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**They'll Never Be Royals:
The “Purple” Textiles of Fag el-Gamous**

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I. Introduction:

Excavations at the Fag el-Gamous necropolis have unearthed a unique collection of textile fragments, among which are some beautifully dyed pieces, including several featuring

purple threads.¹ The purple threads used in the textiles come in a variety of hues, suggesting different dye sources for the threads. In the ancient world, the source for true, enduring purple dye came from the sea snail, Murex.² This dye was highly prized, very expensive, and was frequently used for royal garments.³ Because of its desirable nature, purple dye was frequently imitated with mixtures of blue and red dyes, such as indigo (plant genus *Indigofera*) for blue and madder (plant genus *Rubia*) for red or cochineal (insect family *Margarodidae*).⁴ Due to

¹ C. Wilfred Griggs, "Excavating a Christian Cemetery Near Seila, in the Fayum region of Egypt," in *Excavations at Seila, Egypt*, C. Wilfred Griggs, Wm. Revell Phillips, J. Keith Rigby, Vincent A. Wood, Russell D. Hamblin, eds. (Provo, Utah: Religious Studies Center, Brigham Young University, 1988), 78.

² Charlene Elliot, "Purple Past: Color Codification in the Ancient World," *Law & Social Inquiry* 33/1 (2008): 177; Zvi C. Koren, "Archaeo-chemical analysis of Royal Purple on a Darius I stone jar," *Microchimica Acta* 162 (2008): 381-382; David S. Reese, "Palaikastro Shells and Bronze Age Purple-Dye Production in the Mediterranean Basin," *The Annual of the British School at Athens* 82 (1987): 203.

³ Charlene Elliot, "Purple Past: Color Codification," 179-180, 183; Lloyd B. Jensen, "Royal Purple of Tyre," *Journal of Near Eastern Studies* 22/2 (1963): 104; Robert R. Stieglitz, "The Minoan Origin of Tyrian Purple," *The Biblical Archaeologist* 57/1 (1994): 46; W. Nowik, R. Marcinowska, K. Kusyk, D. Cardon, M. Trjanowicz, "High Performance liquid chromatography of slightly soluble brominated indigoids from Tyrian purple," *Journal of Chromatography A* 1218 (2011): 1244; Harald Bohmer and Recep Karadag, "New Dye Research on Palmyra Textiles," *Dyes in History and Archaeology* 19 (2003): 90.

⁴ Zvi C. Koren, "A New HPLC-PDA Method for the Analysis of Tyrian Purple Components," *Dyes in History and Archaeology* 21 (2008): 26; Max Saltzman, "Identifying Dyes in Textiles," *American Scientist* 80/5 (1992): 479; Dominique Cardon, Witold Nowik, Hero Granger-Taylor, Renata Marcinowska, Katarzyna Kusuk, and Marek Trojanowicz, "Who Could Wear True Purple in Roman Egypt? Technical and Social Considerations on Some New Identifications of Purple from Marine Molluscs in Archaeological Textiles," *Purpureae Vestes III Symposium Internacional sobre Textiles y Tintes del Mediterraneo en el mundo antiguo*, (Nápoles, 13 al 15 de noviembre, Carmen Alfaro Giner, Jean-Pierre Brun, Philippe Borgard, Raffaella Pierobon-Benoit, Centre Jean Bérard, eds. (València: Universitat de València, 2011), 199-200; Naama Sukenik, David Iluz, Orit Shamir, Alexander Varvak, and Zohar Amar, "Purple-Dyed Textiles From Wadi Murabba'at: Historical, Archaeological, and Chemical Aspects," *Archaeological Textiles Review* 55 (2013): 50; Lloyd B. Jensen, "Royal Purple of Tyre," 111; Masanori Sato and Yoshiko Saski, "Blue and Purple Dyestuffs Used for Ancient Textiles," *Dyes in History and Archaeology* 19 (2003): 101; Jan Wouters, Ina Vanden Berghe, Ghislaine Richard, Rene Breniaux, and Dominique Cardon, "Dye Analysis of Selected Textiles from Three Roman Sites in the Eastern Desert of Egypt: A Hypothesis on the Dyeing Technology in Roman and Coptic Egypt," *Dyes in History and Archaeology* 21 (2008): 11.

the variety of hues present in [page 208] this collection, it seems likely that the people using the cemetery at Fag el-Gamous were using imitation purple for their garments. This project determined what, if any, proportion of true purple was used in the textiles recovered from the necropolis and how the presence (or absence) of true purple informs our understanding of the ancient Egyptian population that used this cemetery.

