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Egypt beyond representation : materials and materiality of Aegyptiaca Romana

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1. Rock classification and source determination

“Although the early confidence in macroscopic (“eyeball”) petrofabric analysis was misplaced, there has often been an overcompensating reticence in archaeological publication which frustrates building distribution maps”

Fant (1988a) 1 n. 3

The characterisation of stone materials has been a central issue within the discipline of archaeology. Applications of stone characterisation in archaeology particularly focus on the determination of the geological sources of the studied materials. As early as the mid-19th century, advancements in the knowledge about the composition of rocks and other raw materials led to the idea that correlations in chemical composition could be indicative of their sources. Archaeologists were quick to recognise the potential of this ‘chemical fingerprint’ to contribute to traditionally relevant issues such as trade and exchange. However, it was not until the mid-20th century that technological advancements provided the instrumentation needed for such analyses,²⁵⁹ and since the 1960s archaeological objects of various materials have been the subject of so-called archaeological provenance or sourcing studies.²⁶⁰ Most of these studies have tried to establish a chemical link between the stones of archaeological objects and geographically defined source areas.²⁶¹ These attempts have met with

various degrees of success. Obsidian, for instance, is the classic success story within archaeological provenance studies.²⁶² Partly because of continuous advances in analytical instrumentation, positive results have also been obtained for a range of other stone materials, such as chert, jade, granite, and marble, chemically processed materials like glass and ceramics, and metal alloys like bronze.²⁶³ These data have yielded a wealth of information on traditionally important archaeological issues like trade and exchange processes.²⁶⁴ In addition, material analysis also plays an essential role in the reconstruction of the so-called *chaîne opératoire* of

which states that “there exist differences [that can be measured] in chemical composition between different sources that exceed [...] the differences within a given source” (Weigand *et al.* 1977, 24). In other words, there is a scientifically measurable property that links an archaeological artefact to a specific source area or production site. Discussions on the underlying principles and prerequisites of provenance studies are readily available elsewhere; see, e.g., Luedtke (1978), Wilson and Pollard (2001), Tykot (2003) and (2004), Lambert (2005), and Malainey (2012), esp. 169-171.

262. Thanks to obsidian’s great potential for sourcing using trace element characterisation, there is a vast literature on archaeological obsidian. The methods and techniques for obsidian sourcing are included in most recent archaeological science books: see, e.g., Pollard and Heron (1996), Rapp and Hill (1998), Henderson (2000), and Malainey (2012); cf. Williams-Thorpe (1995) and various contributions in *Archaeological Obsidian Studies* (1998).

263. Theoretically speaking, stone materials have a larger potential for provenance studies than artificially manipulated materials, like glass and metals. This is because the chemical composition of stone materials is less likely to be altered by extraction and production techniques or post-depositional processes: see Wilson and Pollard (2001). With regard to sourcing ceramics, see also the comment by Freestone (2001, 623): “compositional alteration may modify the elemental analysis of a ceramic to the extent that provenance determination becomes seriously affected”. For a discussion on the suitability of different archaeological materials for provenance studies see, e.g., Pollard and Heron (1996), Rapp and Hill (1998) 134-152, Henderson (2000), Tykot (2003) and (2004), Lambert (2005), Tite (2009) 227-230, and chapters 8-17 in *Analytical Archaeometry* (2012), all with additional bibliography.

264. For recent perspectives on ancient trade and exchange and the contribution of material analysis see several contributions in *Trade and Exchange* (2010) and the introduction to that volume: Dillian and White (2010).

259. For the development of scientific applications in archaeology see, e.g., Pollard and Heron (1996) 1-19, Henderson (2000) 324-326, Brothwell and Pollard (2001), and Pollard *et al.* (2007) 5-10.

260. The development of archaeological provenance studies can be shown by means of the analyses of the megaliths at Stonehenge. The first efforts to trace the origin of these stones dates from the mid-18th century. Early observers noticed that the monument was made out of two different types of rocks. The first petrographic descriptions of these types were made in the 19th century. In the early 20th century scholars successfully located the origin of the so-called “bluestones” to the Preseli Hills in south-west Wales. Finally, thanks to technological advancements, in the late 20th century scholars succeeded in attributing these bluestones to seven sub-sources. See Rapp and Hill (1998) 134 with further references.

261. The principal assumption, on which all archaeological provenance studies rely, is the so-called provenance postulate,

artefacts. Originating from within the related field of anthropology, current archaeological thought increasingly takes inspiration from the idea of a cultural biography of things. It considers archaeological artefacts as going through several socio-culturally embedded life stages, from the procurement of raw materials, through fabrication and decoration, to its distribution, use, reuse, and eventual discard. This approach has brought material culture back to the centre of analysis, and its implementation in archaeological studies typically involves (scientific) material analysis.²⁶⁵

The number of available analytical methods has greatly expanded over the years, and ongoing technological advancements ensure a steady continuation of this process. They range from visual examination and thin-section petrography to more experimental methods, which rely on the most recent techniques and analytical equipment. Characterisation studies usually start with macroscopic examination. The term ‘macroscopy’ is meant to indicate visual examination that involves no equipment other than a 8-12x hand lens and low-technology tools for testing a rock’s (mineral) properties, such as colour, lustre and other aspects of appearance, hardness, and refractive index. However, it has been acknowledged that these properties are only rarely sufficient to distinguish among all possible source areas of a certain material.²⁶⁶ The potential of colour as a discriminating aspect of stones has been particularly criticised, mainly because colour variations may result from weathering processes rather than that they are source-specific properties.²⁶⁷ Moreover, the method of

macroscopy has been challenged as a valid heuristic tool. It necessarily depends on the personal expertise of the analyst, which not only requires essential training and experience, which is notably difficult to obtain,²⁶⁸ but which would also render the results “somewhat arcane and difficult to communicate”.²⁶⁹ This in turn would raise important issues in regard to scientific reproducibility and objectivity. Therefore, recent studies generally tend to dismiss macroscopic petrography as a valid method for the classification of rocks. Although it still holds its position as useful tool for preliminary classifications,²⁷⁰ it has become common in archaeological studies to “place characterisations on a more detailed and reliable footing”.²⁷¹

This becomes particularly evident from a survey of the rapidly growing literature on the application of scientific methods in archaeological research that focuses on the available methods for rock characterisation.²⁷² Notwithstanding occasional remarks that characteristic features of rocks, such as veining, or macrofossils in certain sedimentary rocks, may be identified macroscopically,²⁷³ these studies mainly focus on more comprehensive (and especially laboratory-based) techniques. Accordingly, microscopic examination is typically mentioned as a next, second step in analytical procedures of rock characterisations. Thin-section petrography with a polarising microscope is the traditional microscopic approach.²⁷⁴ Originating from

265. The idea of a ‘life-cycle of artefacts’ finds its origin in an article by the anthropologist Igor Kopytoff: Kopytoff (1986). For the possible contribution of material analysis for the reconstruction of an artefact’s cultural biography, see Dobres and Hoffmann (1994), who conveniently define the final goal of material studies as “not to describe microscale prehistoric *activities*, but to understand microscale social *processes*” (p. 213). For the implementation of the characterisation and source determination of raw materials within a *chaîne opératoire* framework see, e.g., Tite (2001) and (2009), Whitbread (2001), and Tykot (2003).

