical Archaeology, as this discipline does not go that far back in time. Some of the questions that I was so keen to answer were, how were people able to quarry stone before the existence of metal tools? What kind of tools did they use? How did they manage to transport the stone? Non-biblical Archaeology did provide me with those answers for the Case Studies of monuments which were built before the Temple in Jerusalem. Starting that far back in time, also helped me to see the development of stone working and tools over a long time, which showed the bigger picture.

### 7.1.2 Does this study make a contribution to Biblical Archaeology?

The answer to the question of whether this study makes a contribution to Biblical Archaeology I believe is ‘yes’, because it makes a case by comparing the account of the construction of Solomon’s Temple with other sites in antiquity where large temples of monumental buildings were constructed, and it shows that the biblical account as found in I Kings 5 and I Chronicles 28 forms a pattern, which gets repeated over and over again in other times, sites, cultural settings and with other materials etcetera. The biblical account is correct in all the aspects it mentions, and this is important in the context of those who deny that this is the case and who doubt its veracity. It shows that the factors distilled from the biblical account in I Kings 5 and I Chronicles 28 are important and essential for the successful completion of a large building project in antiquity. And the most important factor is the one that Solomon refers to in the first place and that is: ‘But now the Lord my God has given me rest on every side and there is no adversary or disaster’ (I Ki 5:4), in short: a time of peace.

## 7.2 THE CONCLUSIONS REGARDING THE PRACTICAL ASPECTS OF STONE WORKING

### 7.2.1 Evolution of stone working

When we summarise how stone was worked in antiquity, it may have been noticed that stone working was not the same experience for all workers involved in this activity over the centuries. Workers encountered different circumstances, different materials, excavated from different types of quarries, with the use of different tools. It seems that the development of tools was the most important factor to start with, and in the description of the development of tools in section 2.6.1 we saw that the Palaeolithic, which was a period of long duration and slow development, gave way to the Neolithic, which was of short duration and saw rapid development. This period coincided with the retreat of the glaciers, which had been formed during the last Ice Age, and during this time, new tools were developed. This took place about 11,700 years ago.

The new tools that were developed were used fairly quickly to start building with stone, and the site of Göbekli Tepe is a prime example, as the construction of the series of temples there started about 11,600 years ago. The area itself where Göbekli Tepe was built, was not affected by a covering of ice, but the change in climate due to the end of the Ice Age did affect it, by the warmer, wetter weather, which produced more vegetation, in turn making for the proliferation of wildlife. These conditions, warmer wetter weather, more wildlife, and more vegetation may have made it possible for a larger number of hunter-gatherer groups to come together and stay in one place for longer, without having to forage for food, in order to build, so there were many more people together to work on the construction of the temples there.

The last Ice Age affected the northerly parts of the world of course more than the area where Göbekli Tepe was built, and the development of tools at this site may have progressed from earlier times and more slowly than just as a result of the end of the Ice Age, but it is interesting that the dates of the end of the Ice Age and the start of construction at Göbekli Tepe are closely together.

The change in circumstances was a kind of chain reaction, enabling people to devote time and effort to construct their series of circular temples. What is remarkable though, is the size of the pillars that were shaped out of limestone for the construction of Göbekli Tepe, as one would have expected the builders only to have made walls of stacked stones (see Figure 6-1) and certainly not to have added decorations on the pillars in the way they did. If this is indeed the oldest stone temple in the world, (and up till now it is claimed to be), it is an impressive effort for first time builders. Basically, the construction of large buildings, such as temples, monuments and so on, started in the Neolithic and has carried on till the present. The difference is that in the distant past, large monumental buildings were built for religious purposes and in this day and age, most large buildings are for economic purposes and are now built of concrete. It shows a shift in mankind’s priorities.

After the initial use of flint and obsidian as tools, access to other materials that the earth had to offer, such as copper, bronze and iron, enabled the making of tools fashioned of these materials, which were the next stages of development, and which allowed for successively better and larger buildings to be constructed.

As for the more northerly areas such as the Orkney Islands (see 6.2.2.1), and similar latitudes, the end of the Ice Age must have been much more pronounced. In those areas, the human beings who inhabited the earth at that time, no longer needed to use all their energy to keep warm and to find food in the harsh climatic conditions of the last Ice Age. Besides that, the materials to make tools, such as flint, became easier to access, as the soil was no longer frozen solid. This also applied to the stone that was needed to build with. This in turn enabled the Orcadians (inhabitants of the Orkney Islands) to start developing better tools and build a religious center, such as was constructed at the Ness of Brodgar. The transition from a hunter-gatherer society to a sedentary agrarian society also was a contributing factor. The location of this site, so far north and on an island, is one of the more remarkable facts.