II. Purple Dye:

Purple in antiquity was seen as a luxury color. It was worn by the highest members of society and, in some periods, was only allowed to be worn by the emperor.⁵ In contrast, indigo is chemically similar to shellfish purple, but never cost as much nor reached such a glorified status.⁶

According to Dominique Cardon, purple is defined as “a violet dye, ranging in shade from purplish-red to violet-blue, composed of colorants that are closely related chemically to the plant indigo, and obtained from various marine mollusks at present all classified in the Muricidae family.”⁷ Tyrian purple (6,6'-dibromoindigotin) is a violet-red color that is derived from the hypobranchial gland of mollusks. The color develops after the death of the animal from a colorless precursor.⁸ These precursors (chromogens) are “water-soluble, colourless sulphate esters of indoxyl.”⁹

[page 209]

A. History:

⁵ Dominique Cardon, *Natural Dyes: Sources, Tradition, Technology and Science* (London: Archetype, 2007), 553.

⁶ Ibid., 551.

⁷ Ibid., 553.

⁸ Ibid., 554.

⁹ Ibid., 555.

Though largely associated with the Levant (especially Tyre), the first evidence of using mollusks to produce purple comes from Crete; large piles of mollusk shells have been discovered there that date between 1800 and 1600 BC.¹⁰ Many Phoenician sites along the coast of the Levant have potsherds with molluskan purple residue with the earliest evidence of the dying process dating to the 13th or 12th century BCE. Tyre, a major Phoenician city, is one of these sites and is the origin of the “Tyrian” moniker for the true purple dye.¹¹

Beginning in the first millennium BCE, purple was established under the Assyrians as a symbol of wealth. This subsequently carried over into other civilizations. Purple did not become associated with prestige in Egypt, however, until the time of the Ptolemies.¹²

For the Romans, purple did not become a status symbol until about the third century BCE. Rome started a thirst for purple that had never before been seen. Rulers dictated who could wear purple and in what qualities.¹³ The most luxurious types of purple were reserved for the emperor. *Purpurae insania* (purple mania) reached its peak in the second century CE. The variety of purples available ranged from expensive “true purple” derived from large quantities of mollusks to cheap imitations from plant dyes. Egyptian and Gaulish dyers were specialists at imitating purple.¹⁴

Under Diocletian and Constantine, official measures were put in place regarding the expensive purple. The higher quality dyes were even classified as “sacred purple.” While the

¹⁰ Ibid., 571.

¹¹ Zvi C. Koren, “Archaeo-chemical analysis of Royal Purple on a Darius I stone jar,” *Microchimica Acta* 162 (2008): 382.

¹² Cardon, *Natural Dyes*, 572.

¹³ Ibid., 573.

¹⁴ Ibid.

imperial court enjoyed the luxurious purple, customers from all social classes had access to imitation purple.¹⁵

B. Dye Production:

A large number of mollusks was required to produce this purple dye. Research shows that on average one mollusk yields about 1.5 grams of dye. In order to dye three kilograms of wool more than 1000 mollusks would be required.¹⁶

To produce the purple dye, the shell of the mollusks must be broken and the hypobranchial gland must be ruptured. When this occurs, the cells in the gland die and release their contents. This results in the precursors coming into [page 210] contact with enzymes—aryl-sulphatases. The purple precursors then undergo one of two reactions depending on the type of mollusk. For one type, oxygen reacts with indoxyl derivatives to form tyriverdins which are converted to purple when exposed to light. In the other type of reaction, indoxyl derivatives form indigoid colorants quickly with exposure to oxygen.¹⁷

In antiquity the technique for extracting and processing the dye was written about by few authors. Three of the most helpful are Aristotle, Vitruvius, and Pliny the Elder, although Pliny's account is not sufficient to reconstruct the entire process. According to these writers, the first part of the process was to collect the secretions from the hypobranchial glands. Vitruvius wrote that the shells were broken open and the glands were pounded in mortars with honey. Salt was also added to the glands in proportion of about .570kg of salt to 34.2kg of purple mixture. The salt and gland mixture was left to macerate for no more than three days. Afterward the mixture was diluted with water. The amount of water varies between accounts. One account says that

¹⁵ Ibid., 574.

¹⁶ Naama Sukenik et al., "Purple-Dyed Textiles from Wadi Murabba'at," 47.

