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Late Antique textiles from Egypt in the Ny Carlsberg Glyptotek, Copenhagen

Abstract
The Ny Carlsberg Glyptotek (NCG) possesses a small collection consisting of 13 fragments of Late Antique textiles from Egypt, possibly from the site of Akhmim. The collection primarily consists of cut-outs of decorative elements. The collection has until now not received much attention nor been thoroughly analysed. The present study seeks to remedy this neglect by performing fibre and dye analyses as well as including archival material from the museum collections.

Keywords: Late Antique textiles, Akhmim, HPLC, dye analyses, fibre analyses

Introduction
Numerous museum collections worldwide include fragments of Egyptian textiles from the Late Antique Period (circa 250 CE to 800 CE), often wrongly termed "Coptic" textiles. Late Antique textiles from Egypt were in previously thought to have been produced by Copts (Christian Egyptians), which has given them the designation "Coptic" textiles. This is, however, a misleading term since their production was not related to any specific religion or ethnicity. Neither is the "Late Roman" the chronological equivalent of what is usually meant by "Coptic". Many dated textiles formerly labelled "Coptic" in fact date to the Roman Period, the Umayyad Period in Egypt or later (Schrenk 2004). Although terminology is still an issue, the term Late Antique textiles is used here to avoid any religious or political affiliation. Many of these museum collections are published in catalogues, which were previously the dominant mode of publication, overshadowing archaeological and technical studies, which today have come to the fore (see, for example, De Moor & Fluck 2009; 2011; De Moor et al. 2007; 2013b; 2015). These collection catalogues established a strong tradition of physical description and art historical interpretation based on motifs and stylistic traits. The fragments were then categorized by their motifs, colour schemes and techniques (Thomas 2007, 139, 142). By the mid-1960s, the catalogue of "Coptic" textiles was an established genre which outlined the history of the collection, gave brief descriptions of materials and techniques followed by entries for ornamental fragments from tunics and, rarely, complete garments. The format was reinvigorated in the 1980s by an explosion of collection and exhibition catalogues that significantly altered the corpus of known works (Thomas 2007, 149). From the 1990s on, technical analyses and results from instrumental methods of analyses as well as studies of function and provenance have grown in significance in the study of these textiles.
The majority of the Late Antique textiles in the collection of the Ny Carlsberg Glyptotek (NCG) in Copenhagen, Denmark have been summarily published in a similar catalogue from 1930, including the larger part of the museum's Egyptian collection (Mogensen 1930). As several new methods of analyses have appeared since then, this paper seeks to include these and make the existence of the small NCG textile collection known and available for comparative studies.
Regrettably, many of these archaeological textiles

in museum collections do not have any contextual information, which makes a thorough study of them challenging. At the end of the 19th century, astonishing amounts of textiles were unearthed in Egypt, primarily in burials at cemeteries and monasteries, but since most of the early digs and exploration campaigns (not to mention illegal looting and plundering) carried out between 1880 and the 1930s predate rigorous archaeological excavation, the majority of the early textile finds have no contextual evidence and suffer from inadequate recording (Thomas 2007, 141; Wild 2012, 17; Pritchard 2006). The first private and museum collections therefore acquired these textiles with little or no information about their archaeological context and in a fragmentary condition. Furthermore, when burials were discovered during these early explorations, the bodies were usually unwrapped after exhumation and the better preserved pieces were removed for collection. Since collectors prized colour and ornamental compositions, decorated pieces, such as panels (*tabulae*), medallions (*orbiculi),* and *clavi* were cut out and retained while the plain-woven and less well-preserved parts were usually discarded together with the bodies. As a consequence, most of the textiles from early excavations and exhumations survive as mere fragments and complete garments are rare (Thomas 2007, 141-142). Owing to the nature of early museum collecting, there are still large gaps in our knowledge on these textiles. There is, for example, no reliable way to differentiate between men's and women's garments (Bazinet 1992, 74). This underlines the necessity of further research into these artefacts.

The textiles in the Ny Carlsberg Glyptotek (NCG)

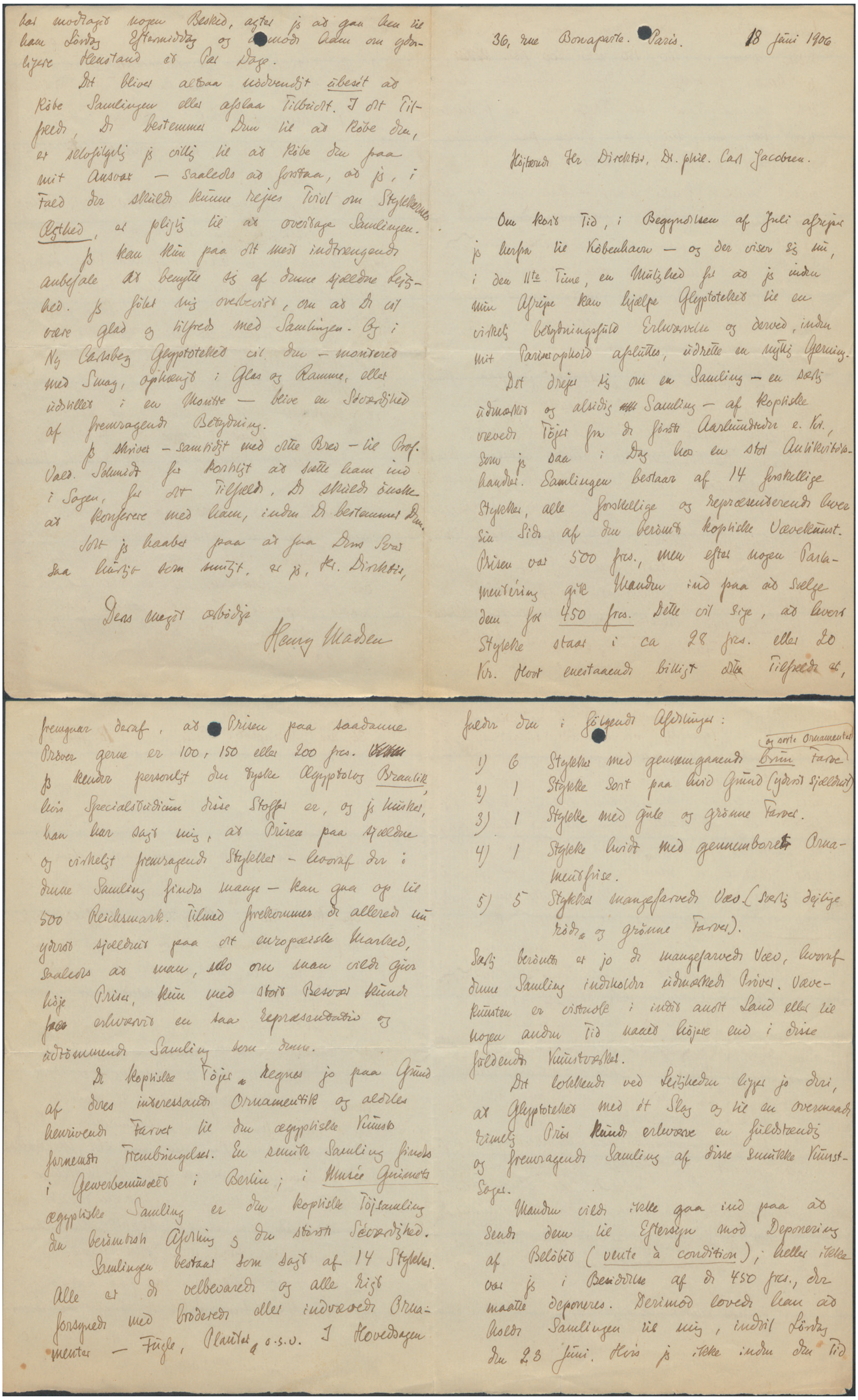
The NCG possesses a small collection of 13 fragments of Late Antique textiles, primarily consisting of cut-outs of decorative elements, which until now have not been thoroughly analysed. It is usually assumed that these kinds of textiles are made of undyed linen, while the decorative elements are of wool dyed in different colours, primarily different shades of purple (Bazinet 1992, 75; Gulmini et al. 2016, 485-86). This assumption is also based on the testimonies of ancient authors such as Herodotus, who describes how flax was used for textiles in ancient Egypt. Priests were required to wear linen garments (2.37) and linen was also the proper fibre for funerary practices, while wool was considered unclean (2.81; 2.86). The museum collection also includes three pieces of undyed linen (Schmidt 1899, catalogue number A 653; Schmidt 1908, catalogue number E 806). The textiles are however without provenance or date and have therefore been excluded from this study.