In Egypt the development of stone working must have been a much more gradual one, in that their first efforts of construction were made with mud-bricks, after which they used small hewn stone blocks and eventually started building with large stone blocks, as were used for the construction of the pyramids in Giza (see 3.2.2). They were fortunate to have large deposits of limestone and sandstone, which were relatively easy to work with copper chisels. To work the harder granite, they did make use of pounding stones to extract it from bedrock, but how they worked granite further, is still an open question. The various possibilities of the use of either meteoric iron for chisels, or of diamonds, either for engraving, or for polishing with diamond dust, have been explained in this thesis (see 4.2.4; 4.2.7.6). Use of meteoric iron and/or diamonds would provide a suitable explanation for what was manufactured from granite, for which copper tools would have been too soft to be used. The fact that Hatshepsut's ships are said to have sailed to the destination called *Ta-Netjer,* rather than just to Punt, is an indication that they may have sailed much further south along the coast of Africa than was thought previously (see 4.2.5). The absence of large quantities of diamonds where there should have been, linked to the finds of more sophisticated artefacts by the Sullivan couple in the alluvial diamond fields of South Africa, that were radically different from the Stellenbosch artefacts found by Doctor Van Riet Lowe in the 1930's (see 4.2.7.4), may point in the direction of large-scale digging for alluvial diamonds by a foreign power, most likely the Egyptians, for use in their stone working activities.

I do believe that the Egyptians mostly developed their own building skills, without much influence from other sources, this due to their relative isolation as a narrow strip of land between the Eastern and the Western deserts, with the Mediterranean to the north of the delta of the Nile, and the Nile cataracts to the south (Casson 1966:11). They developed their own unique style and building techniques, using the walls they created to give an account of their achievements in hieroglyphs. They mostly seem to have used copper chisels, which may seem to have been too soft for the work to be done, but these were hardened both by hammering the copper, as well as by mixing in 6% arsenic. It would be interesting to try and make copper chisels with such a percentage of arsenic and then try them out on materials of different hardness to see what the result will be.

It would not surprise me if the Greeks learned how to construct pillars with the use of drums (see 3.4.2.1) from the Egyptians, which they may have observed when they visited Egypt for trade purposes. It was the Greeks however, who developed the technique of using *empolions* (see Figure 3-38) between the drums, and perfected the practise of fluting the pillars, thus providing the finishing touch.

The Romans took over the construction know-how from the Greeks, and expanded it further. This as a result of the establishment of Greek colonies in Sicily and southern Italy, then called Magna Grecia, where the Greeks had also constructed their temples. The Romans in turn put their own stamp on the development of technology, and also brought materials from further afield than had been the case before, as well as made use of materials of different colours.

The section on the use of mosaics as floor covering was added to show that not just large pieces of stone can be used for construction, but very small pieces as well and to great effect with different colours to create patterns and images.

As for materials used in antiquity, there can be confusion between some kinds of materials that carry the same name, as to their provenance. Moreover, stone that was green in colour when it was first quarried and used, may have lost its colour and become greyish due to the colour seeping out over time, which is a common occurrence with green materials (see 3.7).

The section on the stone vessels in Jerusalem showed yet another use of stone as a very versatile material, which has many uses. Even though the stone vessels were not used for the construction of buildings, which is the main focus of this thesis, this industry developed side by side with a large building project, whereby smaller pieces of stone, which would not be used for construction, were used for the manufacture of the stone vessels, both large and small and by means of different methods (see 3.5).

The belief that the increased use of stone vessels in Jerusalem towards the end of the Second Temple period was solely due to an increased desire for purity, may have to be adjusted by the knowledge that many stonemasons had to turn to another way of earning a living, due to the disastrous consequences for them when the large building project came to an end.

### 7.2.2 My answer to the fellow student who initially asked the question: how?

If I had to give an explanation now to the older female fellow student, who initially wondered how it had been possible for people to build what they did in the time of Hatshepsut, I would tell her, that even though it has often been suggested that the people who built all the temples and monuments, which we now still see the remains of, were slaves, that is not the case and we know now that they were constructed simply by stonemasons with relatively simple tools at their disposal. They were people like you and me, though mostly men, who would first go in search of a suitable deposit of stone. Once they had found that, they would try to make use of natural cracks in the material to try and pry a piece of material loose in order to use it in their construction effort. This would be done with wedges and hammers, and they could also make use of the forces of nature, whereby a wooden wedge (or more than one wedge) wetted with water would swell and force a piece (or pieces) of stone loose from the bedrock. Further loosening of blocks would be done with levers. Teams of stonemasons would work together to loosen larger blocks, individual stonemasons would break up blocks to make smaller pieces, blocks would be squared, uneven protrusions would be removed and pieces of stone would be shaped according to what was the requirement. This would be done with simple hammers, chisels, wedges and measuring tools, which were used by the stonemasons to obtain the desired result. Stonemason work also required a lot of what we would call ‘elbow grease’, especially when it came to sanding and polishing. Besides tools and elbow grease, also experience played a role. Stonemasons who had worked a certain type of stone material would eventually have a thorough knowledge of what could be done with it. With chisel and hammer they could shape a block of stone into any required shape. And experience would be a cumulative process. Moreover, this ability exists to this day, as there still are stonemasons and sculptors who can produce articles out of stone with the use of chisels and hammers. The skill is rarer these days though than it used to be.