266. Exceptions exist and include, for instance, dark green obsidian found in Malta and the south-central Mediterranean, which most likely originates from Pantelleria, and black/grey obsidian, from Lipari: Tykot (2004) 407.

267. Henderson (2000) 299-300, Tykot (2003) 63-64, and (2004) 407. Chert is a classic example of a material for which colour variation is no reliable source-indicator. Although chert from different sources is often visually distinctive, this variability is not necessarily source-dependent or -characteristic: Cackler *et*

al. (1999) report that the colour variations observed in chert from Northern Belize result from weathering instead of different origins. Moreover, Luedtke (1979) has shown that, while cherts from within a single formation can exhibit a large visual variation, visually identical cherts can also occur in different formations.

268. The difficulties of macroscopic petrology are observed by Brown and Harrell (1991) 379. Practitioners need to acquire a basic understanding of rock-forming processes, rock-forming minerals, and (resulting) structural, textural, and compositional characteristics of rocks, which is not compatible with the inferior role of megascopic petrology in academic programs as compared to microscopic petrography and the lack of rock classification systems adapted to megascopic methods.

269. Luedtke (1979) 745; cf. Henderson (2000) 299.

270. See, e.g., Luedtke (1979) 746.

271. Edmonds (2001) 461.

272. See, e.g., Pollard and Heron (1996) 81-99, Rapp and Hill (1998) 147-151, Henderson (2000) 297-323, Edmonds (2001), *Pietre e marmi antichi* (2004), Eryvnyck *et al.* (2009) 163-167, Rapp (2009) 21-43, and Malainey (2012) 311-318.

273. Antonelli – Lazzarini (2004) 33.

274. Thin-section petrography and its applications are extensively discussed in *The petrology of archaeological artefacts* (1983).

around the mid-19th century, it enables both a qualitative and quantitative characterisation of rocks in terms of its mineralogy and structure. The method involves an inherent error in that the quantitative data of the studied sample are extrapolated to the total volume of the rock. While this stresses the need for a representative sample, thin-section petrography generally allows for an exact characterisation of rocks. The obtained data, which gives volume percentages of the mineral components of rocks, underly internationally accepted and widely used analytical rock-classification systems, which essentially tells if a rock classifies, for instance, as granite, granodiorite, or diorite.²⁷⁵ However, although accurate characterisations of many materials can be obtained with thin-section microscopy, optical methods (macroscopy and/or microscopy) are often not sufficient to distinguish between all possible source locations. This applies in particular to materials with little visual variability, like obsidian, a typically homogeneous amorphous volcanic rock, and several white marbles that were used in the Roman world. In these cases an efficient source-distinction is only possible with more comprehensive analytical methods, which measure differences in chemical rather than mineralogical composition: optically identical materials can have quite different chemical compositions.²⁷⁶ Many of the available chemical techniques focus on trace-element instead of major composition of materials, in order to identify a source-specific chemical fingerprint.²⁷⁷ However, practice has shown that a successful discrimination between all possible source-areas is often effectively enabled by a combination of optical and chemical techniques.²⁷⁸

As a result of the proliferation of sourcing studies in archaeology, scientific protocols have been issued as guidelines to enable a proper conduct. These emphasise that a correct implementation of a provenance study in an archaeological research framework involves more than the selection of a suitable analytical technique, and furthermore indicate that its success depends on other than scientific possibilities alone. This can be illustrated by means of the procedure for chert source analysis.²⁷⁹ This procedure consists of six successive steps, which include archaeological question, literature study of possible source areas for relevant objects, study of possible source areas, selection of analytical method, analysis, and matching of artefacts to sources. These successive steps demonstrate that the selection of a suitable analytical technique to investigate a particular archaeological question is not a matter of simply choosing a reliable method.²⁸⁰ Instead, it requires a carefully considered strategy, which first and foremost starts with the definition of the archaeological question. It has been repeatedly stressed in recent literature that useful data can only be obtained from a carefully formulated archaeological question and the ensuing carefully selected analytical method. The nature of the archaeological problem directly affects crucial parameters, such as the required amount of sampling, the analytical method selection, and the allowed margin of error. In other words, the archaeological question should always precede the analytical method.²⁸¹

275. Cf. Streckeisen (1973), Le Maitre *et al.* (2002).

276. Cf. Aston (1994) 11: "It is desirable to be as specific as possible in identifying a particular rock, since this allows one to determine if two similar appearing rocks may be from the same source or are actually quite different in composition".

277. Analytical methods are typically based on the atomic properties of chemical elements, and use element-characteristic properties, such as atomic/molecular mass or energy and wavelengths of electromagnetic radiation, to identify the presence and relative or absolute proportions of certain elements in materials. For discussions on available techniques and their underlying scientific principles see, e.g., Pollard and Heron (1996) chapter 2, *Modern Analytical Methods in Art and Archaeology* (2000), Pollard *et al.* (2007) chapters 3-9, Erynck *et al.* (2009) chapter 6, and *Analytical Archaeometry* (2012) chapters 1-7.

278. This is the case, for instance, with ceramics: see, e.g., Degryse and Braekmans (2014). It should be noted that different

materials commonly require different combinations of (optical and) chemical techniques. Therefore, while a combination of petrography and trace element analysis often gives the best results to distinguish between sources of igneous rocks, stable isotope analysis ($\delta^{13}\text{C}/\delta^{18}\text{O}$) in combination with petrography generally works best with stone materials such as marble (metamorphic) and limestone (sedimentary). For a provenance study of archaeological limestone see, e.g., Degryse *et al.* (2006).

279. This procedure, originally developed by Luedtke (1992, 109-113), has often been used in subsequent studies: cf. Wilson and Pollard (2001) 510-511; see also already Earle and Ericson (1977) 4-5.

280. It has been acknowledged that some techniques work better with specific materials than others. On the basis of these insights, overviews have been created that show the compatibility between, on the one hand, archaeometrical methods and techniques and, on the other hand, archaeological materials: see, for instance, Tykot (2004) 409 Table II.

281. It has even been argued that "[...] the successful application of any technique is as much (if not more) a function of the [archaeological] questions that are asked as a product of reliability or accuracy in description [of a particular technique]": Edmonds (2001) 467. See also Pollard *et al.* (2007, xii-xiv) in

Therefore, the actual selection of a suitable analytical technique only follows from the archaeological question and on the basis of a proper knowledge of the possible source areas. However, in practice it often depends on and is directed by other considerations than technical possibilities and limitations alone. Relevant other considerations include the costs of analysis, the availability of techniques, and sample requirements. This latter aspect is of crucial importance for the present study, and therefore it will be briefly dealt with.