¹⁷ Cardon, *Natural Dyes*, 555.

there should be one amphora (25.92 liters) of water for 50 pounds of the gland mixture.¹⁸

Another source says that there should be 2,952 liters of water added to two kilograms of the gland mixture. After the water was added the mixture was heated and after about ten days the mixture was filtered and tested with ungreased sheep's wool. If the dye was ready, the rest of the wool would be added and left for five hours.¹⁹

Experimental archaeology has tried to replicate the process and has found that the record is incomplete. Purple dye has been successfully produced, but the vat technique of antiquity still remains a mystery.²⁰

C. Mollusks:

All mollusks used to produce purple dye belong to the Muricidae family of sea snails. Muricidae are carnivorous and feed on small worms and crustaceans. They are also known to feed on their own species. The size of Muricidae shells varies in size from about 6mm in length to 20-30cm.²¹ There are about 1,300 species of Muricidae throughout the world, though mostly found in warm or temperate climates. It is unknown if all are capable of producing purple, and very few were actually used for that purpose.²²

In the Mediterranean, three species became famous in the ancient world for producing purple dye: *Bolinus brandaris*, *Hexaplex trunculus* and *Stramonita* [page 211] *haemastoma*.²³

¹⁸ Ibid., 559.

¹⁹ Ibid., 560.

²⁰ Ibid., 562.

²¹ Ibid., 565.

²² Ibid., 566.

²³ Ibid.

Bolinus brandaris yields Tyrian purple. *Hexaplex trunculus* yields a blue-purple.²⁴ *Stramonita haemastoma* yields a red-violet similar to Tyrian purple.²⁵

D. Purple in Egypt:

In Egypt, purple was created from a two-step process using indigo and madder (a red, plant based dye). This purple, while “false,” was still of a high quality and became characteristic of purple dye in Egypt.²⁶ Few examples of Tyrian purple have been found in Egypt, indicating that this more economic method was wide spread, especially in the first millennium AD. When Tyrian purple has been found, it has been limited to small decorative elements because of the expensive nature of the dye.²⁷ Instead, the most common dyes used in Coptic textiles were madder, kermes (insect, *Kermes vermilio*), Armenian cochineal, and lac dye (insect, *Laccifer lacca*) for red and indigo for blue.²⁸

E. Indigo and Madder

Indigo is a blue dye used in combination with other dyes to create purple. While created synthetically in modern times (it is used for denim jeans), the original source of the dye was

²⁴ Ibid., 579.

²⁵ Ibid., 583.

²⁶ De Moor et al., “Radiocarbon Dating and Dye Analysis of Roman Linen Tunics and Dalmatics with Purple Coloured Design,” 44; Lloyd B. Jensen, “Royal Purple of Tyre,” 111.

²⁷ De Moor, et al., “Radiocarbon Dating and Dye Analysis of Roman Linen Tunics and Dalmatics with Purple Colored Design,” 45.

²⁸ Marek Trojanowicz, Jowita Orska-Gawrys, Izabella Surowiec, Bogdan Szostek, Katarzyna Urbaniak-Walczak, Jerzy Khel, and Marek Wrobel, “Chromatographic Investigation of Dyes Extracted from Coptic Textiles from the National Museum in Warsaw,” *Studies in Conservation* 49/2 (2004): 116.

plant-based.²⁹ Madder is a red dye that originates from several different plant species. It has also been manufactured synthetically and has since fallen out of use.³⁰

IV. The Textile Collection of Fag el-Gamous:

The textile samples used in this study draw from several seasons of excavation at Fag el-Gamous. Excavation years include: 1987, 1992, 1994, 1998, and 2000. [page 212] Figure 1 shows a map of the locations for each season; squares with textiles used in this study are circled in purple. Textiles were selected for study if it appeared that purple threads were used in the fragment. All samples were woolen threads. Although linen is the most common material used in burials at Fag el-Gamous, the material does not hold dye well and is usually left undyed. This study was as exhaustive as possible in trying to find all available³¹ fragments with purple threads. They span the life of the surface and 3-meter-deep shafts in the cemetery ranging in use from 100 BC through 700 AD. Some fragments were excluded if it appeared that in trying to extract a thread more harm would be done to the fragment in the process than would be beneficial to the study. [page 213] The samples were also limited to what was available in the collection at Brigham Young University.

Not all samples are immediately identified as purple. Some look black, blue, or even brown. These were included in the study with the hopes of providing data to aid future field and lab identification of color.

²⁹ Encyclopædia Britannica, s.v. “Indigo,” accessed April 13, 2015, <http://www.britannica.com/EBchecked/topic/286171/indigo>.

³⁰ Encyclopædia Britannica, s.v. “Madder,” accessed April 13, 2015, <http://www.britannica.com/EBchecked/topic/355682/madder>.

³¹ All textiles were brought to Brigham Young University by formal and official agreement with the Supreme Council of Antiquities.

Figure 1 - Location of Textiles in this Study; Grid represents the cemetery; purple circles indicate squares that yielded textiles used in this study.