Over time methods were developed, for transport, hoisting and construction, and this enabled builders to envisage larger and more elaborate buildings, which was also helped by technological advances that made the quarrying of larger blocks possible. Ultimately the working of stone was done by the thousands and thousands of nameless stonemasons, who were employed to produce the building blocks of any building constructed in antiquity. As stated, these were not slaves, as has sometimes been assumed, but mostly ordinary inhabitants of the places where large temples or monuments were constructed. In the case of the Solomonic Temple in Jerusalem, the labour may have been enforced, and in the case of the construction projects in Egypt, labourers were expected to work for the pharaoh under the *corvée* system, but in the various case studies as presented in this thesis, no outright slavery, whereby workers were totally at the mercy of their owners, was detected. People built mostly of their own free will, to build or add on to a place of worship, so their motivation to build was religious. And for most professional stonemasons throughout the ages, it simply was a job and a skill to make a living. What is impressive though is the sheer quantity of stone that has been quarried throughout the time that stone was the exclusive building material for the construction of smaller and larger buildings.

## 7.3 THE CONCLUSIONS REGARDING THE REQUISITE CONDITIONS IN SOCIETY TO BUILD A LARGE TEMPLE OR MONUMENT

### 7.3.1 Introduction

From the case studies presented in Chapter Six, the criteria established in section 5.2 based on the account of the construction of the Temple in Jerusalem by King Solomon, seem to be applicable to a wide range of buildings and monuments constructed in antiquity in different times and places and with different materials.

#### *7.3.1.1 A situation of peace*

When King Solomon of Israel sent a message to King Hiram of Tyre after the death of his father David (I Ki 5:2-6), and explained that David could not build a temple because of the wars waged against him, but that God had given him (Solomon) rest on every side and there was no adversary or disaster and that therefore this was the time to build a temple for Name of the Lord his God, he hit the proverbial nail on the head. What seemed like a minor point of importance, namely the situation of peace, was in fact the most important point of all. When we look at the examples in the case studies, we see that a situation of peace, an absence of war or conflict, is absolutely essential for the construction of a large building or monument in antiquity. That was the case for the Temple in Jerusalem, but equally so for the construction of the circular temples in Göbekli Tepe, as well as for the religious center at the Ness of Brodgar in the Orkney Islands. In these latter two places, it may be difficult to absolutely prove the absence of war, but the circumstantial evidence of the absence of fortresses, and time for decoration and artistic expression respectively, are indications of a situation of peace. In Egypt, the Black Pharaohs first had to re-establish peace before substantial additions could be made to the temple complex at Karnak, and when considering the construction of the Parthenon in Athens, Greece, we see what a long-range effect war can have on major construction projects, causing major changes. Peace is an essential factor. In the last example, King Herod also made use of the long period of the *Pax Romana* to enlarge and embellish the Temple Mount complex in Jerusalem. And even in modern times this principle applies, as the construction of the Sagrada Familia Cathedral in Barcelona proves. This project, which began in 1882, was interrupted by the Spanish Civil War from 1936-1939 (Berlin 2010:23-27), has been ongoing ever since, and still needs to be completed (Abend 2019:28-37).

#### *7.3.1.2 A common purpose*

When we look at the account in I Chronicles 28, where King David called all his officials together, and the first five verses of I Chronicles 29, where David called on the whole assembly to consecrate themselves to the Lord, and to assist Solomon in the building of the Temple, we see how it is necessary to have a common purpose to achieve such a task. It is not possible for one man alone to construct a large building or monument. When we look not just at the five case studies in this thesis, but also at the many large monuments and buildings that exist in the world, then we realise that there must have been a common purpose among many people groups who built them, that they must have had a common purpose or belief to have achieved all this. And this common purpose, which in most cases was a common religious belief, seems to have been the most compelling factor in this regard. We may not know what was the belief that spurred on the builders of Göbekli Tepe or of the Ness of Brodgar to construct what they did, but all excavated remains of their religious structures point at the presence of a strong religious conviction. In the cases of the Black Pharaohs at the temple of Karnak, the construction of the Parthenon in Athens and the extension of the Temple Mount in Jerusalem in the time of King Herod, a strong religious conviction is a clear motivating factor.