The destructive nature is an inherent drawback of most analytical methods. The degree of intrusion depends on several factors, including the studied material's characteristics and the selected technique, but a physical sample is nearly always required for microscopic and/or chemical analysis. While not necessarily a limiting factor for a geologist in the field, it is for archaeologists working on precious and valuable artefacts. An example may clarify this. Aswan in Egypt is home to the so-called monumental red and black granites that were extensively used in Pharaonic Egypt and the Roman world for architectural and statuary purposes. The quarrying area at Aswan measures some 20 km². In an area of this size, there are naturally major variations in the rock formations. Nevertheless, the available techniques allow to attribute a sample to a precise location within the extraction area: an error of only ± 100 m has been reported.²⁸² However, due to the specific characteristics of the Aswan rocks, in particular their heterogeneity and coarse nature, and the concomitant difficulties in taking representative samples, a reliable chemical analysis is only possible if at least 1 kg of material is available for preparation.²⁸³ Such samples are generally not available for archaeological investigations. Therefore,

although theoretically speaking it should be possible to characterise and attribute Aswan rocks with great accuracy, in nearly all archaeological case studies the benefits of such accuracy do not outweigh the requirements.

Aswan is, of course, an extreme example. A sample of approximately 100 mg is generally sufficient for a distinct characterisation of heterogeneous materials, and even smaller samples may suffice, depending on the specific characteristics of the analysed materials and the analytical method.²⁸⁴ Moreover, sample requirements are likely to decrease thanks to ongoing technological advancements. Yet, no matter how small the sample, as long as available methods are not entirely non-invasive, there is always a certain impact on the integrity of artefacts. Therefore, in the absence of a ready-made analytical technique that has both a very high accuracy and precision and that is non-invasive at the same time, in practice always a compromise has to be sought between archaeological question and analytical method.

1.1 AEGYPTIACA ROMANA: ROCK CLASSIFICATION AND SOURCE DETERMINATION

Four important inferences can be made on the basis of the above observations with regard to the characterisation and provenance determination of the stones of so-called Aegyptiaca Romana:

- (1) Reliable characterisations can be obtained with existing analytical methods. Thin-section petrography, if necessary in combination with chemical analysis, will yield more accurate and precise data than macroscopic analysis.
- (2) The prospects for a successful source-discrimination are good, considering the (relatively) unaltered chemical composition of lithic materials from geological source to finished object, previously achieved successes with similar stone materials (e.g., granites), and good knowledge of potential (Egyptian and Mediterranean) source areas. A

the preface to their book on applications of analytical chemistry in archaeology: "It is a matter of some debate as to whether it is worse to carry out superb chemistry in support of trivial or meaningless archaeology, or to address substantial issues in archaeology with bad chemistry".

282. Klemm and Klemm (2008) 257.

283. *Ibid.*, 257-258. This is the required sample size if greatest accuracy were desired; a sample of at least 200 g is recommended to allow for a successful chemical analysis of medium- to coarse-grained granodiorite from Aswan: *ibid.*, 265. A sample of about fingernail size is usually recommended to allow for proper petrographic analysis. This again stresses the importance of the archaeological question: what information is exactly desired? On the representativeness of Aswan rocks see also Serra *et al.* (2010), esp. 963.

284. Tykot (2004) 416.

combination of optical and chemical techniques will likely be most effective.

- (3) A provenance study of the stones of Aegyptiaca Romana should start with the formulation of the archaeological research question. Its success not only depends on the technical and theoretical possibilities, but also involves practical aspects, most notably sample requirements.
- (4) At present there is no analytical technique that is at the same time non-invasive and that has both the precision and accuracy to adequately discriminate between source-areas of stone materials. This implies that, in order to answer the archaeological question, a compromise has to be made between, on the one hand, sample requirements and, on the other hand, technical and theoretical possibilities.

What does this imply for the material analysis of the selected objects, and how were the considerations mentioned above translated into a suitable methodology? The aims of the stone analyses in this study are twofold: first, to formulate stone characterisations according to minero-petrographic criteria and, second, to formulate geological provenance hypotheses on that basis. More specifically, in order to assess the question whether the Egyptian provenance of the stones used for the objects that we call Aegyptiaca was considered as an important feature from a Roman perspective, it is crucial to differentiate between Egyptian and non-Egyptian sources. Therefore, rather than focusing on the attribution of stones to specific source-locations, the inclusion or exclusion of Egyptian sources suffices for the present purposes. From a technical and theoretical point of view, it should be possible to answer this question with adequate accuracy by the implementation of a proper archaeological sourcing framework. However, the nature of the relevant objects poses serious limitations to the availability of suitable analytical techniques. The majority of the studied objects are valuable and important museum pieces, which require full non-invasive and *in situ* analysis. Therefore, neither microscopic nor chemical analyses could be carried out. Instead, a non-invasive methodology was implemented, which relies on macroscopic analysis, and which has yielded results of suitable accuracy in the context of the present study. How was this done?

Minero-petrographic descriptions are made on the basis of the recommendations for macroscopic rock classification by Brown and Harrell.²⁸⁵ Adapted from internationally acknowledged non-macroscopic analytical methods, this classification is particularly suitable for the selected 'Aegyptiaca' since it meets the requirements to study these objects non-destructively and *in situ*. All relevant rocks are described in terms of their mineralogy and structure, as far as these can be recognised macroscopically. Rock structure is taken to consist of a rock's mineral structure and texture.²⁸⁶ Together with its mineralogy, it determines the appearance of a rock, which, in turn, results from its geological origin. This relationship between rock appearance and geological origin makes it possible to determine the underlying rock-forming processes on the basis of rock appearance, and this allows for the classification of a particular rock into one of the three genetic rock groups.²⁸⁷ The possibilities for mineral identification are restricted thanks to the nature of the studied objects.²⁸⁸ Additional complicating factors are the typically polished surfaces of the studied rocks and

285. Brown and Harrell (1991).

286. See, e.g., Klemm and Klemm (2008) 11.

287. These are igneous, sedimentary, and metamorphic rocks. For the major rock groups, genetic processes, and the rock cycle, see, e.g., the introductory chapter on rocks (chapter 3) and subsequent chapters on igneous, sedimentary, and metamorphic rocks (chapters 4, 7, and 8, respectively) in Press and Siever (1986).

288. Though only minimally intrusive, methods like the acid test or the determination of minerals' physical properties as hardness, cleavage, fracture, streak, or density, were not available. The acid test is an efficient way to test whether a rock contains certain carbonate minerals, like calcite, dolomite, or copper-bearing malachite. Diluted hydrochloric acid (HCl) is dropped on a rock sample, or, preferably, a small powdered sample, to increase the reactive surface area. If present, the carbonate minerals will dissolve in the dilute HCl, which will cause a typical fizzing. Likewise, the Alizarin Red S (ARS) staining is an easy way to distinguish between, e.g., limestone and dolomite. Physical properties of minerals can be used for their identification; these include hardness (the ease with which a mineral surface can be scratched), cleavage (the ability of a mineral to break along flat planar surfaces), fracture (the way in which minerals break along irregular surfaces other than cleavage planes), lustre (the nature of a mineral's reflection of light), colour (imparted by transmitted or reflected light by crystals or irregular masses), streak (the colour of mineral dust on an abrasive surface), and density (mass per volume unit). More information on minerals and their properties can be obtained from any introductory textbook on geology: e.g., Press and Siever (1998) 26-57, and Rapp (2009) 17-43 with a particular focus on archaeological applications of mineral identification.

the variable light conditions in which they are exhibited. Nevertheless, the most important rock-forming minerals like quartz and feldspar can be identified and, as such, rock classifications can be formulated on the basis of minero-petrographic criteria.

