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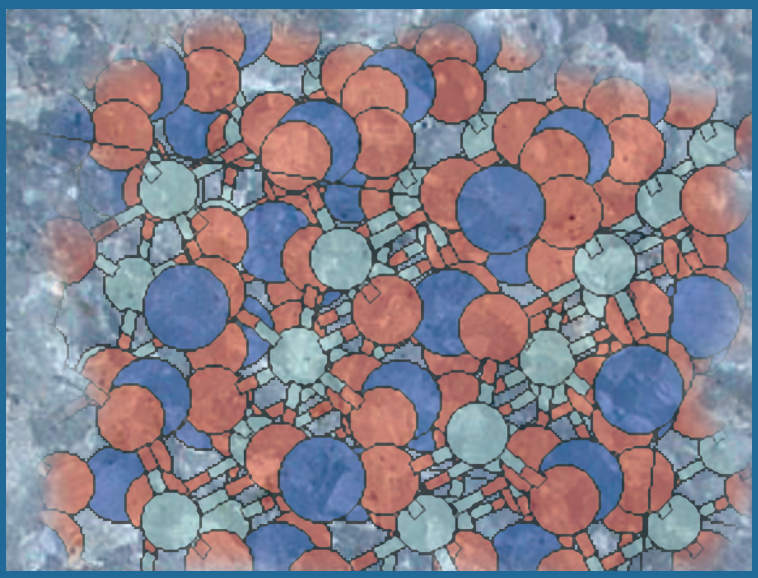
ASMOSIA VII

Actes du VII^e colloque international de l'ASMOSIA
Thasos 15-20 septembre 2003



Proceedings of the 7th International Conference of
Association for the Study of Marble and Other Stones in Antiquity
Thassos 15-20 september, 2003

Études réunies par Yannis MANIATIS

BULLETIN DE CORRESPONDANCE HELLÉNIQUE

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Études réunies par Yannis MANIATIS

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PRÉFACE

L'acronyme ASMOSIA désigne l'*Association pour l'étude du marbre et autres pierres dans l'Antiquité* (Association for the Study of Marble and Other Stones in Antiquity), fondée lors d'un atelier de recherche avancée de l'OTAN qui s'est tenu à l'hôtel Il Ciocco, à Lucca, en Italie, du 9 au 13 mai 1988. L'atelier était intitulé : *Le marbre en Grèce ancienne et à Rome : Géologie, carrières, commerce et artefacts*. Il fut suivi par une cinquantaine de participants qui représentaient de nombreuses professions : des physiciens, travaillant dans le domaine de l'archéométrie, des archéologues, des historiens de l'art et des conservateurs. Il fut organisé par Marc Waelkens et Norman Herz avec le but affiché d'encourager les projets associant scientifiques, historiens de l'art et autres pour une meilleure compréhension des questions relevant de l'usage de la pierre par les Anciens. À la suite de cet atelier, une série de rencontres fut programmée tous les deux ans et demi environ : la seconde rencontre eut lieu du 16 au 20 octobre 1990 à Louvain, en Belgique ; la troisième du 17 au 19 mai 1993 à Athènes, en Grèce ; la quatrième du 9 au 13 octobre 1995 à Bordeaux, en France ; la cinquième du 11 au 15 juin 1998 à Boston, aux États-Unis ; la sixième du 15 au 18 juin 2000 à Venise, en Italie ; la septième du 15 au 20 septembre 2003 à Liménas, sur l'île de Thasos, en Grèce. Cette série de colloques fait partie intégrante de l'association ASMOSIA : ils ont pour objectif de promouvoir la collaboration entre les sciences, l'archéologie et l'histoire de l'art pour une meilleure compréhension de l'exploitation, du transport, du traitement et de l'emploi de la pierre brute dans l'Antiquité.

La publication des actes a été bien accueillie à la fois par les historiens de l'art, les archéologues et la communauté scientifique, comme par les corps de conservateurs; elle a contribué à susciter une coopération interdisciplinaire sans cesse élargie. Dans la mesure où, avant la création de l'association, cette coopération était minimale, ce fut là, en fait, un progrès décisif. Pour la bonne organisation et la publication de ces rencontres, on a également eu la chance de bénéficier du soutien financier d'agences nationales et internationales, comme la fondation Samuel H. Kress Foundation, l'OTAN, etc.

Le nombre de membres de l'association a plus que quadruplé, passant de 50 en 1988 à environ 250 aujourd'hui, représentant 25 pays. En dehors des actes de colloques, ASMOSIA publie également à raison de deux fois par an l'*ASMOSIA Newsletter.*

À ce jour, ce domaine de la recherche a fait preuve d'importantes avancées dans la mesure où les sources matérielles dont on dispose pour l'usage du marbre et des autres pierres dans l'Antiquité ont été largement étudiées et où les matériaux eux-mêmes ont fait l'objet de caractérisations géologiques et physico-chimiques. Les bases de données avec leurs paramètres analytiques se sont développées et les

caractéristiques de différents types de pierres brutes se sont accumulées. Bien des problèmes archéologiques ou relevant de l'histoire de l'art trouvent désormais une meilleure réponse et une meilleure explication par le recours aux analyses scientifiques et aux bases de données, qu'il s'agisse de la provenance, de l'identification, de la diffusion, du traitement, des assemblages et de la préservation d'importants artefacts.

Le 7e colloque international de l'association ASMOSIA s'est tenu à Liménas, la ville principale et le port de l'île de Thasos, en Grèce. Il a été organisé par le laboratoire d'archéométrie-NCSR « Demokritos », l'École française d'Athènes, la 18e éphorie des antiquités préhistoriques et classiques, l'IGME (Institute of Geology and Mineral Exploration). Le comité d'organisation, composé de Y. Maniatis, K. Polikreti, Z. Bonias, S. Papadopoulos, T. Kozelj, M. Wurch-Kozelj et M. Varti-Mataranga, tient à adresser ses remerciements à la Municipalité de Thasos qui a mis à disposition la salle de conférences du « Kalogeriko » et a tout mis en œuvre pour faciliter le bon déroulement du colloque, le ministère grec de la culture et le ministère grec de l'Égée ainsi que l'Association des entreprises du marbre de Thrace et de Macédoine pour leur soutien financier.