#### *7.3.1.3 The availability of enough manpower*

Manpower, (and possibly also women power, as was shown in the construction of the pyramids, see section 5.3.2), was more freely available for the construction of large temples and monuments than one would have thought possible. Instead of every person involved in hunting and gathering, or agriculture, or trade to make a living, depending on the era in which construction of a particular monument took place, there were people available to build monuments or temples. Their activities may not have been continuous, as it seems that in some cases the construction activities were seasonal, such as was the case in Egypt when labourers were called up during the time of the inundation of the Nile (see section 6.2.3.4). In other places, the construction activities may have taken place at the time of the summer and winter solstice, as is postulated by Mike Parker Pearson with respect to the construction of Stonehenge (see section 3.2.5). Another possibility is that in the absence of war, it was possible for an increase in population to take place, such as was for instance the case in the time of the re-construction of the Temple Mount, which made construction of a monument or temple possible.

#### *7.3.1.4 An administrative or organisational system to mobilise manpower*

The factor of an administrative system to mobilise manpower is not always easy to prove to have been present, but there must have been some sort of authority that was able to mobilise the population to build a temple or monument. In the context of Göbekli Tepe, this factor is the least easy to discern, although the single seat of honour excavated in one of the structures may indicate the presence of a person of higher authority, who may have been instrumental in the mobilisation of manpower (see 6.2.1.5). In the case of the Ness of Brodgar site, this administrative system is also not easy to discern, but the later sites discussed in the case studies, show quite clearly that there were administrative systems in place to motivate people to build. This is quite clearly the case for instance for the Parthenon on the Acropolis in Athens (see 6.2.4.5), and the extension of the Temple Mount in Jerusalem (see 6.2.5.5), and a bit less well defined in the case of the Black Pharaohs and the construction of the last additions to the temple at Karnak (see 6.2.3.5).

#### *7.3.1.5 Sufficient food supplies*

What has struck me in this study is that there was far more food available in antiquity than one would have thought. The earth provided in far more abundance than we can imagine and that without our modern artificial fertilisers. In the situation of Göbekli Tepe, the builders simply made use of the abundance of game and wild grains to feed themselves. In this context I want to make a comment regarding the fact that the successive circles at Göbekli Tepe deteriorated in building quality as Klaus Schmidt has reported. To me this indicates that one or more of the ideal conditions for the construction of a large temple no longer existed. This may have been a lack of food, as they possibly had depleted the food supplies that were so lavishly available when the first circles were constructed. This may have been caused by the westward migration of the aurochs and gazelle. Another aspect that may have been a problem, was the availability of water. The nearest water source at present is about 5 kilometers away, but one wonders if there could have been a water source closer to the site, which dried up over time, after the initial warmer and wetter conditions possibly had changed? It could have remained warmer, but what happened to the wetter conditions? This may have become a problem. This in turn may have led to smaller numbers of people to be involved in the construction of the next and the next stone circle, because the site could no longer support a large group of workers.

To revert back to the discussion about the food supplies: in the later situations, food had to be produced by working the land, such as in the Orkney Islands, where agriculture and animal husbandry were practised. In Egypt food was produced with the benefit of the annual flooding of the Nile, which brought fertile silt to the agricultural lands. The Nile also produced ample quantities of fish. In Greece the situation was at times more difficult, with the occasional failed cereal harvest, but it seems that food surpluses were available. In Israel there was enough food production in the time of King Herod, due to the improved technology of better iron implements and water being brought over further distances for irrigation purposes. People were also much more able to grow sufficient food than we would think, so that there was a surplus, which made it possible for workers to build a monument and not be involved in food production as a subsistence farmer. Moreover, populations were also not as large as in present times, which may have been a contributing factor to the sufficient availability of food.

#### *7.3.1.6 Availability of material for construction*

The availability of material for construction seems to be the easiest point to prove, which should come as no surprise, as most sites in the world have some kind of stone available. My home country the Netherlands is one of the few places in the world which does not have rock formations to quarry stone from for building purposes, but that is a rare situation. Limestone, sandstone and marble are available in abundance in many places in the world, and have the added advantage, that they are not exceedingly hard and can be worked with simple tools. Layered materials, such as slate and quartzite are also available in various places in the world and can be extracted in slab form. Granite and basalt are more difficult to work, but were also used in antiquity where available and were often remarkably well worked, despite the seeming lack of suitable tools. Often builders used what was available close to the building site, and at times materials were transported from further afield, which has baffled researchers for instance in the case of the stone materials used for Stonehenge, but transport of stone over long distances had become quite an acceptable practice in the Greek and Roman era.