The fragments are made in the weaving techniques common in this area and period. The body of Late Roman garments and furnishing textiles were usually made in plain tabby weave in linen and wool. The fragments in the NCG collection appear to be parts of larger linen tabbies. Some of them still have part of the tabby preserved (ÆIN 952 and 960, table 1.3 and 1.10). The decorations in purple and other colours were carried out in different techniques, primarily tapestry weave, which is a weft-faced plain weave in which the dyed weft threads entirely cover the warp threads creating coloured areas of pattern and design only where needed. Additional effects are sometimes added in other techniques, such as those using a "flying shuttle" or "flying needle", intended to mimic woven ornaments. The flying shuttle technique is employed at the same time as the tapestry weave is made: a separate yarn is added to the weave with a needle, carried on the front side of the textile and sketching an image with fine lines. The thread only goes into the textile to wrap around a warp thread to secure it (Dross-Krüpe & Paetz gen. Schieck 2014, 207; Verhecken-Lammens 2013). This technique is at first sight very similar to embroidery (which was a relatively rare technique during Antiquity) but is a completely different way of decorating textiles. Embroidered textiles first appear in Egypt during the 18th Dynasty, but it is not until the Hellenistic and Early Roman period that embroidery can be identified again. The number of embroidered textiles slightly increases during Late Roman times, but they are not common until the Byzantine and Early Islamic period, when embroidery becomes one of the most frequently employed decorative textile techniques (Dross-Krüpe & Paetz gen. Schieck 2014).

Pile weaving was also used. Weft-looping is the most common type. It introduces a doubled or trebled strand of linen (or wool), edge to edge (although looping threads can also be introduced locally), in one of the plain weave sheds, while pulling out a length of this extra weft between warp threads at regular or irregular intervals to an even length. When long, the loops look like a fringe. Only one of the textiles studied here is made using this technique (ÆIN 1021, table 1.12).

Provenance

A total of 12 of the textiles (ÆIN 949, 950, 952-960 and 960bis, Table 1.1-1.11) were acquired by the museum via the art market in 1906 from the Danish art historian and Egyptologist Henry Madsen (1881-1921), who lived in Paris from 1905 to 1908. He was a student of H. O. Lange and had a short career in


36, rue Bonaparte. Paris. 18 Juni 1906

Höjtærede Hr Direktör, Dr. phil. Carl Jacobsen.

Om kort Tid, i Begyndelsen af Juli afrejser jeg herfra til København — og der viser sig nu, i den 11te Time, en Mulighed for at jeg inden min Afrejse kan hjælpe Glyptoteket til en virkelig betydningsfuld Erhvervelse og derved, inden mit Parisophold afsluttes, udrette en nyttig Gerning.

Det drejer sig om en Samling — en særlig udmærket og alsidig Samling — af koptiske vævede Töjer fra de første Aarhundreder e. Kr., som jeg saa i Dag hos en stor Antikvitetshandler. Samlingen bestaar af 14 forskellige Stykker, alle forskellige og repræsenterende hver sin Side af den berömte koptiske Vævekunst. Prisen var 500 frcs., men efter nogen Parlamentering gik Manden ind paa at sælge dem for 450 frcs. Dette vil sige, at hvert Stykke staar i ca 28 frcs. eller 20 Kr. Hvor enestaaende billigt dette Tilfælde er, fremgaar deraf, at Prisen paa saadanne Pröver gerne er 100, 150 eller 200 frcs. Jeg kender personligt den tyske Ægyptolog Braulik, hvis Specialstudium disse Stoffer er, og jeg husker, han har sagt mig, at Prisen paa sjældne og virkeligt fremragende Stykker — hvoraf der i denne Samling findes mange — kan gaa op til 500 Reichsmark. Tilmed forekommer de allerede nu yderst sjældent paa det europæiske Marked, saaledes at man, selv om man vilde give höje Priser, kun med stort Besvær kunde faa erhvervet en saa repræsentativ og udtömmende Samling som denne.

De koptiske Töjer regnes jo paa Grund af deres interessante Ornamentik og aldeles henrivende Farver til den ægyptiske Kunsts fornemste Frembringelser. En smuk Samling findes i Gewerbemuseet i Berlin; i Musée Guimets ægyptiske Samling er den koptiske Töjsamling den berömteste Afdeling og den störste Seværdighed.

Samlingen bestaar som sagt af 14 Stykker. Alle er de velbevarede og alle rigt forsynede med broderede eller indvævede Ornamenter — Fugle, Planter o.s.v. I Hovedsagen fordeler den sig i fölgende Afdelinger:

1) 6 Stykker med gennemgaaende brun Farve og sorte Ornamenter
2) 1 Stykke sort paa hvid Grund (yderst sjældent)
3) 1 Stykke med gule og grönne Farver.
4) 1 Stykke hvidt med gennembrudt Ornamentfrise.
5) 5 Stykker mangefarvede Væv (særlig dejlige röde og grönne Farver).

Særlig berömte er jo de mangefarvede Væv, hvoraf denne Samling indeholder udmærkede Pröver. Vævekunsten er vistnok i intet andet Land eller til nogen anden Tid naaet höjere end i disse fuldendte Kunstværker.

Det lokkende ved Lejligheden ligger jo deri, at Glyptoteket med ét Slag og til en overmaade rimelig Pris kunde erhverve en fuldstændig og fremragende Samling af disse smukke Kunstsager.

Manden vilde ikke gaa ind paa at sende dem til Eftersyn mod Deponering af Belöbet (vente à condition); heller ikke var jeg i Besiddelse af de 450 frcs., der maatte deponeres. Derimod lovede han at holde Samlingen til mig, indtil Söndag den 23 Juni. Hvis jeg ikke inden den Tid har modtaget nogen Besked, agter jeg at gaa hen til ham Söndag Eftermiddag og anmode ham om yderligere Henstand et Par Dage.