The following size scale is used: fine, less than 1 mm; medium, 1-5 mm; coarse, 5-30 mm; and very coarse, more than 30 mm. The terms aphanitic and phaneritic are used to determine the degree of coarseness of igneous rocks. Aphanitic rocks are igneous rocks, in which individual crystals are not distinguishable by the unaided eye. In phaneritic igneous rocks crystals are visible with the naked eye. Following the recommendations in the paper by Brown and Harrell, the boundary between aphanitic and phaneritic rocks is set at 1 mm, which means that all fine-grained igneous rocks are considered as aphanitic.²⁸⁹ The terms euhedral, subhedral, and anhedral are used to describe the degree to which crystals have developed their typical crystal morphology. In descending order, these terms indicate how well crystals are shaped, which may help in mineral identification. Some rocks have grains in two different size ranges. These rocks are named porphyritic, with the larger crystals called phenocrysts. Alkali feldspar phenocrysts sometimes cross over into plagioclase at their rims. Macroscopically, this appears as a white mantle around a pinkish core; occasionally, plagioclase phenocrysts also cross over into alkali feldspar at their rims, which appears at a macroscopic level as a pink mantle enveloping a plagioclase crystal. This is called rapaviki texture.²⁹⁰ Other important textural information that is recorded includes the spatial arrangement of minerals. In particular, parallel *versus* directionless textures are taken into consideration, because these provide important genetic information about rocks. Igneous rocks sometimes exhibit a (sub-)parallel arrangement of the feldspar and biotite grains. This type of foliation is caused by magmatic

flowage rather than metamorphism. Igneous rocks with such textures are described as gneissoid rocks. Some igneous rocks contain irregular patches or streaks, which appear as portions richer in biotite than the surrounding mass, and therefore darker in colour or as patches of coarser or finer grains than the main rock; these are known as schlieren.²⁹¹ Although no quantitative mineral proportions can be obtained with the used method, the relative ratios between quartz, alkali feldspar, and plagioclase, in combination with the relative amount of dark-coloured minerals as can be deduced from the overall rock colour, allows for a tentative differentiation between related granitoid rocks like granite and granodiorite.²⁹² Colour descriptions are made according to the Munsell Rock Color Book (rev. ed. 2009) and follow the notation in hue/value/chroma.²⁹³ Since rock colours typically appear darker in a polished surface than on freshly broken surfaces, care is taken to record both colours when applicable.²⁹⁴

291. Gindy (1956), Higazy and Wasfy (1956) 216-220.

292. Granitoid rocks are igneous plutonic rocks that essentially consist of quartz, alkali feldspar and/or plagioclase. The term granitoid is proposed for preliminary “field” classification for plutonic rocks, ranging in composition between granite, granodiorite, and tonalite – the differentiation of which depends on the volumetric percentages of quartz, alkali feldspar and plagioclase (Le Maitre *et al.* 2002, 85-86). The larger proportion of (light coloured) alkali feldspar of the total feldspar component in granites relative to granodiorites, in combination with the smaller proportion of dark-coloured minerals in granites relative to granodiorites, renders granites more felsic than granodiorites. This implies that granite is likely to have a lighter overall colour than granodiorite, which, in turn, means that overall rock colour can be used to relatively distinguish between different lithotypes within the group of granitoid rocks. As such, overall rock colour allows for a relative, provisional classification of a given rock as either granite or granodiorite (see also Brown and Harrell 1998, esp. 36: although some rocks that are classified as granodiorite on the basis of their dark grey to nearly black colour are actually granites [based on volumetric percentages], the authors suggest “to name a rock after the granodiorites that it more closely resembles”). Note that rock colour is not meant to indicate colour index (M’) as defined in Streckeisen (1973, 30): colour index enables more felsic and mafic types of each rock type to be described on the basis of the relative amount of dark-coloured minerals present (e.g., a leucocratic or melanocratic granite).

293. Following the recommendations of the Munsell Rock Color Book, overall rock colour was determined for all fine- and medium-grained rocks, while the colours of the main rock-forming minerals in (very) coarse-grained rocks were recorded separately.

294. For instance, the overall rock colour of the lion statue in Palazzo Attemps (inv. 362624, cf. *infra*, 224-225 no. 106) is medium dark grey (N4) to dark grey (N3) on (freshly?) broken surfaces,

289. Igneous rocks with a phaneritic texture are presumed to have formed by slow cooling, and hence crystallisation, of a magma at large depths; therefore, these rocks are called intrusive igneous or plutonic rocks. By contrast, igneous rocks with an aphanitic texture are presumed to have formed by relatively fast cooling of the magma, which occurs when the magma erupts at the surface; therefore, these rocks are called extrusive igneous or volcanic rocks.

290. Le Maitre *et al.* (2002) 136; cf. Meneisy *et al.* (1979), esp. 126-127, Higazy and Wasfy (1956) 225, and Klemm and Klemm (2008) 253.

A Zebralight H600Fc III headlight is used to ensure comparable light conditions.²⁹⁵

In addition, a neodymium magnet is used to test the magnetic properties of the studied rocks. This is an easy way to determine the presence of certain iron-rich minerals, most notably magnetite, which is an important asset in identifying the genetic origin of rocks.²⁹⁶ This is of particular relevance for the present study, because the magnetic susceptibility of the studied rocks can be used as a diagnostic tool to distinguish between the most frequently mistaken rock types, namely, greywacke, basalt, and granodiorite.²⁹⁷ Although a wide overlap has been reported between different rock types, sedimentary rocks have the lowest average magnetic susceptibility values and basic igneous rocks the highest. This implies that greywacke, a slightly metamorphosed sedimentary rock, will be much less susceptible to the neodymium magnet than granodiorite and especially basalt, which are intermediate and basic igneous rocks, respectively.²⁹⁸ In this study the following (relative) scale for magnetic attraction is used: 0, no visible attraction between the neodymium magnet and the rock; 1, the attraction between the neodymium magnet and the rock is clearly visible, but the magnet will not stick to the rock; and 2,

the attraction is so strong that the magnet will stick to the rock; n/d means that no data is available.

After provisional characterisations were made on the basis of macroscopy, a strategy was developed to allocate the studied materials to a potential source area. Following the scientific protocol for provenance studies, possible source areas for the relevant materials were studied next. It was decided to focus on the geology of Egypt first. This study comprised two components. First, a literature study of potential Egyptian source areas for the materials of the relevant objects was carried out. There is an extensive literature on the geology of Egypt and the numerous stone materials that were quarried for sculptural and building purposes throughout Egyptian history.²⁹⁹ Several of these studies include colour photographs of representative samples of polished slabs and/or of objects made of particular stones, which allow for a good comparison.³⁰⁰ A basic

but typically appears as greyish black (N2) in polished surface.

295. Typical Colour Rendering Index (CRI) = 83-85; nominal Correlated Colour Temperature (CCT) = 4000K. This implies that the device is fairly well able to discriminate and match observed colours accurately.

296. See, e.g., Bourne (1993).

297. On the confusion between dark-coloured, visually indistinct rocks in Egyptian archaeology see Müskens *et al.* (2017); cf. Brown and Harrell (1998), Aston *et al.* (2000), Klemm and Klemm (2001), Lapuente *et al.* (2012) 377, and Bloxam *et al.* (2014).