#### *7.3.1.7 Trade*

With regard to trade, that was hard to prove in the case study about Göbekli Tepe, but was already present in the Orkney Islands, where commodities from far afield were found. In the case studies of later date, trade was quite visibly present. Trade provides an exchange of ideas and materials which are not locally available as well as in some cases profit to pay for the construction of a temple of monument. In the time of the construction of the pyramids in Egypt, trade probably provided wood for the sledges that were used to haul blocks upwards, as wood was scarce in Egypt. Trade was an important factor in the construction of the Jerusalem Temple in Solomon's time, as olive oil and wheat were used to pay for timber and labour from the side of the Phoenicians, as well as for their building expertise. Trade in the time of the Black Pharaohs was possibly not such an important factor for the construction of Taharqa's porch, although wood for barges to transport the stone materials may have come from Phoenicia, and possibly iron tools as well. In the case of the construction of the Parthenon, trade was partially an indirect contributor, in that Athens received contributions from the Delian league, for the protection of the sea-lanes against pirates, so that trade was not hampered, which was used for the construction costs of the Parthenon. In the case of King Herod's extension of the Temple Mount, trade in the commodities that were produced on Herod's agricultural estates, as well as tolls levied on trade passing through his territory, were initially the means by which the project was financed. After Herod's death, this source of income was greatly reduced, causing major hardship for the local population, due to increased taxes.

#### *7.3.1.8 Construction technology*

What has also struck me in the course of this research is, that people always seem to have been able to build something larger and more elaborate than what one would expect and consider them capable of. That is especially the case for the site of Göbekli Tepe. That people with no settled existence and a seemingly limited social organisation and limited access to technology were able to construct monuments of the size that they did, I find incredibly impressive. The pyramids come in a close second place after that, due to their sheer size, but there we can see a gradual development over time, starting with the mud-brick pyramids and earlier attempts to build these structures.

One can really observe that over time technology developed and technology seems to have been transferred from one area to another. Technology improved over time, as people learned from earlier mistakes and adapted it where necessary. It can be compared to the Olympics in the striving for bigger, higher, better, more impressive, more elaborate and sophisticated. And even so, one does not cease to be amazed.

It is not easy to prove that construction in Egypt influenced for instance construction in Greece, although the practice of building pillars by stacking layers, either of blocks or of drums, may have been a technology that came to the Greeks through their trade contacts with Egypt. The lines of transfer run more clearly from Greece to Rome, because of the 'export' of technology by the Greeks to their colonies in Sicily and Magna Grecia. The Romans took over this technology and developed it further.

#### *7.3.1.9 Transport technology*

Besides the actual process of quarrying and working stone, the transport technology which was developed over time is in my opinion the next most interesting aspect of this study. Starting with simple rollers to move large pieces of stone to a nearby building site, to hauling blocks up on sledges to the ever-increasing height of a pyramid under construction, the ingenuity of the technology that was developed is quite impressive. And most of this with human muscle power, or at times assisted with draught cattle where available. Besides this the courage to transport stone on ships over long distances over water, down the river Nile or across the Mediterranean is almost even more impressive. The huge barge built for Hatshepsut's obelisks stands out as the most striking example. People in antiquity must have had great confidence in the strength of their ships to carry such heavy loads. And in some cases, where material was quarried on islands, such as Paros, Naxos and Thaxos in Greece, there really was no other option to transport the marbles quarried there, than over water.

#### *7.3.1.10 Tools*

Despite the fact that iron tools were not available for the construction of the earliest temples or monuments, it is impressive what people were able to build with the use of tools made of flint or antler, copper and bronze, as well as pounding stones and fire-setting. When people wanted to build, they would fashion whatever tools they needed from the available materials to achieve their plans. Their ingenuity is impressive. With the use of copper tools in Egypt, hardened by hammering and mixed with arsenic, the most incredible array of temples and monuments was built. Once iron tools became available, construction of large temples and monuments expanded greatly and became a relatively easier task.

*7.3.1.11 Seasons and weather*

Even though seasons and weather were not part of the original set of essential factors as established in the account of the construction of Solomon's Temple, I decided to include this factor, as there was some information available and it is also something that affects construction of large monuments and temples.

Unfortunately, factors such as seasons and weather are poorly represented in the available material. It would add an extra dimension if we did have this information available for the various examples examined in the case studies. The change of activities in different seasons, often under the influence of changes in weather, were probably accepted as normal in antiquity and did not often warrant any special mention, so references to that are hard to find and at times need to be inferred from the available information. When they are available however, they can shed light on why certain things happened at certain times and not at other times, such as with the quarrying of flint at Grimes Graves, which happened in summer and not in winter.

*7.3.1.11 Safety*

As with the previous factor, also safety is not one of the original factors found in the account of the construction of Solomon's temple, but with the verse about stone working in Ecclesiastes, and a few instances where safety was mentioned, which were found in the initial research for this thesis, the decision was taken to include this factor in the study.