Ce volume réunit les contributions présentées au 7e colloque international de l'association ASMOSIA. Les thèmes abordés dans ces communications sont à la pointe du domaine interdisciplinaire où se rejoignent les sciences, l'archéologie et l'histoire de l'art ; ils reflètent un large spectre de la recherche poursuivie sur les pierres grâce à la coopération des sciences et des humanités. En particulier, les thèmes abordés recouvrent presque tous les aspects qui concernent la pierre depuis la carrière jusqu'au produit décoré dans son état final, sans exclure les questions du vieillissement et de la restauration.

Tous les textes soumis pour publication dans ces actes ont fait l'objet d'une révision attentive par un ou plusieurs réviseurs, ce qui en garantit le haut niveau, le caractère innovant et la portée scientifique.

En la matière, nous exprimons nos sincères remerciements aux membres du comité exécutif de l'association ASMOSIA, N. Herz, L. Lazzarini, P. Storemyr, J.J. Herrmann Jr., Ph. Jockey, S. Kane, J. Harrell, ainsi qu'aux members du comité scientifique du colloque qui ont apporté leur concours à la difficile révision des textes présentés dans ce volume.

En outre, nous voulons remercier V. Zatta, secrétaire de l'Institute of Materials Science-NCSR « Demokritos » pour son aide dans le traitement des actes et les étudiants-chercheurs du laboratoire d'archéométrie-NCSR « Demokritos » D. Tambakopoulos et M. Maniati pour leur aide dans l'organisation et la relecture des épreuves.

Nous tenons aussi à exprimer notre plus profonde gratitude à l'École française d'Athènes et, en particulier, à son directeur, le professeur D. Mulliez : l'École française d'Athènes, en effet, a supporté la totalité du coût de fabrication et du travail de publication des actes dans le *Supplément* 51 du *Bulletin de Correspondance Hellénique*. Nos remerciements vont également à Sandrine Huber, ancienne adjointe aux publications de l'École française d'Athènes, et à Catherine Aubert, qui lui a succédé à ce poste, pour la part qu'elles ont prise dans l'élaboration de la publication.

Yannis Maniatis
Président de l'association ASMOSIA

PREFACE

ASMOSIA stands for the Association for the Study of Marble and Other Stones in Antiquity and was founded at a NATO sponsored Advanced Research Workshop held at Il Ciocco, Lucca, Italy, 9-13 May, 1988. The Workshop was entitled, "Marble in Ancient Greece and Rome: Geology, Quarries, Commerce, Artifacts" and was attended by fifty persons representing many varied professions: physical scientists working in Archaeometry, archaeologists, art historians, and conservators. It was organized by Marc Waelkens and Norman Herz with the avowed goal of encouraging collaborative projects among scientists, art historians and others in order to better understand the problems associated with ancient man's use of stone. Following that a series of meetings were held scheduled approximately every two and a half year: the second meeting was held October 16-20, 1990 in Leuven, Belgium; the third May 17-19, 1993, in Athens, Greece; the fourth October 9-13, 1995 in Bordeaux, France; the fifth June 11-15, 1998, in Boston, USA; the sixth June 15-18, 2000 in Venice, Italy; and the seventh in September 15-20, 2003 at Limenas on the Island of Thassos, Greece. These series of conferences form an integral part of the Association for the Study of Marble and Other Stones Used in Antiquity (ASMOSIA) and their aim is to promote the combined scientific, archaeological and art-historical research for a better understanding of the exploration, transportation, treatment and use of stone raw materials in Antiquity.

The publications of the proceedings have been well received by both the art historical, archaeological, and scientific, as well as museum communities and have helped to inspire an ever increasing interdisciplinary cooperation. Since previous to ASMOSIA, such cooperation was minimal, this has indeed been a great accomplishment. We have also been fortunate in receiving financial support for our meetings and publications from national and international agencies, such as the Samuel H. Kress Foundation, NATO etc.

Membership in ASMOSIA has grown over four-fold, from under 50 in 1988 to about 250 now and representing 25 countries. Publications apart from the conference proceedings include the currently twice-yearly *ASMOSIA Newsletter*.

Today, the field has witnessed important advances as the raw material sources for marble and other stones used in Antiquity have been studied to a great extend and the materials have been characterised geologically and physicochemically. The databases with analytical parameters have been expanding and experience with the characteristics of different types of raw stone materials has been accumulating. Many archaeological and art-historical problems can now be better resolved and explained using the advanced scientific methods and databases. Such problems may be related to provenance, identification, movement, treatment, assemblages and preservation of important artifacts.

The 7th International ASMOSIA Conference was held at Limenas, the main town and harbour of the island of Thassos, Greece. It was organized by the Laboratory of Archaeometry-NCSR "Demokritos", the French School at Athens, the 18th Ephoreia of Prehistoric and Classical Antiquities and the Institute of Geology and Mineral Exploration. The Organizing Committee, Y. Maniatis, K. Polikreti, Z. Bonias, S. Papadopoulos, T. Kozelj, M. Wurch-Kozelj and M. Varti-Mataranga would like to thank and acknowledge the Municipal Authorities of Thassos for providing the Conference building "Kalogeriko" and all the necessary facilities in order to make this Conference possible, the financial support of the Greek Ministry of Culture, the financial support of the Greek Ministry of the Aegean and the financial support of the Association of Marble Enterprises of Macedonia and Thrace.