298. Telford *et al.* (1990) report average magnetic susceptibility values of 70 for basalt and 0.4/0.9 for sandstone/average sedimentary rocks, respectively ($\times 10^3$, SI units); and Hernant (2003) reports maximum volume susceptibility values (SI units) of 0.18 for basalt, 0.062 for granodiorite, and 0.0012/0.0209 for silt/sandstone, respectively. On the magnetic susceptibility of rocks and minerals, cf. Clark and Emerson (1991) and Hunt *et al.* (1995). Following the recommendations by Harrell (2012b, 3), the term (meta-)greywacke is used in this study to refer to the three slightly metamorphosed, compact sedimentary rocks that were obtained from the Wadi Hammamat in Egypt, regardless of grain size and colour. Strictly speaking, greywacke refers to a dark coloured, poorly sorted variety of sandstone (predominant grain size 0.062-2 mm), which contains a range of grain sizes with at least 10 percent of clay and silt matrix (Aston *et al.* 2000, 57). Besides green and dark-grey varieties of sandstones, a third, finer-grained rock was obtained from the Wadi Hammamat, a greyish green siltstone, which is a variety of mudrock (predominant grain-size 0.004-0.062 mm).

299. These studies focus on the identification of the stone types used for Egyptian objects, the topography and archaeology of relevant quarries, and the extracted materials (with a greater or lesser focus on the petrology of the rocks); for a brief outline of (the exploration of) Egypt's geology see Klemm and Klemm (2008) 1-10, with relevant bibliography. Principal references to the geology of Egypt include Hume (1925) and (1934-1937), Said (1962) and the more recent edition of *The geology of Egypt* (1990) with Said as editor, and the geological map of Egypt (1:500,000), which was prepared by Klitsch *et al.* (1987) with financial support of the Conoco Coral oil company. Important (geological-archaeological) studies on Egyptian quarries and their stones include, in chronological order, the chapter on stone materials in Lucas – Harris (1962), De Putter – Karlshausen (1992), Klemm and Klemm (1993), Aston (1994), Harrell *et al.* (1996), Aston *et al.* (2000), Klemm and Klemm (2008), and Harrell and Storemyr (2009). Finally, Sethe (1933) and Harris (1961) studied lexicographical data of ancient Egyptian stones. The list of studies focusing on specific aspects of Egyptian quarries and stones is much longer; a recent bibliography can be found in Harrell (2012b) 26.

300. However, it should be noted that actual colours can be notoriously off when reproduced on a computer screen or in print. Hence, Harrell uses CMY and RGB colour systems for the reproduction of rock colours online, which allow for (subjective!) colour calibration corrections (see http://www.eeescience.utoledo.edu/faculty/harrell/Egypt/Quarries/Images_Info.html). Moreover, the way we perceive colour is affected by factors like lighting conditions and background. The polished slab of a 'violet siltstone' from Egypt's Wadi Hammamat in the Klemm Collection is a good case in point (sample no. 198). Visual examination of the actual hand specimen under lamp light in 2012 showed a colour that is distinctly different from its colour as reproduced in Klemm and Klemm (2008) pl. 88 (the colour plate was examined under the same lighting conditions). This example demonstrates

knowledge of the most typical varieties of Egyptian stone materials was obtained through literature study. In a second phase, this primary knowledge was increased, to also include the variability of rock types within specific source areas, and to get first-hand expertise with Egyptian rock samples. This was done through the study of the two principal reference collections of Egyptian stones.³⁰¹

First is the so-called Klemm Collection, which has been housed in the Department of Ancient Egypt and Sudan of the British Museum in London since 2000. This collection results from the field campaigns that were undertaken by Egyptologist Rosemarie Klemm and geologist Dietrich D. Klemm in the 1970s and 1980s. It currently consists of approximately 1.600 stone samples from 80 ancient Egyptian quarry areas (hand specimens and thin sections). The collection's main strength lies in the sheer quantity of samples, which enables a thorough understanding not only of the most important anciently quarried stones, but also of the variation that occurs within a single quarry area. For instance, the main lithotypes from the quarries at Aswan (granite and granodiorite) are represented by

more than 300 samples,³⁰² which give a good idea of the wide variation that occurs within this anciently worked granitic body.³⁰³ Acknowledging that no two blocks of stone are exactly the same, an understanding of this intra-source variability is essential for a proper classification of stone objects in museums. However, the Klemm Collection excludes most of the Egyptian quarries that were worked in Roman Imperial times. While samples of the most important Roman quarries are available, notably from those at Mons Claudianus and Mons Porphyrites, the collection omits samples of the numerous smaller quarries that were opened during the Roman period.

This is one of the largest differences with the second main reference collection on Egyptian stones in the University of Toledo, Ohio. This university houses the Ancient Egyptian Stone Collection, which has been compiled since 1989 through the work of the archaeological geologist James Harrell. While the total number of samples in this collection is smaller than the number of samples in the Klemm Collection, the Ancient Egyptian Stone Collection includes samples from a larger number of quarries (approximately 200 stone quarries and gemstone mines are represented, including the full range of known Imperial Roman stone sources). Besides hand specimens and thin sections, polished slabs are available for a large number of samples including all hardstones. This feature makes the Ancient Egyptian Stone Collection particularly valuable for macroscopic comparison to the materials analysed in this study, which typically have polished surfaces. In conclusion, through the combination of literature study and the study of the two principal reference collections of Egyptian stones, a good knowledge of the different sources of anciently quarried Egyptian stones and the intra-source variability was obtained.

In a second phase the knowledge of potential source areas was expanded beyond Egypt, in order to include

that colour reproductions are not necessarily accurate; nor are the words we use to describe colour. What is recorded as violet by one examiner, may be perceived as purple, purplish, reddish-grey, or different, by another person. Colour perception, in other words, is subjective. An effective and commonly used means to standardise and communicate the colour of materials, including rocks, is the Munsell colour system. Although its use is not without its (fair) criticism either (for which see especially Jones and MacGregor 2002), it remains a useful reference device for communication among scholars, as it principally serves to codify the recording of colour. As such, it has been widely employed for the recording of archaeological material, including, for instance, rock and pottery colour (for rocks, see, e.g., Antonelli – Lazzarini 2004, 33; for the use of Munsell and alternative systems to record pottery colour see Orton – Hughes 2013, 155-158).

301. These collections stand at the basis of several principal references to Egyptian stones and quarries, including *Stones and quarries in ancient Egypt* (Klemm and Klemm 2008), which is a revised edition in English of *Steine und Steinbrüche im Alten Ägypten* (Klemm and Klemm 1993), and the more recent study on the origins of the building materials of the Old Kingdom pyramids (Klemm and Klemm 2010). A full bibliography of Harrell's publications on Egyptian quarries and mines can be found online at http://www.eeescience.utoledo.edu/faculty/harrell/Egypt/AGRG_Home.html. This website also contains up-to-date information on Egyptian quarries and mines, including coloured images of polished slabs of Egyptian stones. Recent overviews of Egyptian quarries have been published as Harrell and Storemyr (2009), and Harrell (2012a) and (2012b).