Besides the physical research conducted by Sarry el-Din at Giza, by Ann Austin at Deir el-Medina, and by Maria Nilsson and John Ward at Gebel-el-Silsila, it is interesting that Lesko and Lesko have found written records of injuries at Deir el-Medina. When one considers how much stone was quarried over the millennia in antiquity, the safety factor gets very little attention. The workers must have considered physical injuries part and parcel of the job, but they were usually not the people leaving written accounts of such things. Injuries did occur, such as workers getting hurt when dislodging blocks, by flying chips when hewing stone, ropes breaking that would hold a sledge with a block in check as it was being guided down the mountain, rough edges causing cuts in workers' hands, dust being inhaled, and even dangers from snakes and scorpions. And then there were dangers that one can infer from writings, such as the warning by Vitruvius to use stronger cranes for heavier loads. On the whole safety seems to be something that only recently has been looked at as a result of skeletal finds during excavations, as mentioned in section 5.3.2.

As these two latter categories were only additional to the original set of criteria as mentioned in the account of the construction of the Solomonic Temple, they should therefore probably carry less weight in the final conclusions.

## 7.4 COULD ANYONE ELSE BESIDES KING SOLOMON HAVE BUILT THE TEMPLE IN JERUSALEM OR IN ANY OTHER PERIOD OF TIME?

Although it is not the main purpose of this study, it occurred to me that my findings can have an impact on the debate between the archaeologists whether the biblical account in the Bible regarding the reign of the Kings David and Solomon is historically accurate or not. And besides this, also on whether the dates that archaeological scholars assign to certain archaeological finds, such as at Jerusalem, Hazor, Gezer and Megiddo, which attribute these finds to the time of the Kings David and Solomon, are correct or are a century out of kilter (Draper 2010:73). Professor Israel Finkelstein of Tel Aviv University and his followers are proponents of the 'low chronology' and believe that the archaeological finds commonly attributed to the time of the Kings David and Solomon, in fact date to the time of the Omride dynasty of the ninth century (Draper 2010:73)[39].

One of Professor Finkelstein's colleagues, Doctor Omer Sergi of Tel Aviv University, clearly was of the same opinion, as expressed in his presentation at the workshop on the Phoenicians at the Johannes Gutenberg Universität in Mainz on 13 December 2018, which I attended, and he attributed much of what is written about King Solomon in the biblical account, to the later King Jeroboam II of the Omride dynasty of the Kingdom of Israel. Omer Sergi attributed the two stable complexes found at Megiddo

[39] In this section I make use of the words 'findings' and 'finds'. They have different meanings and well as follows: find: something found, a valuable item, and archaeological find (Merriam Webster 1977:430); finding: the result of an investigation (Merriam Webster 1977:430).

for instance to the time of the Omride King Jeroboam II[40], as well as the site of Horvat Rosh Zayyit (see 5.1.4), and played down the combined expedition to Ophir by Hiram and Solomon as only an example of the Phoenician influence and presence in the south of Solomon’s territory.

When weighing up the evidence, both from the biblical account of the construction of the Temple in Jerusalem, and all the factors involved in that project, with the accounts of the construction of large temples or monuments in the case studies, the parallels are clearly visible. The factors derived from the biblical account of the construction of the Temple in Jerusalem, are replicated time and again in the other large construction projects in different eras, places and circumstances. That means, in my opinion, that the author of the biblical account knew what he was writing about, based on the actual construction of the temple, and it is clear that a large building was constructed in Jerusalem in that time. In fact, there were two buildings, as besides the temple, also a palace was built for Solomon.

That brings us to the question if this construction did take place? Was this indeed in Solomon’s time, or was this in another time? The answer can be found in the factor that was mentioned in the very first place in the biblical account, namely a situation of peace (I Ki 5:4), which has been shown in the case studies to be a much more important factor than it seemed to be at first sight. A situation of peace is essential for a large construction project to proceed.

With that in mind, we need to ask the question, when was there peace in Israel? That was not the case in the time of King Saul, who was regularly at war with the Philistines (I Sam 13; 17; 31). It also was not the case in the time of King David, who defeated enemies left, right and center (see 5.2.1), to achieve the situation of peace that Solomon mentioned in his letter to King Hiram of Tyre (I Ki 5:4). The time of King Solomon seems to have been a peaceful interlude between his predecessors and those who succeeded him. After the death of King Solomon, his kingdom was split, whereby his son Rehoboam became king of the kingdom of Judah, which also included the tribe of Benjamin. The remaining ten tribes continued as the Kingdom of Israel under Jeroboam who was chosen as their king (I Ki 12:1-20). The emasculated

[40] Omer Sergi actually made a mistake by stating that King Jeroboam II belonged to the Omride dynasty, as King Jeroboam II was in fact the fourth king of the Jehu dynasty (King 1988:8)

Kingdom of Judah would never have had enough resources to build a temple of any magnitude as described in the biblical account. They also lacked the support of the Phoenicians, who were location-wise and ideologically closer to the Kingdom of Israel. Moreover, the two small kingdoms of Israel and Judah lived in a state of friction with each other, and the Kingdom of Israel also established its own centers of worship at Bethel and Dan (I Ki 12:25-33), of which so far only the latter has been found through archaeological excavation (Scheepers & Scheffler 2000:55). In later times both kingdoms came increasingly under threat, first from the side of Aram (Syria) in the time of Elisha (2 Ki 6:8; 6:24) and then from the side of the Assyrians (2 Ki 17:3-6; 18:9-16).