This book contains the papers submitted to the 7th International ASMOSIA Conference. The subjects of the papers represent the state-of-the art in the field and reflect a very broad range of research and applications carried out in cooperation between the sciences and the humanities. In particular, the subjects cover almost everything on stone from the quarry to the final decorated object, including even aspects of weathering and restoration.

All the papers submitted for publication in these proceedings went under a peer reviewing process by one or more reviewers. This guarantees that the papers published in this volume are of high standards, innovative and scientifically sound.

For this, we expresses his sincere thanks to the Executive Committee of ASMOSIA, N. Herz, L. Lazzarini, P. Storemyr, J.J. Herrmann Jr., Ph. Jockey, S. Kane, J. Harrell, and the Scientific Committee of the Conference and also to other professional colleagues who helped with the difficult task of reviewing the papers presented in this volume.

In addition, we want to thank Mrs V. Zatta, the Secretary of the Institute of Materials Science of NCSR "Demokritos" for her help in processing the proceedings and the research students of the Laboratory of Archaeometry-NCSR "Demokritos" Mr. D. Tambakopoulos and Mrs. M. Maniati for their help in organising and proof readings of the papers.

We also expresses his deepest gratitude to the French School at Athens and particularly to its Director prof. D. Mulliez for undertaking the full cost and effort of publication of the proceedings as *Supplement* 51 of the *Bulletin de Correspondance Hellénique*. Thanks are also due to Mrs. S. Huber, former publication officer of the French School, and Mrs. C. Aubert, present publication officer, for organizing the publication.

Yannis Maniatis

Current President of ASMOSIA

GPS AND GIS METHODOLOGY IN THE MAPPING OF CHEPHREN'S QUARRY, UPPER EGYPT: A SIGNIFICANT TOOL FOR DOCUMENTATION AND INTERPRETATION OF THE SITE

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5. *Leeds University, UK*
6. *Geological Survey of Egypt* (*EGSMA*)

ABSTRACT

Chephren's Quarry is one of the world's oldest hard-stone quarries, from which the famous life sized statues of Chephren and a large number of pre- and early Dynastic stone vessels were made. Archaeological investigations in January 2003 included a comprehensive geo-archaeological survey. In total, five ancient stone quarry areas, one ancient mine and one ancient track were mapped. This included 665 quarries and 166 features related to the ancient quarrying infrastructure. Several thematic maps were compiled, covering geological, archaeological and protection-relevant information. The paper presents the survey results and gives examples of how spatial databases can be applied in geological and archaeological interpretations.

KEYWORDS: ANCIENT QUARRIES, EGYPT, OLD KINGDOM, CHEPHREN, GIS, ANORTHOSITE

INTRODUCTION

Chephren's Quarry is one of the world's oldest hard-stone quarries. It is situated in the easternmost part of the Sahara - covering nearly 100 km^2 of flat, hyper-arid desert, some 60 km west of Lake Nasser (River Nile) and the famous Abu Simbel temple in the extreme south of

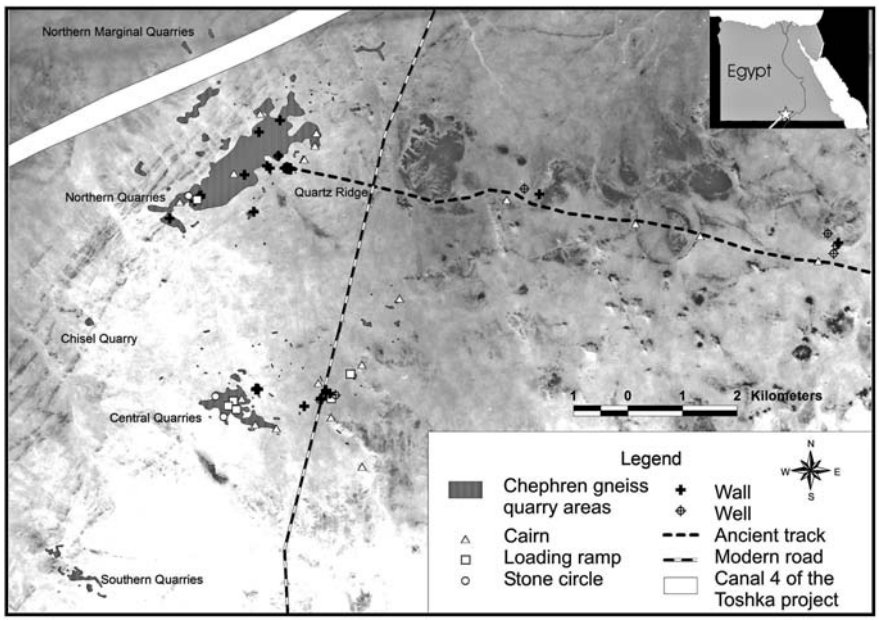

Fig. 1. — Chephren's Quarry - archaeological registration map and distribution of quarry sub-sites. Grid interval 2 km (UTM WGS84).

Egypt (**fig. 1**). In the 3rd and 4th millennium BC, the quarry was used for extraction of stone for now world-famous sculptures and thousands of smaller funerary objects, especially vessels (**fig. 2**). ENGELBACH (1933, 1938) and MURRAY (1939) made the first archaeological and geological investigations of Chephren's Quarry in the 1930's and designated the main workings into four areas: "Khufu Stele Quarry", "Quartz Ridge" "Chisel Quarry" and "Stele Ridge". The first three areas are mainly Old Kingdom quarries and "Stele Ridge" an area of predominantly Middle Kingdom carnelian mining. More recent geoarchaeological research was undertaken by HARRELL and BROWN (1994), and archaeological survey and excavation was undertaken in 1997, 1999 and 2000, directed by Dr. Ian Shaw. During these seasons an area of settlement, bakery, two stone-built loading ramps and wells associated with the Old Kingdom exploitation were excavated (SHAW and BLOXAM 1999, BLOXAM 2000, 2003; SHAW 2000; SHAW *et al.* 2001). This work demonstrated that the region is still a significant source of archaeological and epigraphic evidence (including pottery from the Early Dynastic to the Roman period, and inscribed steles of the Old and Middle Kingdoms). In June 2002, a preliminary survey of the area was carried out (STOREMYR *et al.* 2002), and was the first attempt at mapping the total extension of the quarry site. This was followed up in the 2003 survey, which is presented in this paper, aimed at providing detailed maps of the Chephren's Quarry