302. Samples from Aswan: nos. 11, 471-499, 571, 579-750, 800-822, 958-972.

303. Aswan granitoids compositionally range from granite to granodiorite and tonalite (however, see Brown and Harrell 1998 for a critical discussion of the occurrence at Aswan of tonalite). Several textures are attested, including isotropic, porphyritic and gneissoid; grain-sizes typically range from (very) coarse to fine-grained. The rocks are gradational with one another, and they may be intruded by granitic or quartz veins. Cf. Klemm and Klemm (2008) 233-267.

the major stones of the Imperial Roman Mediterranean world. This expansion is necessitated by this study's geographical and chronological context. The fact that material goods circulated across the Roman world and could function independently from ideas and people, implies that it needs not be surprising to find, for instance, an (originally) Egyptian theme worked in a non-Egyptian stone by an Egyptian, Roman or, for that matter, Greek or Jewish sculptor. The flexible relationship between ideas and material goods can be illustrated by the numerous 'Aegyptiaca' made from white marble. Despite its rich geology, Egypt had no major workable deposits of marble, like, for instance, the Greek world. While marble occurs in numerous small veins throughout the Egyptian Eastern Desert, only three deposits are known that were large enough to be worked. Of these, only the deposits at Gebel Rokham seem to have been quarried anciently, and only to a very limited extent during the 18th Dynasty (New Kingdom).³⁰⁴ Therefore, it can reasonably be assumed that the great majority of objects with (originally) Egyptian themes and iconography in white marble were carved from non-Egyptian stones. This observation has important consequences for the material analyses of the selected objects. Since the sample does not include

objects in white marble that date to the 18th Dynasty, and because no Ptolemaic or Imperial Roman statuary carved from Egyptian marble has been recognised to date, the exclusion of an Egyptian source directly follows from the classification of the studied materials as marble. Therefore, in the case of white marble, the distinction between Egyptian and non-Egyptian sources, defined as one the main objectives of the material analyses in this study above, can be made on the basis of an identification as marble alone.³⁰⁵

However, in the case of the numerous coloured stones that were used in the Roman world, the determination of the geological provenance usually does not directly follow from its classification. Although Egypt was an important supplier of such materials, it certainly was not the only one, as the discussion in Part II has made clear. Therefore, a proper evaluation of the materials of the selected objects can only be made by also taking non-Egyptian coloured stones into account. This is all the more important because the natural variability within and across different source areas makes it likely that a certain stone type has look-alikes from other formations.³⁰⁶ Moreover, there is good reason to believe that the Romans were aware of such similarities, and actively used them to substitute, for instance, highly prestigious materials for less prestigious materials with comparable appearance.³⁰⁷ These considerations

304. For the marble from Gebel Rokham see, e.g., Aston *et al.* (2000) 44, Harrell (2002) 240, and Klemm and Klemm (2008) 312-314. The location of the quarry is indicated on the geological map in Harrell and Storemyr (2009) no. O3. Most of the known statues in Egyptian marble date to the reign of Thutmose III (approximately 1479-1425 BC), with rare exceptions dating to his later successors Amenhotep II, Akhenaten, and Tutankhamun: see De Putter – Karlshausen (1992) 108-110 pl. 38-39, Aston *et al.* (2000) 45, Harrell (2002) 240, and Klemm and Klemm (2008) 313-314. Imperial Roman exploitation of Gebel Rokham marble is suggested by the find of pottery that dates from the Roman period in an ancient 'workshop', an area with abundant white marble chips (Prof. Harrell, pers. comm.), plus the discovery of some marble fragments at two Roman period *praesidia* in the quarry's vicinity; cf. Brown and Harrell (1995) 231. Although the use of Egyptian marble has not been demonstrated for Roman period sculpture to date, and, moreover, Egypt seems to have chiefly relied on marble imports from eastern Mediterranean sources during Imperial Roman (and Hellenistic) times, it is nevertheless possible that sculptures carved from Gebel Rokham marble exist but have gone unnoticed, as suggested in Aston *et al.* (2000, 45) and Harrell (forthcoming). No research has been done on the use of Egyptian marble for the production of Imperial Roman sculpture to date; however, this kind of research may benefit from the fact that Gebel Rokham marble appears to be compositionally unique among the white marbles used in Antiquity (isotopic and petrological data in Brown and Harrell 1995).

305. This has ensured the success of the macroscopic methodology that is implemented in this study. While some marble varieties can be distinguished on the basis of macroscopic observations, in many cases (invasive) chemical analyses are needed which, as argued above, were not possible for the studied objects. Nevertheless, it would be interesting to identify the marble varieties from which so-called Aegyptiaca were carved. Not only could this lead to a better understanding of the ways in which these objects were understood in the Roman world (some marbles were more sought-after and held in higher esteem than others), knowledge of the different marble types of the numerous extant relief fragments could also help in reconstructing wall reliefs with originally Egyptian subject matters and executed in conceptual styles, which, as a result of their fragmented state of preservation and widely scattered nature, remain poorly understood (cf. Capriotti Vittozzi 2005, 140-141).

306. See for instance Luedtke (1992) 109. The argument of similar visual appearance of stones from different source areas owing to inter- and intra-source variability was used in Waelkens *et al.* (1988, 84 n. 13) as a general warning against relying too heavily on macroscopic analysis of Roman stones. While such remarks emphasise the need for caution, our current knowledge on the source areas of Roman coloured stones enables a more nuanced approach, as will be argued below.

307. Cf. *supra*, section II.2.2.2.

underline the importance to expand the knowledge of potential source areas beyond Egypt. This was principally done through literature study, while first-hand experience with the relevant stones was acquired during several field trips to archaeological museums and sites in Rome and different cities.³⁰⁸

The most widely used coloured stones of Pharaonic Egypt and the Imperial Roman world often had notable visual characteristics, which may have contributed to their appreciation, as demonstrated above.³⁰⁹ The distinct qualities of stones like *breccia verde d'Egitto* and Imperial porphyry from Egypt, Tunisian *lumachella orientale*, *occhio di pavone* and *alabastro fiorito* from Turkey, Greek *serpentino*, and *broccatello di Spagna* from Spain, made them unique in the ancient Egyptian and Roman worlds. Consequently, they can be safely identified on the basis of visual inspection. Moreover, since only one source area is known for each of these materials, the geological provenance automatically follows from their characterisation.³¹⁰

Things are different if stones are not unique in their visual appearance, and if they extracted from more than one locality. For example, visual ambiguity exists between some of the grey granitoid rocks that were used in Antiquity. With main extraction sites in present-day Italy, Turkey, and Egypt, and smaller quarries of mainly local importance in areas like France, Spain, and Germany, these rocks were among the most frequently used stone materials of the Roman world.³¹¹ However, owing to their neutral colour, similar mineralogy, and frequent overlap between other macroscopic aspects, such as texture, it may be very difficult to make a positive distinction between these stones on the basis of macroscopic analysis alone. Notorious overlap exists, for instance, between *granito del foro* and *granito di Nicotera*,³¹² and *marmor misium* and (some varieties of) the Tuscan Archipelago Granitoids (*granito dell'Elba*, *granito del Giglio*).³¹³ Other granitoid rocks that may

308. An extensive body of literature exists on the coloured stones of the Roman world, and several works include colour photographs of representative samples. Relevant studies include, first and foremost, the numerous contributions in the ten volumes of ASMOSIA-proceedings that have been published to date: *ASMOSIA I-X* (1988-2015). Many articles in these volumes deal with the characterisation and provenance determination of archaeologically attested stones, or the topography, archaeology, and petrology of specific quarries and their stones. Lazzarini (2009) provides an important synthesis that integrates a large body of (previously published and unpublished) data. Other relevant volumes, chiefly in Italian, include, in chronological order: Dworakowska (1983), Mielsch (1985), Gnoli (1988), *Il marmo e il colore* (1998), *Marmi Antichi II* (1998), *Marmi Antichi e Pietre Dvire* (2000) (in particular the contribution by Martano – Calogero 2000 in that volume), *Marmi colorati* (2002) (especially Antonelli 2002, Bruno 2002b, and Lazzarini 2002), *Marmi Antichi* (2004), *Pietre e marmi antichi* (2004) (especially Lazzarini – Sangati 2004), Lazzarini (2007), and Price (2007). Russell (2013c) gives a useful overview of known stone quarries in the Roman world with relevant bibliography.