Det bliver altsaa nödvendigt [illegible] at köbe Samlingen eller afslaa Tilbudet. I det Tilfælde, De bestemmer Dem til at köbe den, er selvfölgelig jeg villig til at köbe den paa mit Ansvar — saaledes at forstaa, at jeg, i Fald der skulde kunne rejses Tvivl om Stykkernes Ægthed, er pligtig til at overtage Samlingen.

Jeg kan kun paa det mest indtrængende anbefale at benytte sig af denne sjældne Lejlighed. Jeg föler mig overbevist om, at De vil være glad og tilfreds med Samlingen. Og i Ny Carlsberg Glyptoteket vil den — monteret med Smag, ophængt i Glas og Ramme, eller udstillet i en Montre — blive en Seværdighed af fremragende Betydning.

Jeg skriver — samtidigt med dette Brev — til Prof. Vald. Schmidt for hurtigt at sætte ham ind i Sagen, for det Tilfælde, De skulde önske at konferere med ham, inden De bestemmer Dem.

Idet jeg haaber paa at faa Deres Svar saa hurtigt som muligt, er jeg, Hr. Direktör,

Deres meget ærbödige

Henry Madsen

Fig. 1: Photograph and translation of the letter from Henry Madsen to Carl Jacobsen, dated 18 June 1906 (Image and translation: Cecilie Brøns)

To: The Highly-Esteemed Carl Jacobsen

In a short while, at the beginning of July, I shall be departing from here for Copenhagen – and it appears that, at the 11th hour, there is the possibility that I can help the Glyptotek in making a really significant acquisition and thereby do something useful before the end of my stay in Paris.
It is the question of a collection – a particularly remarkable and very varied collection – of Coptic woven garments from the first century AD, which I saw today on the premises of a major dealer in antiquities. The collection consists of 14 separate pieces, all different and each representing an aspect of the renowned Coptic art of weaving. The price was 500 francs, but after some negotiation the man agreed to drop this to 450 francs. That means that each item is going for 28 fr. or 20 kr. How cheap this is becomes apparent when one compares the price of samples of such work which can be as high as 100, 150 or 200 fr.
I am personally acquainted with the German Egyptologist Braulik, whose special field of study these fabrics are, and I remember him telling me that the price of such rare and truly excellent pieces – of which there are many in this collection – can go as high as 500 Reichsmarks. Add to this the fact that already they only appear extremely rarely on the European market, so that even if one desired to offer high prices one could only acquire such a representative and exhaustive collection as this with considerable difficulty.
Because of their interesting ornamentation and absolutely ravishing colours, the Coptic garments are reckoned as the most illustrious creations of Egyptian art. One beautiful collection is to be found in the Gewerbemuseum in Berlin; in the Musée Guimet's Egyptian collection, the collection of Coptic costume is the most famous department and the greatest "attraction".

The collection, as I said, consists of 14 pieces. All are well-preserved and richly decorated with embroidered or woven-in ornaments – birds, plants etc. In principle, it falls into the following divisions:

1) 6 pieces with a brown colour throughout and black ornaments.
2) 1 piece with black on white ground (extremely rare)
3) 1 piece with yellow and green colours
4) 1 piece white shot through with ornamental frieze
5) 5 pieces of multi-coloured weave (especially lovely red and green colours)

Particularly renowned is the multi-coloured weave, of which this collection contains remarkable samples. The art of weaving has certainly never been raised to greater heights in any other country or at any other time than in these consummate works of art.
What is enticing about this opportunity is that, at a stroke, the Glyptotek could acquire a complete, exciting collection of these beautiful works of art at an exceedingly reasonable price.
The man was not prepared to agree to send them for inspection against the paying of a deposit (*vente à condition*); neither was I in possession of the 450 francs, the deposit of which was required. On the other hand, he promised to hold the collection for me until Saturday 23 June. If before that time, I have not received any communication I intend to go to him on Saturday afternoon and ask him to give me a few more days.
It will, therefore, be necessary to buy the collection unseen or miss out on the offer. In the event of your deciding to buy them, I am of course prepared to buy them at my own risk – on the understanding that, should any doubts be raised about the *authenticity* of the items, I am obliged to take over the collection.
I can only recommend in the strongest terms the making use of this rare opportunity. I feel certain that you will be happy and satisfied with the collection. And that installed in the Glyptotek, tastefully mounted, hung behind glass in frames or exhibited in a glass case – they will be an attraction of truly great consequence.
Together with this letter, I enclose one to Professor Valdemar Schmidt giving him a quick apprisal of the situation in case you wish to confer with him before making your decision.
Hoping to receive your answer as quickly as possible, I remain, Herr Director,

Your devoted

Henry Madsen

Egyptology, publishing about 16 articles, but he never conducted any excavations in Egypt (Hagen & Ryholt 2016, 122).

The last textile (ÆIN 1021, Table 1.12) was given to the museum as a gift in 1908 by Emile Guimet, founder of the Museé Guimet in Paris. The museum archives have revealed a letter from Henry Madsen to Carl Jacobsen from June 1906 wherein Madsen enthusiastically tries to convince Jacobsen to buy the collection of textiles from an unknown art dealer in Paris for the price of 450 francs (fig. 1). Henry Madsen's letter mentions 14 textiles, but only 13 were included in the museum's collections.

According to the museum records, the textiles are from the cemeteries of ancient Panopolis, the modern city of Akhmim, on the east bank of the Nile in Upper Egypt. The city was known as Panopolis in Greek, and later, Shmin in Coptic. According to Strabo (*Geography* XVII, 41), Akhmim/Panopolis was a well-known production centre for linen fabrics from Pharaonic times. Up to now, there has been little literary evidence of textile production at the site throughout the Late Antique Period, although some documents attest textile specialists worked in the city during the fourth century CE and an inscription on a rug from the Islamic Period confirms that Akhmim remained a centre of textile production in Islamic times (Fluck 2008, 211).

The excavations of the three major cemeteries at Akhmim were conducted over several years beginning in 1884 by the team of the French Egyptologist and director of the Cairo Museum Gaston Maspero (Pritchard & Verhecken-Lammens 2001, 21). Enormous quantities of textiles were uncovered. Akhmim is generally considered one of the major find-spots in Egypt for textiles of the first millennium CE and it has been claimed that there is no doubt that most of the textiles circulating in the late 19th century, specifically in the years 1885 to 1886, when the excavations led by Maspero took place, came from this site, particularly from the al-Hawawis necropolis, placed northeast of the city. Thus, inspired by Maspero's finds, other contemporary scholars and collectors such as Vladimir G. de Bock, Theodor Graf, Carl Schmidt, and Robert Forrer visited the site to purchase textiles, many of which ended up in museum and private collections (Fluck 2008, 212-213). However, Akhmim became well known as a source of Late Antique and Early Islamic textiles and the toponym Akhmim may have been given to objects, especially textiles, which did not come from the site (O'Connell 2008). Thus, it is not certain that the textiles in the NCG are from this particular site.