Fig. 2. — One of the life-sized statues of Chephren made of light banded Chephren Gneiss (upper) and a vessel of light speckled gneiss (lower).

site and a spatial database covering both the ancient quarries and remnants of the infrastructure related to the quarrying, such as settlements, roads, wells and other constructions. An important goal for the survey was the compilation of maps usable to the future management and preservation of the site, which is currently at high risk due to land reclamation programmes; this side of the work is briefly presented by STOREMYR and HELDAL (2009).

SURVEYING METHODS

Chephren's Quarry is situated in an area characterized by relatively flat desert with few hills, valleys, wadis and other significant terrain features. No detailed topographic or geological maps were available for the survey. Thus, Corona satellite images from the 1960s with 2-5 metres resolution were used as background for the surveying, maps and geological interpretations. The mapping had to be carried out systematically, covering the whole previously known Chephren's Quarry site as well as the surrounding areas within the outcropping parts of the exploited rocks. For the mapping, it was decided to use ordinary GPS, which due to the low

topographic relief proved to be an efficient method with sufficient accuracy (generally better then 5 metres), considering the short period available for surveying (4 weeks).

GPS point registrations, with a number of properties related to each observation, GPS tracklog maps of larger features observed in the field and geological structures interpreted from the satellite photo were joined in GIS tables (ArcView shape files) forming the base for several thematic maps. Much effort was put into the design of the map table structures - i.e. the properties to be registered at each GPS point. Among these properties were rock type or variety of rock type, type of archaeological feature (quarry, loading ramp, well, hut etc.), and registrations of exotic tools, pottery etc. In total, the survey included registration and documentation of 665 quarries, of which 41 are large-sized ones, 166 ancient infrastructural features and 148 rock outcrops outside the quarries. In addition, 348 digital photographs, each linked to a GPS point with description, were selected for an image database. Several thematic maps were compiled, including geological map, archaeological site registration map, map of suggested protection areas and several detailed maps of the sub-sites and features for archaeological interpretation.

GEOLOGY

Chephren's Quarry is situated within a complex of Precambrian, metamorphic igneous rocks, occurring as a "window" where younger rocks have been removed by erosion (**fig. 3**). The rock type subjected to quarrying is a light bluish, greyish to white gneiss with dark bands and spots- hereafter referred to as the "Chephren Gneiss". It is predominantly composed of plagioclase feldspar (light coloured) and amphibole (dark coloured), and will lithologically range from anorthosite gneiss to amphibolite gneiss. Chephren Gneiss occurs as large and small inclusions in granitic rocks, resulting in a highly irregular outcrop pattern, as shown on the map in Figure 3. Almost all the outcrops of Chephren Gneiss have been exploited to some degree.

Surrounding the Chephren Gneiss are various intrusive granitoids and undifferentiated gneiss. In the northwestern part of the area, the rocks are intruded by a "swarm" of northeast-southwest oriented dykes of dioritic composition (**fig. 3**), composing the youngest rocks within the Precambrian metamorphic complex. These are significant for the understanding of the quarrying, since the dyke rock was used as tools. Deposited on top of the Precambrian rocks occurs thick Mesozoic sandstones (Sandstone of the Nubia Group), predominantly exposed to the east of the ancient quarries. Various sized occurences of Tertiary basalt and trachyte occur at several places in the area.

The Chephren Gneiss itself varies from dark banded, amphibolite gneiss to plagioclase rich, almost white, anorthosite gneiss. Within this range, several sub-types have been recognised and mapped (**fig. 4**). Most of these sub-types have been found in the large amount of vessels and funerary objects recognised as being made of the Chephren Gneiss. However, there seems to have been a preference for using the light coloured, speckled sub-type for such purposes, while a banded variety was selected for the life-sized statues of King Chephren (**fig. 2**).

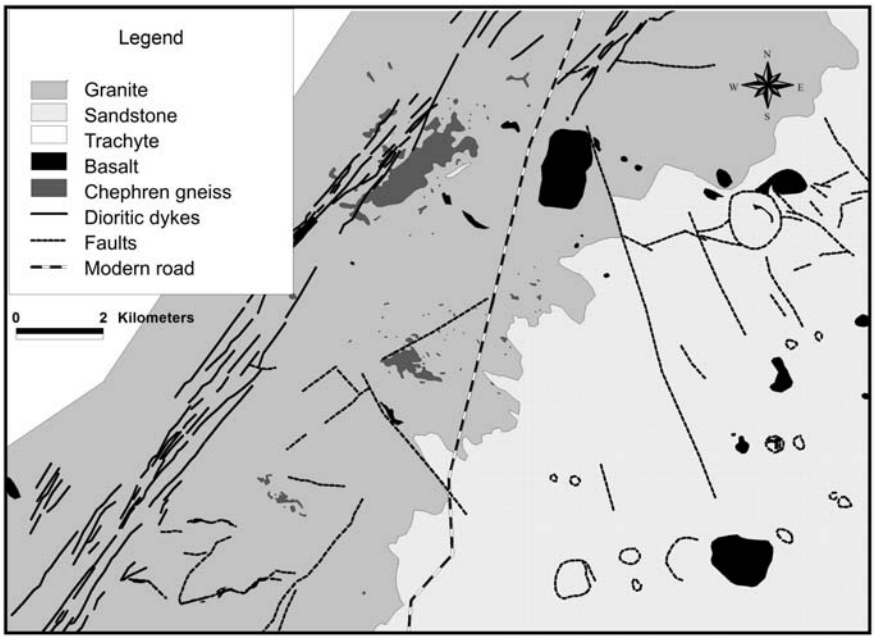

Fig. 3. — Geological map of the Chephren's Quarry area. Grid interval 2 km (UTM WGS84).