V. Methods of Dye Analysis:

Dye analysis was conducted according to the process described in W. Nowik, R. Marcinowska, K. Kusyk, D. Cardon, and M. Trojanowicz, "High performance liquid chromatography of slightly soluble brominated indigoids from Tyrian purple," *Journal of Chromatography A* 1218 (2011): 1244-1252.

The first step was to collect the samples. The experiment requires 1–3 mg of textile sample for analysis; this is approximately 1–2cm of a single thread. A few threads from each textile sample were collected and put in plastic screw-top vials. As it was not feasible to weigh the textile sample before removing a thread, a more visual standard was applied for collection. Sometimes, this was a single thread approximately 1–2cm in length, other times it was several smaller pieces that resulted in a comparable measurement.

Once the threads were collected, 0.5 mL of dimethylsulfoxide (DMSO) was added to the vial. The vial with the textile sample and DMSO was incubated in a water bath at 80° C for 15 minutes.

The solution was then extracted out of the plastic vial using a pipette and filtered using a syringe and filter into glass vials to send to the high performance liquid chromatography (HPLC) lab to identify the dye components.

The BYU HPLC lab followed the experiment as outlined in the previously mentioned article. The results of HPLC analysis are given in minutes. HPLC analysis measures the flow rates of a solution after it has interacted with another material in the column. These flow rates make it possible to identify different compounds. We were able to compare HPLC profiles of pigments extracted from the Fag el-Gamous textiles with the profiles of a Tyrian purple standard (6,6' dibromoindigotin) and an indigo standard (Sigma-Aldrich, product 229296). Some samples were neither indigo nor Tyrian, and further testing must be done in order to determine the compound(s) used for the dye on these threads.

Analyses were conducted eight times. After four runs, a standard was included within each data set, resulting in four runs that were not attached to a standard and four runs that were attached. Thus, results from Runs 1–4 can be compared to one another, but they cannot be

directly compared to Runs 5–8. [page 214] The standards used for Run 1 held for Runs 2, 3 and 4. Runs 5, 6, 7, and 8 were run in comparison with a standard contained in the sample set.³²

Run 7 retested threads with inconclusive results from Run 1. While Run 7 is later chronologically than Runs 2–6, its results will be reported with Run 1 to provide the best comparison and understanding of the data.

Run 8 was conducted without a consistent comparison standard. It was not known until after this run of tests that the equipment in the HPLC lab can only analyze samples in batches of 20. While this did not affect results from earlier runs, it is clear that the results here are internally inconsistent. For this reason, the resulting data will be provided in Table 8, but there will be no additional analysis.

IV. Results:

A. Data and Analysis - Standards:

Tyrian Standard:

HPLC results of the Tyrian standard indicate that there is a peak at 13.742 (also 13.733) minutes for Run 5, 15.885 minutes for Run 6, 15.953 minutes for Run 7, and 15.877 minutes for Run 8. None of the textile samples show a peak at these times.

Indigo Standard:

HPLC results of the indigo standard show a peak at 12.913 minutes for Runs 1–4, 13.309 (also 13.315) minutes for Run 5, 14.974 minutes for Run 6, 15.489 minutes for Run 7 and 15.000 minutes for Run 8. Nearly every sample shows a peak at these times.

Tyrian and Indigo Standard Mixture:

³² As each run was conducted, more about the process was understood, as a result the data does not look the same across the entirety of the project. For example, in the inaugural run, a Tyrian standard had yet to be obtained. Due to time constraints it was decided to move forward with the testing. Results not immediately identified as indigo were later retested.

Figure 2 - HPLC Results of a Mixture of Tyrian and Indigo Standards from Run 6 (Sample IT1)

HPLC results of a mixture of both indigo and Tyrian standards (Figure 2) from Run 6 show that Tyrian and indigo could be viewed separately. Earlier results were not clear in distinguishing two separate peaks (although Sample 53 from Run 5 came close). The first peak is from the indigo standard and the second is the Tyrian standard.

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B. Data and Analysis – Runs 1 and 7:

The first run tested 8 different threads from 6 different textile fragments and included an indigo standard. Results and descriptions are summarized in Table 1. Images and some HPLC profiles of the samples can be seen in Figure 4 following the analysis.

Sample 1:

200/210N 30/40E SW #50 is a textile fragment most likely from a tunic. The *clavus* (vertical decorative stripe) is formed by two different shades of purple wool and yellow wool.

A close up of 200/210N 30/40E SW #50 (Figure 3) shows the difference between the two purple wools used in the tapestry design. One shade is very dark, almost black, and is very similar to indigo. The other shade is lighter and is very similar in color to other textiles that have been positively identified as Tyrian purple.