Dating

Dating the textiles is a complicated issue as discussed by scholars elsewhere (De Moor et al. 2007). The lack of known find contexts for these textiles makes dating extremely complicated. Previous scholarship has therefore tended to base the chronology of these textiles on iconographical and stylistic comparisons with other artefacts such as mosaics, paintings or sculptures. Since the textiles appear to have been less influenced by artistic and technical changes than other art forms, stylistic dating methods are generally vague and highly subjective (Cabrera & Rodríguez 2007, 136-37; De Moor et al. 2007, 9). Radiocarbon dating has become more common, but this method of dating is not without complications either. A high level of purity in the sample is necessary, i.e. no contamination, which is sometimes not possible. Most importantly, however, the method requires sample material and is destructive. Although sample sizes for radiocarbon dating have decreased significantly over the years, sampling is often not possible due to the state of preservation of the textiles. Owing to the state of the NCG textiles, it has not been deemed possible to take an extra sample of each for radiocarbon dating.

The database of radiocarbon-dated textiles, run by the University of Bonn, is therefore an extremely helpful tool when seeking to date fragile, archaeological textiles, since it provides easy access to reliably dated textiles from the first millennium BCE and CE (Internet source 1). Luckily, during the last few decades, a number of textiles have been radiocarbon dated, which provides expanding possibilities for comparison.

Four of the NCG textiles (ÆIN 950, 952, 953, and 955) are quite similar with regard to decoration, motifs as well as technique and colour. All four pieces correspond to parallels, which have been radiocarbon dated. Three similar medallion pieces from unknown sites in Egypt (now in the Musée du Louvre) thus provide reliable comparison for dating the NCG textiles. One is a weft-looped linen tabby with decoration in tapestry weave, dated to 1750 ±35 BP (calibrated calendar date: 2σ 211 AD [92.8%] 395 AD) (Internet source 2). A second, which is also a tapestry weave in linen and wool, is dated to 1720 ± 30 BP (calibrated calendar date: 2σ 248 AD [95.4%] 390 AD) (Internet source 3). A third, which is also a tapestry weave in linen and wool, is dated to 1610 ±25 BP (calibrated calendar date: 2σ 403 AD [95.4%] 536 AD) (Internet source 4). A final example for comparison, provided by the database, is a linen tabby with tapestry woven decoration in wool from Antinoe/Antinoupolis/Shech Abade and now in the Museu del Monasteri de Montserrat. The piece has been dated to 1770 ±40 BP (calibrated calendar date:

2σ 134 AD [93.3%] 352 AD) (Internet source 5). A likely parallel for ÆIN 949 is another piece from the Musée du Louvre. It is a tabby with decoration in tapestry weave from an unknown site in Egypt. It has been radiocarbon dated to 1560±35 BP (calibrated calendar date: 2σ 419 AD [95.4%] 574 AD) (Internet source 6). Another possible parallel for ÆIN 949 (although in a different colour) is a fragment of a breast panel in tapestry weave of a tunic, now in a private collection. It showed a radiocarbon age of 1653 ±54 BP (Paetz gen. Schieck 2007, 169).

A linen textile with brocaded, geometric pattern in wool from Arsinoë/Krokodilopolis is very similar to ÆIN 956 and 957. The brocaded parts have been radiocarbon dated to the period from 660 to 780 AD, which thus provide a possible parallel date for the two NCG pieces (Fluck & Mälck 2007, 158-59) (Internet source 7).

The two bands ÆIN 958 and 956 have been variously dated. According to Mogensen, they belong to the eighth or ninth century AD (Mogensen 1930, 79, Cat. A 626). Spies, on the other hand, suggests a date in the 14th or 15th century AD, based on similarities with tablet-woven bands used to decorate ecclesiastical vestments belonging to the period from the eighth to the 16th century AD (Spies 2000, 218). But, no radiocarbon dating has been performed, and the question must, for now, remain open.

The dates given in table 1 are the stylistic dates estimated by Mogensen, who briefly dealt with the textiles in her publication in 1930, as well as the dates provided by comparison with similar radiocarbon-dated textiles (where possible).

Dye analyses

Detailed information on the dye composition – and therefore on the original appearance and connotations of the ancient textiles – is obtainable via high performance liquid chromatography (HPLC). This method has, until now, allowed for the identification of the largest number of colourants in art and textile objects (Pozzi et al. 2012, 185). Over the last few decades, a large number of Egyptian textile finds from different sites and a wide timespan has been analysed for dyes. These have revealed more and more information about dye traditions, the provenance and the exchange of dyes, and the complexity of dye technology in Egypt (De Moor et al. 2010, 2013a; Vanden Berghe 2017b, 2016b and 2011; Van Strydonck et al. 2011; Wouters et al. 2008). The dye investigations made it clear that a very restricted palette of dye sources was used until the seventh century AD. Madder root for red, indigo or woad as a vegetal source for blue, and a luteolin-based dye plant, weld or an equivalent such as sawwort, dyer's greenweed or chamomille, for yellow being most prominent. In addition, a few identifications show the use of kermes, cochineal, lichen and muricid purple. A good knowledge of yarn and fleece dyeing, frequently using a combination of different dyes and multi-step processes with combinations of mordant and vat dyes, compensated for the limited range of dye sources. In addition, a range of metal mordants was used to produce even more shades. New dye sources such as sappan wood (also known as redwood), young fustic and Indian lac were added to the existing palette or used as substitutes after the Islamic conquest of Egypt in the middle of the seventh century AD, owing to political and economic changes and the emergence of new trade routes (Forbes 1956; Vanden Berghe, 2011, 2017b; Wouters et al. 2008). The discovery of Indian lac in Egyptian textiles was further refined to the period between the last quarter of the seventh century and the last quarter of the ninth century AD (De Moor et al. 2017).

The knowledge gained on the use of dyes and dyeing techniques in specific groups of firmly dated Egyptian textiles makes it increasingly possible to link identified dye sources to dating and/or origin, provided that the analytical technique used is highly sensitive and selective. The technique must permit a separation between chemically very closely related dye molecules. It must also permit detection of and distinction between components present in large and small quantities because the latter is often important for detailed specification of the dye source. So far, despite promising progress in the field, this is still a major challenge for many non-destructive spectroscopic techniques compared to chromatographic separation techniques. Dye identification has been performed with HPLC in all cases where sampling was possible.