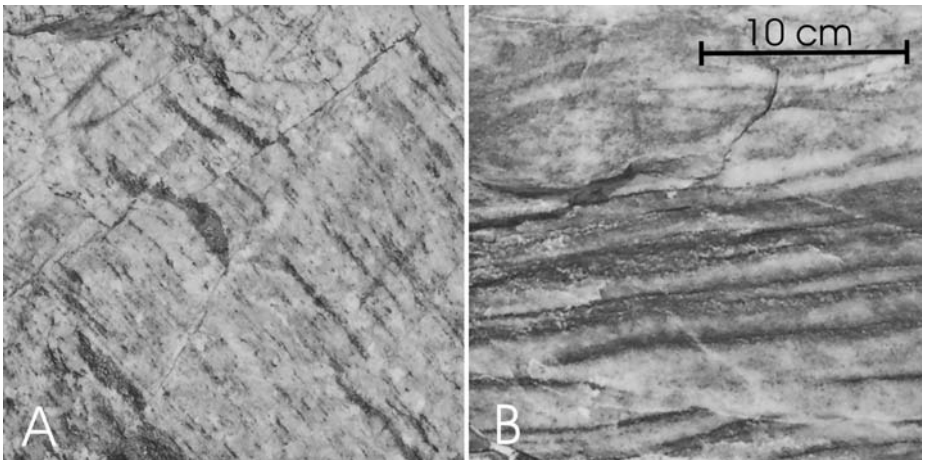

Fig. 4. — Chephren Gneiss sub-types. A: light speckled (best vessel quality), B: light banded (statue-quality).

QUARRY AREAS

It is convenient to separate the Chephren Quarry site into several different quarry areas, following the outcropping pattern of the Chephren Gneiss. Partly, these coincide with the quarries denominated by previous authors. However, due to the recent discovery of several quarries, a new division in five main quarry areas is suggested: Northern Marginal Quarries, Northern Quarries, Central Quarries, Chisel Quarry and Southern Quarries (**fig. 1**).

The Northern Quarries defines the largest gneiss outcropping area and the most significant exploitation area, regarding to the number of quarries and extracted volumes. The area contains many small and several large quarries, work areas, huts and shelters. It includes the Quartz Ridge settlement and quarries (ENGELBACH 1933, 1938; MURRAY 1939), as well as Cairn Quarry and Pounder Quarry mentioned by STOREMYR *et al.* (2002). Most of the Chephren Gneiss subtypes are found here, including the light speckled one. The main type of production that took place in the Northern Quarries was for vessels. However, statue blocks have been extracted in the southeastern part of the area.

The Northern Marginal Quarries include a group of small extraction sites north of the Toshka Project Canal 4 (**fig. 1**). Possibly, these quarries represent a northern continuation of the Northern Quarries, separated from the latter by the construction of the Canal. Light speckled and light banded Chephren Gneiss dominate, and only traces of vessel production are seen.

The Central Quarries consists of a cluster of large quarries in the western part (including the Khufu Stele Quarry found by Engelbach) and, additionally, several scattered, smaller quarries. Predominantly, the light banded type of Chephren Gneiss is found in the area. Both vessel and statue blocks have been extracted, the latter only in the eastern part.

The Chisel Quarry, which got its name from the finding of a copper chisel (Engelbach), is one large vessel quarry to the west of the Central Quarries, located in an isolated gneiss outcrop. The light speckled subtype of Chephren Gneiss dominates.

The Southern Quarries is a quarry area quite isolated from the rest, not previously described. Several small extraction sites are found, as well as some huts. The area displays most of the Chephren Gneiss subtypes, but only the lighter ones (light speckled gneiss) have been exploited. Thus, the quarrying in this area deviates from the others in being far more selective aimed on the (presumably) most attractive subtype for vessels.

QUARRYING TECHNIQUES

The weathering of the hard, crystalline Precambrian rocks has resulted in a terrain of in situ, rounded boulders, resting in soil formed by deep weathering of the surrounding rock. Initially, the weathering starts along cracks, eating its way into the rock and leaving a pattern of

concentric shells around solid stone ("onion-skin weathering"). The boulders thus represent the "surviving" remnants of sound rock. In the Chephren's Quarry, the collection and working of such boulders, resting in the upper two metres of soil, was essential. Only in rare cases, the quarrying went deeper into more solid rock. The quarries have often a concentric shape, where the "outer circle" consists of spoil heaps, consisting of soil from deeply weathered rocks that was removed in order to clear the space around the boulders in the central part. The size of the individual quarries varies significantly, reflecting the extraction of almost any usable boulder in the area, from single ones to clusters of several. In areas where there have been larger populations of neighbouring groups of boulders, the quarries have grown together to sizeable extraction sites (**figs 5** and **6**).