The situation of peace under Solomon seems to have been the only peaceful interlude in the history of Israel at that time, during which the temple at Jerusalem could have been built, also because at that particular time all the other factors needed for the construction of a large temple were present. That no traces of the Solomonic Temple can be found or have been found up till now, is not surprising, as the destruction by the Babylonians, subsequent rebuilding after the Babylonian exile and extension of the Temple Mount under the Hasmoneans (see 6.2.5.1), have all been buried under the massive extension constructed in King Herod's time (see 6.2.5). As far as that is concerned, Herod has done the archaeologists of our present time a massive disservice.

Maybe the stables at Megiddo date to the Omride dynasty, or to the time of Jeroboam II, and maybe Solomon did not have as many horses as the biblical account states, but if I take the above investigation into account, the Temple in Jerusalem could *never* have been built in the time of the Omride dynasty, as the Kingdom of Israel at the time of that dynasty, or alternatively at the time of the Jehu dynasty, did not have access to Mount Moriah in Jerusalem. The Kings Omri and Ahab also were not known for their dedication to the worship of Yahweh, and would not have spent so much effort and expense to build a temple for the Lord's Name, and neither would King Jeroboam II have done so.

Another question would be, 'why would King Jeroboam II have given Horvat Rosh Zayyit to the then King Hiram of Tyre? As payment for what? Moreover, how could the Phoenicians have had access to Ezion Geber to undertake the expedition to Ophir in the time of either the Omride dynasty or the Jehu dynasty, when they did not have access to Ezion Geber, which was part of the Kingdom of Judah and not of the Kingdom of Israel?

Without the wealth of Solomon and his co-operation with King Hiram of Tyre, as well as all the factors analysed in this study, the Jerusalem Temple would not have been built, so King Solomon was not as insignificant as Israel Finkelstein, and his colleague Omer Sergi, are wanting us to believe. I sent an email with a number of questions to Omer Sergi after the December 2018 workshop in Mainz, which up till now has not been answered. Archaeology should not be used to prove the veracity of the Bible, but should not be used to try to disprove the biblical account either.

The account of the construction of the Solomonic Temple in Jerusalem, describing the many factors that needed to be present to achieve the desired result, indicates to me that the Temple was indeed constructed under the reign of King Solomon, and that King David had probably already done large part of the planning and some preparations during his lifetime (I Chron 28, 29:1-5). In another setting, such as that of the Omride or Jehu dynasty, the necessary factors, which were needed for a successful completion of the project, simply did not come together. And as also has been shown in the case studies, these factors are important and should all mostly be present for the successful completion of a project of such magnitude.

## 7.5 TOPICS FOR FURTHER INVESTIGATION

As a topic for further investigation, I would like to recommend that a test would be performed by first manufacturing a pure copper chisel with a 6% addition of arsenic (as discovered by Odler, see 2.6.3). Then this copper chisel also needs to be hammered, to harden it further (see 2.6.3). This chisel should then be used by a trained stonemason to try and chisel inscriptions into a piece of granite (see problem stated in 4.2.3 about the granite being too hard to be worked with a copper chisel). By doing this test it could be shown whether granite can or cannot be worked with copper chisels that have been hardened as described in the above.

Another topic for investigation, which has already been mentioned in 3.2.5.2 would be to use the fire-setting method to quarry granite by making a fire in a reduced oxygen environment, to see if that would result in the mudbricks surrounding the fire, turning red or yellow instead of black as a result of the firing process. It would be interesting to let this kind of fire burn a little longer, to investigate whether this would result in less pounding work afterwards, as more of the granite would have gotten hot and might have pulverised in the process.

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## APPENDIX 1

## RESTORING THE MOSAIC AT MESSENE, GREECE

The restoration process of the mosaic in Messene proceeded as follows:

We started out by lifting the mud off the mosaic with trowels and brushing the dry dirt away. After that the mosaic needed to be washed with clean water and sponges. This was repeated a number of times until the silt in the grouting had also been washed off as much as possible. Then scalpels were used to scrape the grouting between the *tesserae* to remove all cement that was soft and had crumbled. The dust resulting from this scraping process was brushed away and the last vestiges were blown away with a small ball-shaped rubber bellows. After this the cement had to be mixed. For the restoration a special mix had been made containing the local dark pink/red stone material, which had been ground. This was sifted before use to remove the largest particles, and then the remainder was mixed with white cement in a ratio of three parts red sand and one parts cement.