Methodology

Samples of 3 mm to 5 mm of threads were taken from most of the textiles. Organic dyes were identified using HPLC with photo diode array detection (HPLC-DAD) (Vanden Berghe 2016a and 2017a). In the cases of ÆIN 950, 952, 958, 959, and 960bis it was not possible to remove fibres of the relevant hues without causing damage to the weave. ÆIN 957 was not sampled either since it is represented by its counterpart ÆIN 956. The HPLC analysis therefore included red and purple fibres from ÆIN 949, 953-956, and 960 as well as bluish-black fibres from ÆIN 1021. In a few instances, including ÆIN 960bis, blue and yellow fibres were

ÆIN 949 (Mogensen A 618) Small square decorative element (*tabula*) probably from a tunic. The woven decoration depicts a standing male figure raising his left arm in the air and holding a hare in his right hand. Branches and leaf ornaments fill the background. Measurements: H. 6.7 cm, W. 6.5 cm. Technique: Eccentric tapestry and flying shuttle technique. Date: 4th – 5th century CE (Mogensen) 14C dated parallels: 1560±35 BP (calibrated calendar date: 2σ 419 CE (95.4%) 574 CE). Dyes: Mollusc purple Fibre: Wool	
ÆIN 950 (Mogensen A 614) Oval purple medallion (*orbiculus*) richly ornamented with different patterns in white thread. Along the edge of the medallion is a border in a wave pattern. Measurements: W. 30.8 cm, H. 25 cm. Technique: Eccentric tapestry and flying shuttle technique. Date: 3rd – 4th century CE (Mogensen) 14C dated parallels: 1: 1750 ±35 BP (calibrated calendar date: 2σ 211 CE (92.8%) 395 CE). 2: 1720 ± 30 BP (calibrated calendar date: 2σ 248 CE (95.4%) 390 CE). 3: 1610 ±25 BP (calibrated calendar date: 2σ 403 CE (95.4%) 536 CE). 4: 1770 ±40 BP (calibrated calendar date: 2σ 134 CE (93.3%) 352 CE). Dyes: N/A Fibre: Wool	
ÆIN 952 (Mogensen A 619) Purple, circular medallion (*orbiculus*) sewn onto a support of yellowish linen fabric. It is not possible to determine whether the current mounting is original. Measurements: W. 15 cm, H. 15.5 cm. Technique: Weft-faced, plain weave with decoration in flying shuttle technique. Date: 3rd – 4th century CE (Mogensen) 14C dated parallels: 1: 1750 ±35 BP (calibrated calendar date: 2σ 211 CE (92.8%) 395 CE). 2: 1720 ± 30 BP (calibrated calendar date: 2σ 248 CE (95.4%) 390 CE). 3: 1610 ±25 BP (calibrated calendar date: 2σ 403 CE (95.4%) 536 CE). 4: 1770 ±40 BP (calibrated calendar date: 2σ 134 CE (93.3%) 352 CE). Dyes: N/A Fibre: N/A	

Table 1: Description of the textiles in the Ny Carlsberg Glyptotek collection, Copenhagen, Denmark (Images: Pernille Klemp)

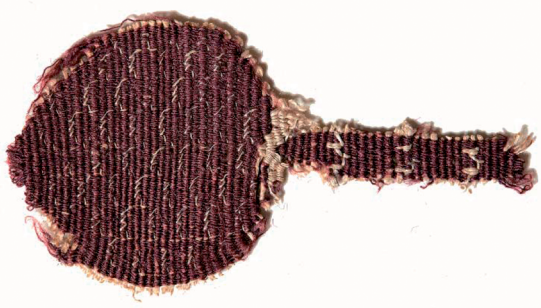
ÆIN 953 (Mogensen A 616) Dark purple, square piece of decoration (tabula) from a tunic. Central square decoration made of fine windings of white thread. Along the edge, a wide border made in a similar pattern forms a fine frame. Measurements: W. 27 cm, H. 28 cm. Technique: Weft-faced, plain weave with decoration in flying shuttle technique. Date: 3rd – 4th century CE (Mogensen) 14C dated parallels: 1: 1750 ±35 BP (calibrated calendar date: 2σ 211 CE (92.8%) 395 CE). 2: 1720 ± 30 BP (calibrated calendar date: 2σ 248 CE (95.4%) 390 CE). 3: 1610 ±25 BP (calibrated calendar date: 2σ 403 CE (95.4%) 536 CE). 4: 1770 ±40 BP (calibrated calendar date: 2σ 134 CE (93.3%) 352 CE). Dyes: Madder. Fibre: Wool	
ÆIN 954 (Mogensen A 620) Purple band (clavus) from a tunic. Meander-shaped decoration in fine, white yarn. Measurements: W. 5.7 cm, L. 31.7 cm. Technique: Weft-faced, plain weave with decoration in flying shuttle technique. Date: 4th – 5th century CE (Mogensen) 14C dated parallels: N/A Dyes: Greyish purple: indigo/woad and madder. Fibre: Wool	
ÆIN 955 (Mogensen A 617) The small fragment has the shape of a pomegranate. It originally belonged to the decoration of a tunic. Quite fine, white yarns are woven onto the violet background. A stalk completes the leaf. Measurements: W. 4.9 cm, H. 9.1 cm. Technique: Weft-faced, plain weave with decoration in flying shuttle technique. At the touch point of shaft and medallion is a small area of eccentric tapestry. Date: 4th – 5th century CE (Mogensen) 14C dated parallels: 1: 1750 ±35 BP (calibrated calendar date: 2σ 211 CE (92.8%) 395 CE). 2: 1720 ± 30 BP (calibrated calendar date: 2σ 248 CE (95.4%) 390 CE). 3: 1610 ±25 BP (calibrated calendar date: 2σ 403 CE (95.4%) 536 CE). 4: 1770 ±40 BP (calibrated calendar date: 2σ 134 CE (93.3%) 352 CE). Dyes: indigo/woad and madder. Fibre: Wool	

Table 1 (Continued): Description of the textiles in the Ny Carlsberg Glyptotek collection, Copenhagen, Denmark (Images: Pernille Klemp)

ÆIN 956 (Mogensen A 621) Rhomboid fragment with geometric star-shaped ornament in red and yellow. Measurements: W. 16.5 cm, H. 15.4 cm. Technique: Plain weave with brocaded decoration. On top of the ground weave a coloured pattern weft is inserted after every second change of the sheds. Date: 7th – 8th century CE (Mogensen) 14C dated parallels: 660 to 780 CE Dyes: Greenish blue: indigo/woad and a yellow dye source (weld, sawwort, dyer's greenweed or chamomile). Orange/red: madder. Fibre: Wool	
ÆIN 957 (Mogensen A 622) Very similar fragment to the above, but less well-preserved. Probably originally part of the same textile. Measurements: W. 19.5 cm, H. 15.8 cm. Technique: Plain weave with brocaded decoration. Date: 7th – 8th century CE (Mogensen) 14C dated parallels: 660 to 780 CE Dyes: (see ÆIN 956). Fibre: N/A	
ÆIN 958 (Mogensen A 625) Band with geometric decoration in many colours. Measurements: W. 2.5 cm, L. 48.5 cm. Technique: Tablet weaving. The decoration is made in supplementary weft brocading (broché). Number of tablets: 34 (7 in each border, 20 in central section). Brocade pattern: On front only. Borders: Straight lines. Centre section: Diamond-filled triangles separated by areas of 3 diagonals. Warp: White linen: S-spun, Z-plied. Wool: S-spun, single thread (not plied). Weft (ground): White linen, S-spun, single thread (not plied). Weft (brocade): Borders brocaded with ground weft; centre section brocaded with dyed wool. Wool: loose to no spin, probably 2-ply. Date: Mogensen suggests a date in the 8th or 9th century CE, while Spies suggests a date in the 14th or 15th century CE (Spies 2000, 218). 14C dated parallels: N/A Dyes: N/A Fibre:N/A	

Table 1 (Continued): Description of the textiles in the Ny Carlsberg Glyptotek collection, Copenhagen, Denmark (Images: Pernille Klemp)