309. See *supra*, section II.2.2. The popularity of stone materials also depended on other than visual characteristics, like availability (the rarer the more prestigious) and technical features, such as workability and durability.

310. See already Fant (1988a, 1 n. 3): “[...] most of the marbles at any Roman site can usually be assigned with a high degree of certainty”, namely on the basis of macroscopy alone. While this means of positive source attribution is feasible for easily recognisable materials, it contrasts with the fundamental premise of provenance studies that rely on geochemical and petrographical approaches. Theoretically speaking, the source of archaeological materials can only be determined if all potentially

relevant sources and all intra-source variation are available for comparison. However, in practice this is often not feasible and, consequently, inadequate sampling strategies of potential rock sources (both intra- and inter-variability) may be considered as a serious flaw of many provenance studies that rely on geochemical and petrographic approaches. This discrepancy between theory and practice implies that it is impossible, from a theoretical point of view, to attribute studied materials with absolute certainty to a particular source. Therefore, provenance studies work with the principle of negative exclusion: based on significant compositional differences between the archaeological material in question and studied sources, source areas can be excluded until, ideally, one source area remains, which then can be considered as the area of origin with a certain degree of certainty. See also Wilson and Pollard (2001), esp. 510.

311. See Galetti *et al.* (1992), Peacock *et al.* (1994).

312. *Granito del foro* (quarried at Mons Claudianus in Egypt's Eastern Desert) and *granito di Nicotera* (quarried on the western coast of Calabria, Italy) were used from the 1st century AD onwards for the production of pillars and columns. They are medium-grained granitoid rocks with a white/grey matrix with black patches; a positive discrimination between these rocks is only possible on the basis of modal mineralogy and chemical trace-element analysis: see Antonelli *et al.* (2009) and (2010).

313. *Marmor misium* (quarried in the area of Kozak, western Turkey) and *granito dell'Elba* (from Elba Island, Italy)/*granito del Giglio* (from Giglio Island, Italy) were particularly used from the 1st century AD onwards for architectural purposes. The typical Turkish lithotype is a fine- to medium-grained grey granite; rocks with similar appearance are common among the Tuscan Archipelago Granitoids (Poli's 'Main Facies', no. 1: Poli 1992, 42). De Vecchi *et al.* (2000) report that these rocks can be easily differentiated through the combination of petrography and geochemistry, although new discoveries from the Elba and Giglio quarries demonstrate that previous characterisations not always allow for a positive discrimination: S. Diebner, F. Capitanio, S.

be confused due to macroscopic similarities are Aswan granite and (some varieties of) *granito sardo* and Fawakhir-granite, the three main sources of pink and red granite in the Roman world.³¹⁴ Other rock types that may be easily mistaken as a result of visual ambiguity

Fulloni, *The grey-granite quarries of Cavoli and Seccheto on the Elba island. A new research project starting from the archive of Dr. J. Röder (1914-1975) at the DAI Rome*, unpublished paper delivered at the Xth International ASMOSIA Conference, Rome 2012. On granitoids from Elba Island and Giglio Island see Rocchi *et al.* (2003) and Westerman *et al.* (2003), respectively.

314. It has been noted that the appearance of *granito rosso antico*, the famous pink and red granite from the quarries at Aswan in southern Egypt, is so typical that “[...] there is almost no way that it could be mistaken for other types of granite from elsewhere in the world [...] despite the quite wide range of varieties involved” (Klemm and Klemm 2008, 250). However, some authors have drawn attention to the visual overlap that may exist between certain pale pink varieties of Aswan granite and *granito sardo* from the Italian island of Sardinia (e.g., Galetti *et al.* 1992, 169, Poggi – Lazzarini 2005, and Williams-Thorpe – Rigby 2006). The similarities between Aswan granite and *granito sardo* were such that, from the early 2nd century AD onwards, the (less expensive) Sardinian granite was occasionally used as a substitute for its more famous Egyptian counterpart (Pensabene 1992, Lazzarini – Sangati 2004, 97, and Lazzarini 2009, 465). It has even been suggested that there was a certain demand for Sardinian granite for the production of “Egyptianising monuments” as a cheap substitute for Aswan granite (Wilson 1988, 110). To support his hypothesis, Wilson draws attention to a pair of sphinxes in the Cagliari Museum, and two “Egyptianizing monuments from an Isaeum at Catania, Sicily”. The recent geochemical analysis of a pink granite sphinx from the Cagliari Museum suggests that this object was indeed carved from pale pink Sardinian granite (Williams-Thorpe – Rigby 2006, 104). Unfortunately no inventory numbers are given in the two aforementioned papers, but we may reasonably assume that the sphinx analysed by Williams-Thorpe and Rigby is one of the pair of sphinxes mentioned by Wilson, and this is almost certainly the pair of sphinxes that was exhibited in 2014 in Paris (Museo Archeologico Nazionale di Cagliari, inv. 6111-6112). In the accompanying exhibition catalogue, these sphinxes are said to be carved from Aswan granite, which is considered as an indication of their Egyptian origin. Subsequently, they are dated to the Ptolemaic period (*Le mythe Cléopâtre* 2014, 38-39 no. 6-7). This is a telling example of the easy confusion between the two stones, and the wrong interpretations that may result from a direct equation between the origin of materials and the place of a sculpture’s manufacture (for which see *supra*, section 1.2). The granite quarries in Sardinia appear to have been active between the early 2nd and the first part of the 3rd century AD (Wilson 1988, 109, Poggi – Lazzarini 2005, 57), which implies a terminus post quem of the 2nd century AD for the sphinxes if they are indeed carved from *granito sardo*, and which renders an Egyptian origin very unlikely. For representative slabs of *granito sardo* see Mielsch (1985) pl. 23 no. 788-789, Lazzarini – Sangati (2004) 97 fig. 45, and Price (2007) fig. p. 218 left.

include certain famous breccias of the Roman world, for instance *africano* and *portasanta*,³¹⁵ and *breccia di Settebasi* and *pavonazzetto*.³¹⁶ Another factor that complicates the macroscopic identification of rocks is the discovery of new quarries that produced stones that were previously thought to come from one single quarry location. *Cipollino* is a marble with distinct undulating or parallel green (chlorite) impurities. The quarries near the modern city of Karystos (ancient Carystus), on the island of Euboea in Greece, were long thought to be the only source for these stones. However, in the 1990s, a quarry was discovered at Kourelos, near Cape Matapan in the southern part of the Greek Peloponnese, where another *cipollino*-marble was anciently extracted with a very similar appearance to Euboean *cipollino*. Consequently, more comprehensive analysis is now needed to positively distinguish between *cipollino* and this recently discovered *cipollino tenario*.³¹⁷

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315. *Africano*, quarried at present-day Sigacik in Turkey (ancient Teos), may closely resemble *portasanta* (from the Island of Chios in Greece) when large pink clasts are present. The two can be positively set apart by the fact that *africano* is dolomitic, whereas *portasanta* is calcitic: Lazzarini (2002) 251, and 262.