Figure 3 - A close-up of 200/210N 30/40E SW #50

Initial HPLC results from Sample 1, light purple wool from 200/210N 30/40E SW #50, seemed to indicate that sample is Tyrian purple. The results were retested in Run 7, and all three samples were confirmed to be indigo (See Table 2 for Run 7 results). Samples 166, 167, and 168 (part of Run 7, but from the same textile as Samples 1 and 2) are all nearly identical with peaks around 15.5 minutes. Sample 166 is from a broken portion of the tapestry design. Sample 167 is from a more intact portion of the tapestry design. Sample 168 is from the [page 216] grape-like design at the bottom of the *clavus*. These results indicate that the light purple is indigo, but in a lesser concentration than Sample 2, which is the dark purple from 200/210N 30/40E SW #50. It is probable that the lighter purple is also mixed with another dye, though what that other component is remains to be discovered.

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Sample 2

The dark purple from 200/210N 30/40E SW #50 was also tested. Sample 2 was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, was initially recorded at 12.9 minutes matching Sample 2 which was also recorded at 12.9 minutes.

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Samples 3 and 4:

Light purple wool that may have been discolored from 2000 Season SE 12 (wool) 1 was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, was initially recorded at 12.9 minutes matching Sample 3 which was also recorded at 12.9 minutes.

Sample 4 from the same textile yielded the same result.

Sample 5:

Medium purple wool from 160/170N 10/20E SW #26A.2 was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, was initially recorded at 12.9 minutes matching Sample 5 which was also recorded at 12.9 minutes.

Sample 6:

Medium purple wool from Square 2 #5 was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, was initially recorded at 12.9 minutes matching Sample 6 which was also recorded at 12.9 minutes.

Sample 7:

Dark purple wool from 150/160N 0/10E SW Mud Brick Tomb was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, was initially recorded at 12.9 minutes matching Sample 7 which was also recorded at 12.9 minutes.

Sample 8:

Dark purple wool from 2000 Season SE #35 (Figure 24) was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, was initially recorded at 12.9 minutes matching Sample 8 which was also recorded at 12.9 minutes.

Sample 9:

Sample 9 is the indigo standard with a peak recorded at 12.9 minutes.

Based on these results, Samples 2, 3, 4, 5, 6, and 8 are indigo. Other threads from Sample 1 were retested in later runs and confirmed to be indigo. Sample 7 is undetermined, but is neither Tyrian nor indigo.

Figure 4: Photos of Samples from Run 1 (and Run 7)

Table 1: Dye Analysis Run 1

Sample	Location	Description	Results (in minutes)	Conclusion
Sample 1 (S1)	200/210N 30/40E SW #50	Light Purple Wool	13.447 (and 19.539 ³³)	Inconclusive
Sample 2 (S2)	200/210N 30/40E SW #50	Dark Purple Wool	12.924	Indigo
Sample 3 (S3)	2000 Season (170/180N 20/30E) SE 12 Wool 1	Light Purple Wool (possibly discolored)	12.917	Indigo
Sample 4 (S4)	2000 Season (170/180N 20/30E) SE 12 Wool 1	Medium Purple Wool	12.923	Indigo
Sample 5 (S5)	160/170 N 10/20E SW #26A.2	Medium Purple Wool	12.908	Indigo
Sample 6 (S6)	Square 2 (150/160N 0/10E NW) #5	Medium Purple Wool	12.916	Indigo
Sample 7 (S7)	150/160N 0/10E SW Mud Brick Tomb	Dark Purple Wool	9.662	Undetermined
Sample 8 (S8)	2000 Season (170/180N 20/30E) SE	Dark Purple Wool	12.907	Indigo

³³ Some samples exhibited two peaks. When that is the case, both peaks are noted. If the peak is irrelevant to the current question (meaning it demonstrates a peak in an element that does not affect the color) then it is put in parentheses.

	#35			
Sample 9 (S9)	N/A	Indigo Standard	12.913	N/A

Table 2: Dye Analysis Run 7

Sample	Location	Description	Results (in minutes)	Conclusion
Sample 166 (S166)	200/210N 30/40E SW #50	Light Purple from Broken Tapestry Design	15.512	Indigo
Sample 167 (S167)	200/210N 30/40E SW #50	Light Purple from more intact Design	15.608	Indigo
Sample 168 (S168)	200/210N 30/40E SW #50	Light Purple from Grape-like Design	15.619	Indigo
T2	N/A	Tyrian Standard	15.953	N/A
I2	N/A	Indigo Standard	15.489	N/A
IT2	N/A	50% Indigo 50% Tyrian (200/200 μ L)	15.560 and 16.438	N/A

C. Data and Analysis – Run 2:

The second run tested 11 threads from 10 different textiles. Results and descriptions are summarized in Table 3. Images of the samples can be seen in Figure 5 following the analysis.