This was stirred to mix it well and then water was added by squeezing a wet sponge full and another one, thus preventing too much water from being added. The mixture was stirred and had to be of a runny porridge consistency to be ready for use. The mosaic floor was wetted lightly with wet sponges and then the cement mix was applied either with spatulas or rubbed in by hand (we were wearing thin rubber medical gloves throughout the entire restoration process). The mixture was pressed into the grooves resulting from the scraping process. The cement was then allowed to dry for about 20 minutes to half an hour. Then the remainder of the cement had to be brushed off vigorously and the entire area which had been cemented had to be washed again several times to make sure that the remaining cement was removed off the surface of the stones completely. After that, the repaired section was then covered with plastic sheeting, held down by stones, and left overnight to allow for proper drying. The purpose of the plastic sheeting was to prevent the cement from drying too quickly.

We managed to finish the restoration process on the last day of our stay there, for which the staff members from the museum were very grateful, and which gave those who had worked on it a deep sense of achievement (see Figure 3-64). During the winter season, from about November onwards, the mosaic is covered with cloths to protect it against the winter rains.

The repair process with the cement as mentioned above is what is called ‘grouting’ in our day and age. I have done this in my own house to fill in the gaps between the tiles, which my husband and son had laid on our kitchen floor. This process of grouting also must have been applied in antiquity to fill the spaces between the *tesserae,* as laying the pieces of stone only in the cement underneath them would have been insufficient to keep them in place. This would not have filled the gaps between them. The washing process is also applied in this day and age, and would also have been necessary in antiquity to remove the remains of the grouting cement. For this reason, the description of the restoration process is included in this thesis.

That the process to repair the mosaic was not without health risks, I discovered after getting home. As we had been lying on our knees to brush the excess grouting mixture off the mosaic, we had breathed in a considerable amount of fine dust. I realised that I had picked up a mild case of Silicosis (see 5.3.2 for an explanation of Silicosis). As I did not inhale any further dust from the brushing process, because the task was finished, my lungs managed to clear what I had inhaled in Greece in the course of the next few months. For me it was an experience on a small scale of what stone workers over the centuries routinely used to be exposed to.

## APPENDIX 2

## MODERN ARCHAEOLOGICAL RESEARCH INTO ANCIENT QUARRIES

In the earlier days of archaeological research, more attention was given to excavating in places where rich and spectacular finds of artefacts could be made, but in recent years there has also been a move towards more research into ancient quarries, and in this section a few examples will be highlighted.

As was already mentioned in 3.3.5, the researchers Doctor Roland Enmarch and Doctor Yannis Gourdon went to the old alabaster quarry of Hatnub in Egypt to re-investigate the inscriptions on the walls with more modern methods, and in the process the stepped hauling ramp was found there, which upon further analysis will provide more insight into the methods of transporting the blocks out of the quarry, and possibly also into the transport of stone blocks up the pyramids at Giza.

Similarly, the husband and wife team of archaeologists Doctor Maria Nilsson and John Ward have been excavating in the sandstone quarries of Gebel el-Silsila in Egypt. These quarries are enormous. They have extensively researched the inscriptions there, as that seems to be Maria Nilsson’s specialised field of expertise, while John Ward has made the spectacular find of a large ram-headed sphinx, which had been left behind as it was damaged, together with a small model sphinx, which is believed to have been a practice piece. Also, remains of a temple and many other finds have been made (https://gebelelsilsilaepigraphicsurveyproject.blogspot.com).

Also, of interest is the research by a team of diverse specialists into old stone quarries. Their organisation ‘QuarryScapes’, is focussed on the conservation of ancient stone quarry landscapes in the eastern Mediterranean. This group, under the leadership of the Norwegian Tom Heldal, who is the head of the Geological Survey of Norway, has done research into the location and state of affairs in a whole number of ancient and abandoned quarries in Egypt, Jordan, Turkey and Greece. Their reports about these quarries can be found on their website: www.Quarryscapes.no. Other contributors to these reports besides Tom Heldal are, Per Storemyr, Elizabeth Bloxam and Adel Kelany. The team has been advocating the identification and investigation of old quarry sites as well as protection of these sites against destruction by incorporation into cities or further exploitation. This is done with the intention that research should be conducted into how these quarries were exploited in antiquity and to prevent information from being lost. The project has officially been terminated, but the website is still available for consultation.

Other quarries which have been investigated, such as those at Widan el-Faras, Umm es-Sawan, Gebel Gulab and Chephren's quarry, are mentioned in the article by Doctor Elizabeth Bloxam (2005:23-27).

Attention is being paid by means of archaeological research into the work of ordinary people, quarry workers and stonemasons, who made the construction of the many stone temples and monuments possible through their sheer hard work, and stone extraction techniques.