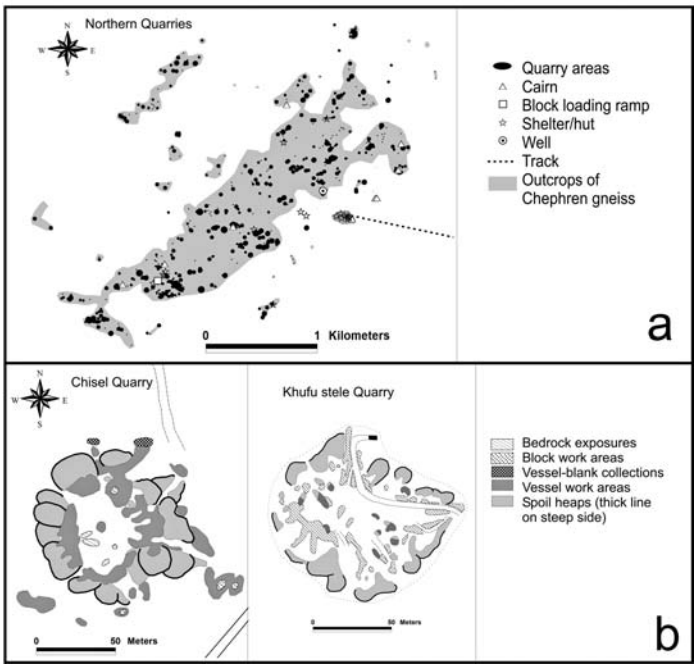

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Fig. 5. — a: Map of the Northern Quarries showing the distribution of quarries and related features. b: Very detailed maps of a vessel quarry (left) and a quarry with significant statue block production (right), displaying roads and a loading ramp.
Fig. 6. — Examples of quarries. Very small, single extraction site (top), small single extraction site (middle) and part of a large quarry (below).

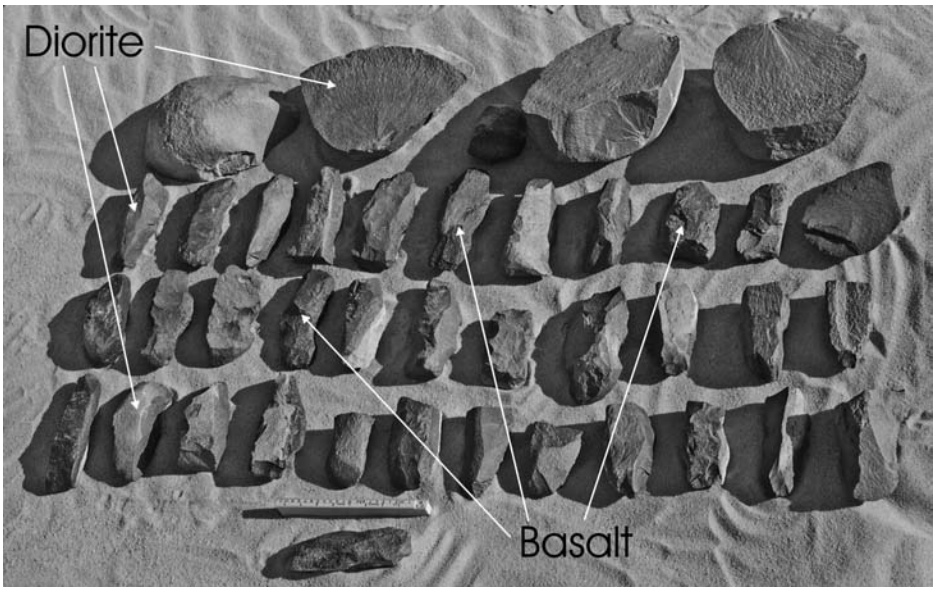

Fig. 7. — Diorite pounders and hand axes found in the Northern Quarries.

The most prominent and sizeable part of the quarrying of the Chephren Gneiss was for funerary objects, predominantly vessels of different shape and form. This activity took place during a long period, more or less continuous, from Pre-Dynastic times to well into the 5th Dynasty (ASTON 1994; BLOXAM 2003 and BLOXAM *et al.* 2009). After releasing the gneiss boulders from the soil, they were roughly shaped into more or less cubic pieces by the use of heavy hammer-stones, or pounders (**fig.** 7). The crudely shaped pieces were then collected and further worked to vessel blanks, representing the last stage of working in the quarries. The observation of a large amount of small hand-axes made of diorite and basalt suggest that such tools were commonly in use for this stage of the working (**fig.** 7). Frequently, this work was carried out at sheltered places (work areas ; Fig. 8) and the final vessel blanks were then collected and placed in the outskirts of the quarries, ready for transport (**fig. 9**). The transport of the vessel blanks to the Nile Valley, probably was along the ancient track discovered by ENGELBACH (1933, 1938) and MURRAY (1939). New dating of pottery found along it, after its rediscovery in 2003, clearly suggests an Old Kingdom predominance of activity (BLOXAM 2005; SHAW and HELDAL 2003). Further descriptions of the organisation of the quarrying during the Old Kingdom is given by BLOXAM *et al.* (2009).

Fig. 8. — Ancient infrastructure features. A: shelter in front of granite boulder, B: work area, C: excavated loading ramp showing the deep grooves in front of the ramp, D: Old Kingdom hut found along the ancient track to the Nile, E: large well construction along the ancient track during excavation, F: cairn marking the ancient track.

The extraction of statue blocks was probably related to one or a few campaigns during the 4th and 5th Dynasties (BLOXAM 2003), exploiting the already old and well-known vessel quarry areas. Basically, the method of extraction was similar, however with some important differences. Fire-setting was applied in several cases in order to "peel off" the loose and weathered skin of the boulders. Thereafter, the final shaping of the statue blocks was carried out with hammer stones (**fig. 10**). The blocks, of which the largest would be between 1,5 and 2 tons, were loaded onto some kind of transport vessel by the help of loading ramps, found in most statue block extraction areas. Parallel, deep grooves in front of the ramps (**fig. 9**) suggest that the type of transport media would be either a tall sledge or, as suggested by BLOXAM (2000, 2003), a Kelek-type amphibious float. Yet, there is no evidence to suggest that the ancient track to the Nile was used for transporting the statue blocks, such as tracks. Moreover, the ancient track appears to have serviced the Northern predominantly vessel quarries, rather than the Central Quarries which was predominantly the area of block quarrying. Another possibilitiy would be to transport the blocks northwards to Wadi Tushka. Given more humid climatic conditions in the Old Kingdom, seasonable flooding of that system of wadis could have contributed in reducing overland transport of the blocks significantly. Clearly, much more research is necessary to solve this problem

Huts and shelters (**fig. 9**) and (rarely) small permanent settlements are found in the quarry areas and the surrounding area. The huts and shelters were used for 1) Taking a break, 2) Work areas/studios. Most of these relates to the Old Kingdom quarrying, confirmed by dating of pottery. A few of them, especially in the Quartz Ridge area, show a Middle Kingdom "overprint", probably due to Middle Kingdom use of the tracks passing through the quarry areas. However, there is no indication of any large Old Kingdom settlements in the area, suggesting that the quarrying of the Chephren gneiss, including the statue quarrying campaigns, was carried out by small groups of workmen (BLOXAM *et al.* 2009).