Sample 10:

Medium purple wool from 200/210N 20/30E SE #8 was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, was initially recorded at 12.9 minutes matching Sample 10 which was also recorded at 12.9 minutes.

Sample 11:

Dark purple wool from 160/170N 10/20E SE #22A.1 was unidentified. Results were recorded at 11.4 minutes.

[page 220]: a chart found below

[page 221]

Sample 12:

Light purple wool from 150/160N 0/10W NE #14.2.2 was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, was initially recorded at 12.9 minutes nearly matching Sample 12 which was recorded at 12.79 minutes.

Sample 13:

Medium purple wool from 150/160N 0/10W NE #14.2.1 was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, was initially recorded at 12.9 minutes matching Sample 13 which was also recorded at 12.9 minutes. The other peaks are unidentified.

Samples 14 and 15:

Both samples of dark purple wool from 2000 Season SE #12 (wool) 2 were identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, was initially recorded at 12.9 minutes matching Samples 14 and 15 which were recorded at 12.9 minutes and 12.89 minutes.

Sample 16:

Light purple wool from tapestry from 150/160N 0/10E NW #13.2 was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, was initially recorded at 12.9 minutes matching Sample 16 which was recorded at 12.89 minutes.

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Sample 17:

Light purple wool from tapestry from 150/160N 0/10E NW #13.1 was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, was initially recorded at 12.9 minutes matching Sample 17 which was recorded at 12.89 minutes.

Sample 18:

Medium purple wool from 160/170N 10/20E SW #26EFabric5.2 was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, was initially recorded at 12.9 minutes matching Sample 18 which was recorded at 12.88 minutes.

Sample 19:

Medium purple wool from 160/170N 0/10W SW #8AFolder1.1 was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, was initially recorded at 12.9 minutes matching Sample 19 which was recorded at 12.89 minutes.

Sample 20:

Medium purple wool from 160/170N 0/10W SW #8AFolder1.2 was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, was initially recorded at 12.9 minutes matching Sample 20 which was also recorded at 12.9 minutes.

Based on these results, Samples 10, 12, 13, 14, 15, 16, 17, 18, 19, and 20 are indigo. Sample 11 is undetermined, but is neither Tyrian nor indigo.

Figure 5: Photos of Samples from Run 2

Table 3: Dye Analysis Run 2

Sample	Location	Description	Results (in minutes)	Conclusion
Sample 10 (S10)	200/210N 20/30E SE #8	Light Purple Wool	12.904	Indigo
Sample 11 (S11)	160/170N 10/20E SE #22A.1	Dark Purple Wool	11.491	Undetermined
Sample 12 (S12)	150/160N 0/10W NE #14.2.2	Light Purple Wool	12.792	Indigo
Sample 13 (S13)	150/160N 0/10W NE #14.2.1	Medium Purple Wool	12.905 (and 19.237)	Indigo
Sample 14 (S14)	2000 Season (170/180N 20/30E) SE #12 (wool) 2	Dark Purple Wool (main)	12.901	Indigo
Sample 15 (S15)	2000 Season (170/180N 20/30E) SE #12 (wool) 2	Dark Purple Wool (small band)	12.898	Indigo
Sample 16 (S16)	150/160N 0/10E NW #13.2	Light Purple Wool (from tapestry)	12.896	Indigo
Sample 17 (S17)	150/160N 0/10E NW #13.1	Light Purple Wool (from tapestry)	12.893	Indigo
Sample 18 (S18)	160/170N 10/20E SW #26EFabric5.2	Medium Purple Wool	12.889	Indigo
Sample 19 (S19)	160/170N 0/10W SW #8AFolder1.1	Medium Purple Wool	12.891	Indigo

Sample 20 (S20)	160/170N 0/10W SW #8AFolder1.2	Medium Purple Wool	12.901	Indigo
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D. Data and Analysis – Run 3:

The third run tested 11 threads from 11 different textiles. Results and descriptions are summarized in Table 4. Images of the samples can be seen in Figure 6 following the analysis.

Sample 21:

Light/medium purple wool from 150/160N 0/10E NW #4 was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, was initially recorded at 12.9 minutes nearly matching Sample 21 which was recorded at 12.58 minutes.