316. Lazzarini (2000a, 260) reports close similarities between the appearance of *pavonazzetto*, a breccia from İscihisar in Turkey (ancient Dokimeion), and a dolomitic variety of *breccia di Settebasi*, a metaconglomerate/-breccia from the Island of Skyros in Greece. Thin-section and isotopic analyses are needed to safely discriminate between these two rocks. Other examples of rocks that can be confused due to similar appearance include *rosso antico* from the Mani Peninsula in Greece and a uniformly red coloured variety of *cipollino rosso* from Kiyikislacik in Turkey (in which case geochemical trace-element analysis is needed to tell the two apart: Gorgoni *et al.* 2002), and *giallo antico* from Chemtou in Tunisia and the yellow breccia with violet veins from the quarries at Montagnola Senese in Italy, known as *giallo di Siena* (Lazzarini 2002, 244, and Bruno 2002b, 281-283).

317. For the quarries and the characterisation of *cipollino tenario* see Lazzarini (1998), Bruno (2002a). A similar example exists for *pavonazzetto*, the famous breccia with white marble clasts in a deep violet (hematite-rich) matrix. It was long thought that this rock was only quarried at ancient Dokimeion in Asia Minor, but recent research shows that the term *pavonazzetto* in fact covers a whole family of similar rocks rather than a single unique variety. Quarries producing *pavonazzetto* have been discovered near Aphrodisias and east of Milas, while *pavonazzetto*-like stones were anciently extracted from quarries at Kavaklıdere and Beyler, all in modern Turkey. Moreover, *pavonazzetto*-like breccias are known from the Apuan Alps in Italy (*rosso fantastico* from Vagli, and *breccia di Seravezza* from Monte Corchia). While most of the mentioned varieties can be discerned by simple visual inspection, in other cases more comprehensive analyses are needed for a safe distinction (e.g., petrographic and isotopic analysis): D. Attanasio, M. Bruno, W. Prochaska and

Visual discrimination is also difficult for materials with little or no visual variability, which were extracted from different sources. This applies, for instance, to the dark-grey to black limestones that were used in Antiquity. Grouped under the header of *neri antichi*, these materials were extracted from various localities across the Roman world, most notably Turkey (Göktepe, Adapazari and Teos), Tunisia (Ain el Ksir, Djebel Aziz, Djebel Oust, and presumably Thala), Greece (Island of Chios and Capo Tenaro in the southern Peloponnese), and Italy (Palombino). While some types of *neri antichi* may be positively distinguished by visual inspection, particularly if large fossils are present, macroscopy is generally insufficient for the provenance determination of samples that lack such ‘guide-fossils’, and which consequently appear as very fine-grained, homogeneous, and therefore indistinct black rocks.³¹⁸

1.2 CONCLUSION:

THE MACROSCOPIC ANALYSIS OF THE STONES OF AEGYPTIACA ROMANA

Depending on the studied materials and the desired levels of precision and accuracy, macroscopy emerges

as a viable method for a positive discrimination between the most frequently used stones of ancient Egypt and the Roman world. Its successful application stands or falls on the archaeological question and a proper definition of the relevant context. This is needed to delimit the number of potentially relevant look-alikes from other formations. Of course, not every look-alike is equally important.³¹⁹ Therefore, in practice a compromise needs to be made between the necessity to extend the potential number of source-areas beyond the most likely sources and logical reasoning.

Within the framework of the present study, the confines of the Roman world were appointed as relevant context. The inter- and intra-source variability is very large in an area as outstretched as the Roman Empire and, consequently, it is likely to find certain macroscopic overlaps. However, by mainly focusing on the quarries that are known to have been worked in Pharaonic Egypt and Roman Antiquity, the number of potentially relevant sources can be substantially lowered. Considering that the materials of the studied objects generally do not belong to the problematic stone types mentioned above,³²⁰ geological provenance hypotheses can be formulated on the basis of macroscopy. Where possible, source attributions are supported by references to relevant rock samples in reference collections or by references to relevant published slabs.³²¹

B. Yavuz, *Analysis and discrimination of Phrygian and other Pavonazzetto-like marbles*, unpublished paper delivered at the Xth International ASMOSIA Conference, Rome 2012.

318. Lazzarini (2002) 265, Brilli *et al.* (2010) 994. Recent research has shown that a good discrimination between several source areas of *nero antico* is possible by adopting a multimethod approach that includes both geochemical methods and petrography: Brilli *et al.* (2010), Lapuente *et al.* (2012), Agus *et al.* (2006), and Fornaseri *et al.* (1995). It has become evident that the large majority of statuary and architectural objects of *nero antico* are made from Göktepe stone (Bruno *et al.* 2015). Besides *neri antichi*, other frequently used grey to dark-grey stones of Antiquity include *bigio antico* and *bigio morato*. The division between these stone types is ambiguous, as it mainly relies on different colourations, the latter being the darker of the two (on *bigio morato* see Cioffarelli 1989). *Bigio antico* was extracted from numerous localities across the Roman world, including several sites on the Aegean coast of Asia Minor (e.g., Izmir, Teos), other present-day Turkish sites (e.g., Iznik, Afyon, Göktepe), eastern Aegean Greek islands (most notably at Moria in Lesbos, as well as Rhodes and Chios), Saint B  at in the French Pyrenean Mountains, and Macael in south-eastern Spain. For *bigio antico* and its sources, several of which have been discovered in recent years, see Pensabene and Lazzarini (1998), Lazzarini *et al.* (1999), *Marmi Antichi* (2004) 158-159 no. 16 (M.C. Marchei), Attanasio *et al.* (2009), and Yavuz *et al.* (2009) and (2012).

319. Granite, for example, is one of the most common rock types found worldwide. Given the frequency with which these rocks occur, it would not be surprising to find close macroscopic similarities between the granites from the Egyptian quarries near Aswan and certain varieties from, say, North America. However, there is no reason whatsoever to include such remote sources in a provenance study that concerns Pharaonic Egypt or Classical Antiquity.

320. The pale pink granite of an obelisk fragment from Palazzo Valentini is a possible exception; it is not clear whether this is Egyptian granite from Aswan or *granito sardo* (see *infra*, 292-293 no. 140).

321. AESC is used as an abbreviation for the Ancient Egyptian Stone Collection, University of Toledo, Ohio. Polished slabs of hand specimens from this reference collection are published online at http://www.eeescience.utoledo.edu/faculty/harrell/Egypt/Quarries/Quarries_Menu.html. The numbering system is similar to that used on the website.