ÆIN 959 (Mogensen A 626) Identical band to the above. The two bands originally belonged together. Measurements: W. 2.5 cm, L. 48.5 cm. Technique: Same as ÆIN 958. Date: Mogensen suggests a date in the 8th or 9th century CE, while Spies suggests a date in the 14th or 15th century CE (Spies 2000, 218). 14C dated parallels: N/A Dyes: N/A Fibre: N/A	
ÆIN 960 (Mogensen A 624) Fragment with woven decoration in the shape of a red leaf with a stem. A female figure, possibly a mermaid, rendered in different colours is depicted inside the leaf. Measurements: W. 14 cm, H. 20 cm. Technique: Tapestry weave with eccentric wefts and lazy lines. Date: 6th – 7th century CE (Mogensen) 14C dated parallels: N/A Dyes: Orange/red: madder; Dark blue: indigo/woad and madder; Yellow: madder and a yellow dye source (weld, sawwort, dyer's greenweed or chamomile). Fibre: Wool	
ÆIN 960bis (Mogensen A 623) Small, oval medallion (orbiculus). The symmetric pattern is unusual for late Roman textiles. Measurements: W. 10.3 cm, H. 7.7 cm. Technique: Eccentric tapestry (yellow warp and blue weft). Date: 5th century CE (Mogensen). 14C dated parallels: N/A Dyes: indigo/woad and lichen dyes (?). Fibre: Wool	
ÆIN 1021 (not included in Mogensen) Large rectangular fragment with a dark, almost black decoration in the shape of a swastika. Measurements: W. 53 cm, H. 33 cm. Technique: Plain weave with loop piling. The dark stripe is weft-faced, plain weave with three threads in every shed. The remaining part of the textile is woven in 1/1 plain weave. The decoration is brocaded into the weave with simple weft loops. Date: unknown 14C dated parallels: N/A Dyes: Indigo/woad and small amount of madder. Fibre: Wool	

Table 1 (Continued): Description of the textiles in the Ny Carlsberg Glyptotek collection, Copenhagen, Denmark (Images: Pernille Klemp)

Inv. no.	Colour	Dye composition
ÆIN 949	Purple	52 6-monobromoindigotin, 27 indigotin, 21 6,6'-di brominated indigotin (DMSO, 255 nm) 39 6-monobromoindigotin, 34 indigotin, 27 6,6' -di brominated indigtotin (DMSO, 288 nm)
ÆIN 953	Red	81 purpurin, 18 alizarin, 1 munjistin (HCl, 255 nm)
ÆIN 954	Greyish blue	69 indigotin, 20 alizarin, 10 purpurin, 1 indirubin (DMSO, 255 nm) 63 purpurin, 37 alizarin (HCl / DMSO, 255 nm)
ÆIN 955	Red	58 indigotin, 34 alizarin, 8 purpurin (DMSO, 255 nm) no dyes detected (HCl) [Note: extremely small sample size]
ÆIN 956	Greyish blue	92 indigotin, 2 indirubin, 2 luteolin, 2 luteolin-7-0-glucoside, 2 apigenin-7-0-glucoside (DMSO, 255 nm)
ÆIN 956	Orange red	51 purpurin, 46 alizarin, 3 munjistin, 1 anthragallol (HCl, 255 nm)
ÆIN 960	Blue	36 alizarin, 32 indigotin, 29 purpurin, 2 luteolin, 1 anthragallol (HCl, 255 nm)
ÆIN 960	Red	91 purpurin, 9 alizarin (HCl, 255 nm)
ÆIN 960	Yellow	38 luteolin, 38 alizarin, 24 purpurin (HCl, 255 nm)
ÆIN 960b	Blue	100 indigotin (DMSO, 255 nm and 288 nm) 100 indigotin (HCl, 255 nm) 98 indigotin, 2 indirubin (HCl, 288 nm)
ÆIN 1021	Bluish black	85 indigotin, 8 alizarin, 5 purpurin, 2 indirubin (DMSO, 255 nm) 66 purpurin, 18 alizarin, 16 indigotin (HCl, 255 nm)
ÆIN 1021	Black	8 munjistin, 34 alizarin, 6 indigotin, 52 purpurin (DMSO, 255 nm)

Table 2: HPLC-DAD results. Percentages of the detected dye molecules in the acidic (HCl) or solvent (DMSO) extract, calculated after the relative ratios of the peak areas measured at the indicated wavelength (nm)

included in the analysis for comparison. Prior to the chromatographic analysis, the samples were examined under a microscope in order to determine the colour of the fibres and to remove potential contamination.
The chromatographic analyses were done with HPLC equipment Alliance and photo diode array detector from Waters (USA). Identification of the dye molecules is done based on comparison of both absorbance spectrum and retention time with spectra from the in-house reference library of natural and synthetic organic dyes. The colourants were recovered from the fibres using either strong acidic extraction with hydrochloric acid whereas dimethyl sulfoxide was used in particular for the bluish and black samples. A detailed analytical protocol for this is published elsewhere (Vanden Berghe et al. 2009).

Results

The dye molecules identified after chromatographic analysis are listed in table 2. The detection of the anthraquinone dye compounds alizarin, purpurin, anthragallol and munjistin is indicative of the use of the roots of the madder plant (*Rubia tinctorum* L.) as a red dye source. Indigotin and indirubin are the marker compounds for blue dyeing with indigo (*Indigofera sps.*) or woad (*Isatis tinctoria* L.). They are formed through fermentation from the precursors naturally occurring in these plants (Gulmini et al. 2013, 137). It is not

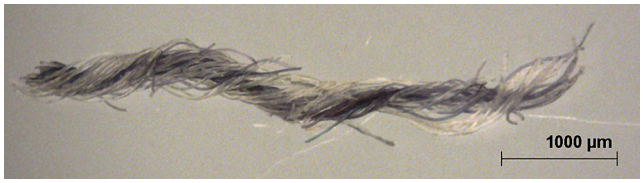


Fig. 2: Micrograph of purple thread from ÆIN 949 (Image: images@KIK-IRPA)

possible to distinguish between the two plant sources since indigotin is the main chromophore in both of them (Pozzi et al. 2012, 189). Thus, the HPLC results can only show the presence of indigotin, but not the origin, making it impossible to distinguish between indigo and woad from the dye composition. When brominated indigoid dye molecules are detected, an indigoid source of animal origin, known as muricid purple, has been applied. Luteolin, apigenin and their glucosides are flavonoid compounds suggesting the use of a yellow dye source, such as weld (*Reseda luteola* L.), sawwort (*Serratula tinctoria* L.), dyer's greenweed (*Genista tinctoria* L.), chamomile (*Anthemis sps.*) or another equivalent.

Microscopic examination of the purple yarn from ÆIN 949 shows that the thread is composed of white-undyed, and blue-dyed fibres indicative for yarn production with a mixture of undyed and fleece-dyed fibres (fig. 2). The HPLC analyses revealed that the blue fibres were dyed with real purple from molluscs. The red/brown yarns from ÆIN 953 are dyed with madder, while the dark red/purple threads from ÆIN 955 were achieved by dyeing with a combination of indigo/woad and madder. Fragment ÆIN 954 is made of more greyish-purple threads, dyed with a combination of indigo/woad and madder. From fragment ÆIN 956, greenish-blue and orange/red yarns were investigated. The greenish-blue is the result of the use of a combination of indigo/woad and a yellow dye source, which might be weld, sawwort, dyer's greenweed or chamomile. The orange red is obtained with madder.