Sample 22:

Light/medium purple wool from 160/170N 10/20E SW #22A.1 was identified as indigo based on the initial run of the indigo standard. The indigo standard, [page 223, table 4, or 9.4 in the published version] [page 224] Sample 9, was initially recorded at 12.9 minutes matching Sample 22 which was recorded at 12.89 minutes.

Sample 23:

Medium purple wool from 160/170N 10/20E SW #26CHHead#1.2 was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, was initially recorded at 12.9 minutes matching Sample 23 which was also recorded at 12.9 minutes.

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Sample 24:

Disintegrated purple wool from 200/210N 30/40E SW #25.2 was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, was initially recorded at 12.9 minutes matching Sample 24 which was also recorded at 12.9 minutes.

Sample 25:

Dark purple wool from 160/170N 10/20E SW #46C.1 was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, was initially recorded at 12.9 minutes matching Sample 25 which was also recorded at 12.9 minutes.

Sample 26:

Discolored light purple wool from 160/170N 10/20E SW #16.2 was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, was initially recorded at 12.9 minutes matching Sample 26 which was also recorded at 12.9 minutes.

Sample 27:

Blue/purple wool from 160/170N 10/20E SW #8.1 was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, was initially recorded at 12.9 minutes matching Sample 27 which was also recorded at 12.9 minutes.

Sample 28:

Discolored medium purple wool from 160/170N 10/20E SW #8.5 was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, was initially recorded at 12.9 minutes matching Sample 28 which was also recorded at 12.9 minutes.

Sample 29:

Dark purple wool from 160/170N 10/20E SW #14.2 was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, was initially recorded at 12.9 minutes matching Sample 29 which was also recorded at 12.9 minutes.

Sample 30:

Dark purple wool from 160/170N 10/20E SW #39L.1 was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, [page 226] was initially recorded at 12.9 minutes matching Sample 30 which was also recorded at 12.9 minutes.

Sample 31:

Dark purple wool from 160/170N 10/20E SW #39L.3 was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, was initially recorded at 12.9 minutes matching Sample 31 which was also recorded at 12.9 minutes.

Based on these results, Samples 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, and 31 are indigo.

Figure 6: Photos of Samples from Run 3

Table 4: Dye Analysis Run 3

Sample	Location	Description	Results (in minutes)	Conclusion
Sample 21 (S21)	150/160N 0/10E NW #4	Light/Medium Purple Wool	12.583	Indigo
Sample 22 (S22)	160/170N 10/20E SW #22A.1	Light/Medium Purple Wool	12.899	Indigo
Sample 23 (S23)	160/170N 10/20E SW #26CHead#1.2	Medium Purple Wool	12.900	Indigo
Sample 24 (S24)	200/210N 30/40E SW #25.2	Disintegrated Purple Wool	12.911	Indigo
Sample 25 (S25)	160/170N 10/20E SW #46C.1	Dark Purple Wool	12.908	Indigo
Sample 26 (S26)	160/170N 10/20E SW #16.2	Discolored Light Purple Wool	12.915	Indigo
Sample 27 (S27)	160/170N 10/20E SW #8.1	Purple/Blue Wool	12.910	Indigo
Sample 28 (S28)	160/170N 10/20E SW #8.5	Discolored Medium Purple Wool	12.916	Indigo
Sample 29 (S29)	160/170N 10/20E SW #14.2	Dark Purple Wool	12.912	Indigo
Sample 30 (S30)	160/170N 10/20E SW #39L.1	Dark Purple Wool	12.914	Indigo

Sample 31 (S31)	160/170N 10/20E SW #39L.3	Dark Purple Wool	12.907	Indigo
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E. Data and Analysis – Run 4:

The fourth run tested 8 threads from 8 different textiles. Results and descriptions are summarized in Table 5. Images of the samples can be seen in Figure 7 following the analysis.

Sample 32:

Medium purple wool from 160/170N 10/20E NW #2.3 was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, was initially recorded at 12.9 minutes matching Sample 32 which was also recorded at 12.9 minutes.

Sample 33:

Dark purple wool from 160/170N 10/20E SE #2.2 was unidentified. Results were recorded at 9.6 minutes.

Sample 34:

Mix of red and blue wool fibers from 160/170N 10/20E SE #10.3 was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, was initially recorded at 12.9 minutes matching Sample 34 which was also recorded at 12.9 minutes.

Sample 35:

Dark purple wool from 160/170N 10/20E SE #25B.2 was unidentified. Results were recorded at 9.6 minutes.

Sample 36:

Medium purple wool from 160/170N 10/20E SW #21AFabric6.2 was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, was initially recorded at 12.9 minutes matching Sample 36 which was also recorded at 12.9 minutes.