TYPES OF EXPLOITATION AREAS

In the exploitation areas, several varieties of Chephren Gneiss are found, varying from strongly banded hornblende-plagioclase gneiss to massive, white anorthosite with dark spots (**fig. 4**). From a technical point of view, the most massive type would be most suitable for the carving of vessels and other small artefacts, due to it being more isotropic, homogenous and more technically predictable than the banded one. Supporting this, BLOXAM (2003) has stated that the massive variety is the most common one observed among the population of Chephren Gneiss vessels found at different Old Kingdom and Predynastic sites. The banded types, on the other hand, can be aesthetically attractive, due to the "marble-like" appearance and bluish hue.

Fig. 9. — Collection of vessel blanks in front of a quarry. Example of vessel blank in top right corner.

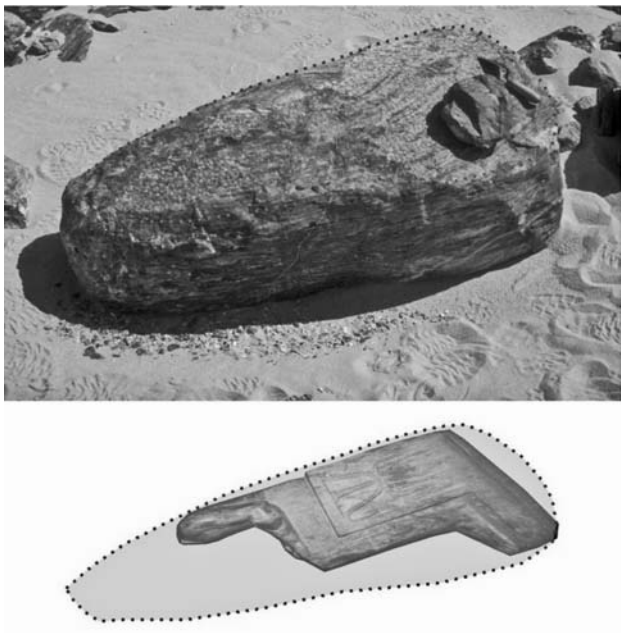

Fig. 10. — Examples of statue block showing the asymmetric shape designed for a sitting Pharao sculpture.

The light speckled, massive type gneiss does not occur as large, homogenous bodies in any of the quarry areas, but are found as layers intercalating with banded types. The Central Quarries differs from the others in displaying more homogenous, banded varieties. This geological pattern coincides quite well with features related to statue block quarrying, such as ramps and leftover blocks. Hence, the campaigns of statue block extraction took place where the most homogenous, banded Chephren Gneiss is found, outside the zone of the most attractive vessel quality. It is, however, difficult to establish if this is due to a preference for the use of the banded subtype gneiss for statues, or to more practical reasons - going for the previously unexploited parts of the deposits where large boulders still could be found.

THE USE OF TOOLS

The stone tools used in the gneiss extraction can be divided in two groups: pounders and hand axes. The latter group is mainly found in the Northern Quarries, where they were used for fine working of vessel blanks. The axes were made of diorite and basalt, both from local sources (**figs 3** and 7).

Unlike the axes, the pounders were not shaped or worked in any way, but were simply naturally occurring, rounded, and (preferably) slightly edge-shaped pieces of stone. Their size can vary significantly, from the size of a fist and up to 80 kilos. The pounders were taken from three different sources (rock types): the Chephren Gneiss itself, granite from outcrops in between the gneiss, and diorite occurring in a series of penetrating dykes in the northwestern part of the area (**fig. 3**). It is difficult to map the extension of the former type, since the gneiss pounders (especially the broken ones) are difficult to separate from other stone fragments in the quarries. However, when we plot the use of the diorite pounders (**fig. 11**), a clear pattern is seen. The population of such pounders are denser close to the dykes, and almost absent in more distant areas. Obviously, the ancient quarry workers considered the diorite as the best pounder quality, but not so supreme that they bothered to carry them more than a few hundred metres. Unlike stone tools found in the Old Kingdom basalt quarry at Widan el Faras, which have a provenance far away from the quarry site and probably were quite valuable items (HARRELL 2002; BLOXAM 2003), the pounders of the Chephren's Quarry were clearly of less value, short lasting and not worthwhile transporting. Evidence of a high consumption of pounders is clearly seen in many of the quarries, where piles of broken pounders are found beside worked blocks.