Fragment ÆIN 960 contains a pattern made of orange/red, dark blue and yellow threads. Madder was applied for the red colour, indigo/woad and madder to produce the blue shade and the yellow was obtained with the combination of madder and a yellow dye source again either weld, sawwort, dyer's greenweed or chamomile.

By examination of the bluish fibres from fragment ÆIN 960bis under magnification, they appear to be composed of blue, reddish and uncoloured fibres suggesting yarn production with a mixture of different fleece-dyed and undyed fibres (fig. 3). The identified dye compounds of the two analysed extracts (table 2) only refer to dyeing with woad/indigo, while any evidence of a red dye compound is lacking. Moreover, the red dye is extremely light sensitive, as complete fading of the red colour is observable during the microscopic examination of the sample. As a result, it can be suggested that lichen dyes might have been used.

From fragment ÆIN 1021, dark bluish and black threads were analysed. The dark, bluish black fibres have been dyed with woad or indigo and a minor amount of madder. Dye compounds from the same dye sources are also present in the black threads but the small amounts detected in the black excludes that the black colour is the result of dyeing alone. Possibly condensed tannin not detectable with HPLC was added to produce the dark shade but it is even more likely that naturally pigmented wool fibres were used.

The identified dye sources present in the Late Antique textiles under investigation are madder, indigo or woad and weld or an equivalent yellow dye such as sawwort, dyer's greenweed or chamomile. Several yarns described as purple, blue, greyish or blackish-blue and red are dyed by the combination of a vegetal indigoid dye, top dyed with red mordant dyes from the roots of madder (*Rubiaceae* family), the most common way to create purple shades in the Roman and later "Coptic" periods. The purple yarns from textile ÆIN 960bis were dyed with indigo/woad together with lichen. One textile fragment, textile ÆIN 949, is created with a purple configuration made of "true purple", obtained by the use of seashells. Such muricid purple dyeing is identified rarely in Egyptian textiles and can be considered as direct

Fig. 3: Micrographs of fading red colour in blue thread from ÆIN 960bis. Top: Colours observed initially. Bottom: The red colour is no longer visible after five minutes (Images: images@KIK-IRPA)

evidence of the extremely high value of that textile fragment (Vanden Berghe 2011; De Moor et al. 2010; Wouters 2009; Wouters et al. 2008).

Fibre analyses

Although the coloured yarns in these kinds of weaving are usually made from wool, nine textiles were selected for fibre analyses to verify this. In the cases of ÆIN 952, 958, 959 it was not possible to remove fibres of the relevant hues without causing damage to the weave. ÆIN 957 was not sampled since it is represented by its counterpart ÆIN 956. Thus, the fibre analysis included coloured fibres from ÆIN 949, 950, 953-956, 960, and 960bis, as well as from ÆIN 1021. Two samples were taken from ÆIN 956, one of the blue fibres and one of the red fibres, as well as from ÆIN 960. Thus, 1 mm to 2 mm of thread was cut from each of 11 yarns in nine textiles. The analyses were carried out with a Primo Star iLED microscope from Zeiss equipped with and AxioCam ERc5s camera. The fibres from each of the selected yarns were spread on to microscope slides using liquid paraffin for mounting and viewed in longitudinal sections using a 10 x objective (circa 100 x magnification) and digitally photographed for

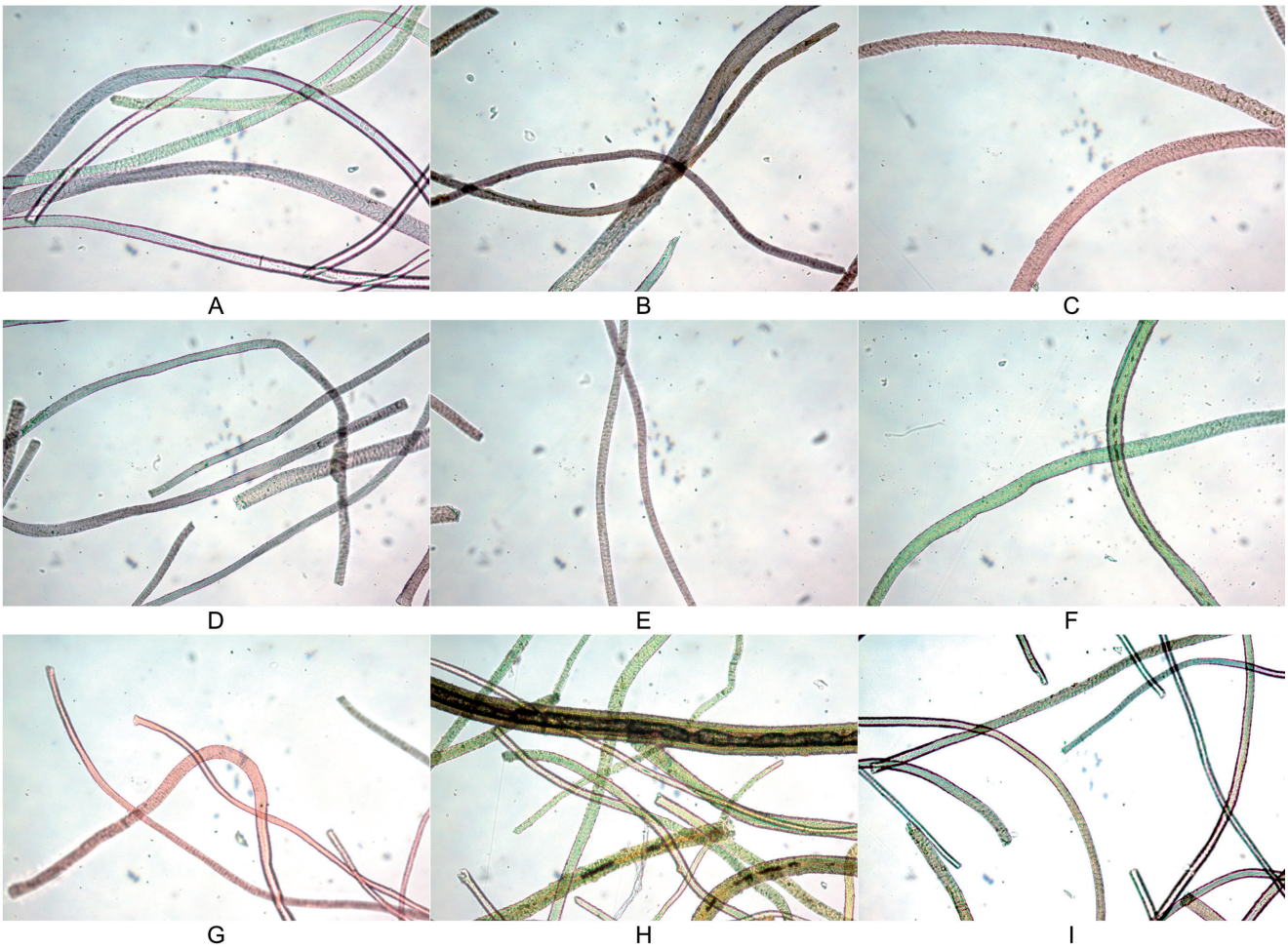


Fig. 4: Micrographs of fibres (100 x magnification). A) ÆIN 949 purple sample: The fibres appear uniform and with a clearly visible scale layer. Different nuances of blue, green and purple can be distinguished. The light green fibres are probably the undyed fibres observed in the dye analyses. B) ÆIN 950 blue sample: Different shades of blue and purple can be seen in the fibres. The fibre diameters appear slightly uneven. C) ÆIN 953 red sample: The fibres have slightly pink nuances. They have a visible scale layer and a round shape. The fibre diameters appear slightly uneven. D) ÆIN 954 blue sample: The fibres have bluish-purple nuances. They are uniform and have a clearly visible scale layer. E) ÆIN 955 red sample: The fibres appear slightly pink. They are uniform and have a visible scale layer. F) ÆIN 956 blue and red samples: The blue fibres appear greenish and with discontinuous medulla. The red fibres are uniform and in orange nuances. G) ÆIN 960 blue and red samples: The blue fibres have a visible scale layer and the fibres are damaged. The red fibres appear with pink and orange nuances. The fibre diameters vary. H) ÆIN 960bis blue sample: The fibres have green and yellowish-green nuances. The fibre diameters vary and continue as broken medullas are visible. I) ÆIN 1021 blue sample: The fibres have green and purple nuances (Images: Irene Skals)

documentation. All samples were identified as wool (table 1). This identification is evident from the often very visible scale structure and the roundish shape of the fibres (fig. 4).

Conclusion and future perspectives

Although the NCG collection is small the information that has been extracted from the technical and instrumental analyses is a valuable addition to the general knowledge about this particular group of textiles. The lack of archaeological methodology during their excavation has meant a great loss of information about the society which now has to be extruded by analyses of the preserved fragments.

A more exact dating of the textiles is of great interest since very few late antique textiles have an exact date. Furthermore, knowledge about the dye sources and dyeing practices is most helpful together with other material-based characteristics, such as the weaving technology and iconography, to further situate the individual finds in a broader historical context. To date, there is an agreed understanding of the most common dye sources in Egyptian textiles, but knowledge about the less common dye sources is based on only a few detections. This merits further study by widening the range of analysed textiles. This will improve and refine knowledge about the possible relationship between the use of a dye and a particular period or economic situation, which may eventually facilitate dye analyses as an indirect dating method as was recently the case with Indian lac (De Moor et al. 2017).

It would be highly relevant to compare the HPLC results with non-invasive techniques for detecting dyestuffs, particularly colour spectrometry. A study by Fuchs and Paetz gen. Schieck performed on 19 late Roman textiles from Egypt in the collections of the Deutsches Textilmuseum in Krefeld (Germany) has demonstrated how dyestuff s can be detected with colour spectrometry also known as VIS spectrometry. This non-invasive method records how a sample reflects incident light in the range of 380 nm to 730 nm (visible light). Computer software allows the spectrum to be plotted with its first derivation and the result is visualised in a diagram, which is compared to a reference database. The method is efficient in certain cases, but has its limitations: black and white are not detectable by the instrument, and yellow dyes cannot be distinguished on textiles. In addition, the identification of dye mixtures is another major challenge. The species of scale insects cannot be identified from the red shades. The study was able to detect the following dyestuffs: shellfish purple, cochineal, madder, indigo, and possibly safflower, sawwort, and weld (Fuchs & Paetz gen. Schieck 2011). Further ways forward in the study of the textiles could be to include the identification of mordants through either examination with micro-invasive SEM-EDX, which is an accepted technique for such identifications, or through examinations with micro x-ray fluorescence spectroscopy (μXRF), which is a non-invasive technique suitable for the detection of inorganic compounds. Thus, Zvi Koren has recently suggested an XRF method for the identification of muricid purple based on the detection of bromine (Koren 2016). However, bromine has also been detected in the presence of lichen dyes, and thus, this method can only be used in combination with the detection of organic indigoid dye compounds to provide evidence for the presence of muricid purple (Aceto et al. 2015). Moreover, it is possible that XRF could be useful for the identification of iron-based mordants (Pozzi et al. 2012, 187). It should be noted, however, that there are certain limitations to this technique for the detection of light elements such as aluminium, which is important for the identification of textiles mordanted with alum. High-resolution x-ray images are a further non-destructive method to consider in the study of ancient textiles. Thus, a study of 39 Late Antique Egyptian textiles in the collections of the Museum of Montserrat, Barcelona (Spain), illustrated how x-ray images makes it possible to follow the weft and warp threads on a computer screen and gain data and insights into the ways of working the loom. Furthermore, the study showed how x-rays can illustrate, for example, the use of substances as consolidants in the fibres (Borrego & Vega 2015, 376-378). The same study included multispectral analyses involving images taken in the visible and near infrared ranges (FIR), and by ultraviolet fluorescence (UVF). This study showed that UVF photography can assist in differentiating linen from wool fibres if they are undyed (wool presented a bluish fluorescence, linen a pinkish one) as well as revealing stylistic details, which were no longer visible to the naked eye (Borrego & Vega 2015).

A further step could be to test the use of photoluminescence photography as a non-invasive method for the identification of red dyes. The efficiency of photographic techniques for detecting colourants in archaeological textiles (although not specifically Egyptian) was suggested by a study, employing ultraviolet and infrared photography (Baldia & Jakes 2007). The study showed that photographic techniques can determine the exact nature of the applied colourants on cellulosic or proteinaceous textiles, thus providing a means to select sampling sites of clearly different chemical compositions based on differences

indicated in the respective images. Photoluminescence is a form of luminescence (emission of light) following photoexcitation (excitation by photons) of a shorter wavelength than that of the emission (see, for example, Dyer et al. 2013 for the use of multispectral imaging). A combination of UV-induced visible fluorescence (UVF) photography and visible-induced visible (Vis-Vis) luminescence photography could be interesting to test in relation to ancient textiles. UVF photography is widely used in the examination of artefacts to reveal the presence and spatial distribution of red, organic lakes which fluoresce in a characteristic coral-red (De la Rie 1982; Costello & Klausmeyer 2014; Grant 2000a; 2000b; Dyer et al. 2013). Vis-Vis luminescence, on the other hand, is a very recently published technique aimed at detecting and mapping organic, red lakes (Kakoulli et al. 2017). It could be of great interest if such photographic, non-invasive techniques could be employed as a preliminary indication of dyes, since this would allow a more targeted sampling strategy.
A similar non-invasive study has recently been carried out on the collection of ancient Egyptian textiles from the Museo Egizio in Torino (Italy). This collection was analysed with fibre optics UV-Vis diffuse reflectance spectrophotometry (FORS) and portable fibre optics fluorimetry (FL), which proved to be a very useful technique for the identification of dyes (Gulimini et al. 2016). Other authors have considered Late Antique Egyptian textiles as case studies for the comparison of UV-Vis, fluorescence, and mass-spectrometry detectors in HPLC detection of natural dyes (see, for example, Szostek et al. 2003).

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