CONCLUSIONS

The flat and contour less desert in the Gebel el-Asr area is literally hiding a great secret - a huge, industrial landscape, one of the oldest in the world of its sort. Viewed on the ground, only small fragments of this spectacular site is seen, perhaps wrongly leaving the visitor the impression of being just some small heaps of more or less worked stone. To get a full impression

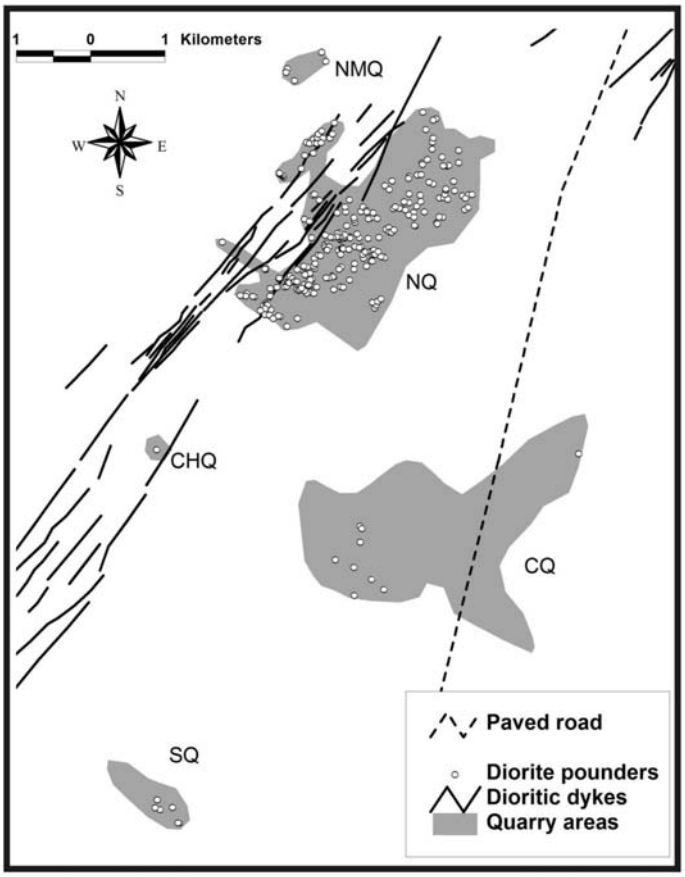

Fig. 11. — Observations of diorite pounders and outcrops of diorite dykes. Northern Quarries (NQ), Northern Marginal Quarries (NMQ), Central Quarries (CQ), Chisel Quarry (CHQ) and Southern Quarries (SQ).

of the site, it must be seen from above. Hence, a spatial database, which facilitates the compilation of different thematic maps, is extremely useful. The survey of the Chephren's Quarry demonstrates that such datasets can satisfy the needs for documentation of the cultural heritage authorities, and help the scientific interpretation of the quarries. Especially, GIS data are of great value in the quantitative interpretation of spatially distributed observations. In the case of Chephren's Quarry, the distribution of tools, semi-finished products and the spatial distribution of Chephren Gneiss sub-types have been used as examples in this paper. However, there are also other datasets that will be explored in further detail, such as extraction

volumes. The GPS/GIS methodology applied in the Chephren's Quarry proved to be quick and sufficiently accurate, and gave high benefits within a limited period of time. Obviously, the methodology could be transferred to other ancient quarry sites involving a large area, or could be adapted to other types of cultural landscapes. In Egypt alone, there are numerous ancient quarry landscapes in need of surveying, some of them already in acute danger of being destroyed by modern development.

The 2003 field seasons revealed significant new information about the ancient quarrying processes, especially concerning the identification of statue blocks, tools and re-discovery of the ancient track to the Nile. Archaeological excavations confirmed the Old Kingdom dominance of the quarry site, the use of fire-setting in the extraction of blocks, and gave new evidences about the organisation of the ancient quarrying, as described by BLOXAM *et al.* (2009). The excavations and the survey clearly increased our knowledge of the site and brought us closer to a reconstruction of the various aspects of this huge, ancient industrial landscape.

ACKNOWLEDGEMENTS

Several people and institutions contributed in various ways to the project. The Norwegian Directorate for Cultural Heritage is greatly acknowledged for believing in the project, and the Norwegian Ministry of Foreign Affairs and the Egypt Exploration Society (EES) for financial support. The Supreme Council of Antiquities (SCA) in Egypt and their project Egyptian Antiquities Information Systems (EAIS) made the survey possible and helped in the dissemination of the results. The Geological Survey of Egypt (EGSMA) contributed with valuable help in logistics and geological background information. Thanks also to Ashraf el-Senussi for his work on the dating of pottery.

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Ce volume comprend les textes des communications d'ASMOSIA VII, 7e conférence internationale de *l'Association pour l'étude du marbre et des autres pierres dans l'Antiquité* (Association for the Study of Marble and Other Stones in Antiquity), qui s'est tenue dans l'île de Thasos, en Grèce. Les thèmes abordés dans ces communications sont à la pointe du domaine interdisciplinaire où se rejoignent la science, l'archéologie et l'histoire de l'art ; ils reflètent un large spectre de la recherche sur les pierres, depuis la carrière jusqu'au produit décoré dans son état final. Les sujets plus particulièrement abordés sont les suivants : (1) *Considérations archéologiques et emploi du marbre* ; (2) *Carrières, techniques d'extraction, géologie et propriétés de la pierre* ; (3) *Identification de provenance et caractérisation : le marbre* ; (4) *Identification de provenance et caractérisation : autres pierres* ; (5) *Techniques et développements* ; (6) *Bases de données* ; (7) *Propriétés de la pierre – Vieillissement –Restauration* et (8) *Pigments et peintures sur marbre.*

This book contains the papers submitted to ASMOSIA VII, which is the 7th International Conference of the *Association for the Study of Marble and Other Stones in Antiquity*. The conference was held in the island of Thassos, Greece. The subjects of the papers represent the state-of-the-art in the interdisciplinary field of Science and Archaeology and Art-History and reflect a very broad range of research and applications on stone, from the quarry to the final decorated object. In particular, the subjects cover: (1) *Archaeological considerations and use of marble*, (2) *Quarries, Quarrying Techniques, Geology and Stone properties*, (3) *Provenance Identification and Characterisation: Marble*, (4) *Provenance Identification and Characterisation: Other stones*, (5) *Techniques and Developments*, (6) *Databases*, (7) *Stone Properties – Weathering – Restoration* and (8) *Pigments and paintings on marble*.

ÉCOLE FRANÇAISE D'ATHÈNES