[page 227, table 5, or 9.5 in the published version]

Sample 37:

Medium purple wool from 160/170N 10/20E SW #26Dhead#2.3 was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, was initially recorded at 12.9 minutes matching Sample 37 which was recorded at 12.87 minutes.

Sample 38:

Medium purple wool from 160/170N 10/20E SW #26B.2 was identified as indigo based on the initial run of the indigo standard. The indigo standard, Sample 9, [page 228] was initially recorded at 12.9 minutes matching Sample 38 which was also recorded at 12.9 minutes.

Sample 39:

Dark purple wool from 160/170N 10/20E SW #39B.2 was unidentified. Results were recorded at 11.37 minutes.

Based on these results, Samples 32, 34, 36, 37, and 38 are indigo. Samples 33, 35, and 39 are undetermined, but are neither Tyrian nor indigo.

Figure 7: Photos of Samples from Run 4

Table 5: Dye Analysis Run 4

Sample	Location	Description	Results (in minutes)	Conclusion
Sample 32 (S32)	160/170N 10/20E NW #2.3	Medium Purple Wool	12.908	Indigo
Sample 33 (S33)	160/170N 10/20E SE #2.2	Dark Purple Wool	9.646	Undetermined
Sample 34 (S34)	160/170N 10/20E SE #10.3	Wool – Mix of Blue and Red Fibers	12.918	Indigo
Sample 35 (S35)	160/170N 10/20E SE #25B.2	Dark Purple Wool	9.653	Undetermined

Sample 36 (S36)	160/170N 10/20E SW #21AFabric6.2	Medium Purple Wool	12.913	Indigo
Sample 37 (S37)	160/170N 10/20E SW #26Dhead#2.3	Medium Purple Wool	12.871	Indigo
Sample 38 (S38)	160/170N 10/20E SW #26B.2	Medium Purple Wool	12.911	Indigo
Sample 39 (S39)	160/170N 10/20E SW #39B.2	Dark Purple Wool	11.375	Undetermined

F. Data and Analysis – Run 5:

The fifth run tested 11 threads from 9 different textiles and 7 standards. Results and descriptions are summarized in Table 6. Results from Samples 40–50 are compared with the results of the standards tested in Samples 51–57. Images of the samples can be seen in Figure 8 following the analysis.

Sample 40:

Medium purple wool from band from 160/170N 10/20E SW #39G was identified as indigo based on the second run of the indigo standard. The indigo standard, Sample 51, was recorded at 13.3 minutes matching Sample 40 which was also recorded at 13.3 minutes.

Sample 41:

Medium purple wool from roundel from 160/170N 10/20E SW #39G (Figure 89) was identified as indigo based on the second run of the indigo standard. The [page 229, table 9.6]

[page 230, continuation of table 9.6] indigo standard, Sample 51, was recorded at 13.3 minutes similar to Sample 41 which was recorded at 12.7 minutes.

Sample 42:

Medium purple wool from band from 160/170N 10/20E SW #39G was identified as indigo based on the second run of the indigo standard. The indigo standard, Sample 51, was recorded at 13.3 minutes matching Sample 42 which was also recorded at 13.3 minutes.

Sample 43:

Medium red/purple wool from 160/170N 0/10W NW #7D.3 was identified as indigo based on the second run of the indigo standard. The indigo standard, Sample 51, was recorded at 13.3 minutes matching Sample 43 which was also recorded at 13.3 minutes.

Sample 44:

Medium purple wool from 160/170N 0/10W NW #7D.2.3 was identified as indigo based on the second run of the indigo standard. The indigo standard, Sample [page 231] 51, was recorded at 13.3 minutes matching Sample 44 which was also recorded at 13.3 minutes.

Sample 45:

Medium purple wool from 160/170N 10/20E SW #38A was identified as indigo based on the second run of the indigo standard. The indigo standard, Sample 51, was recorded at 13.3 minutes matching Sample 45 which was also recorded at 13.3 minutes.

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Sample 46:

Medium purple wool from 160/170N 10/20E SW #46A.2 was identified as indigo based on the second run of the indigo standard. The indigo standard, Sample 51, was recorded at 13.3 minutes matching Sample 46 which was also recorded at 13.3 minutes.

Sample 47:

Medium purple wool from 160/170N 0/10W NW #6F.2 was identified as indigo based on the second run of the indigo standard. The indigo standard, Sample 51, was recorded at 13.3 minutes matching Sample 47 which was also recorded at 13.3 minutes.

Sample 48:

Medium purple wool from 160/170N 0/10W NW #6F.1 was identified as indigo based on the second run of the indigo standard. The indigo standard, Sample 51, was recorded at 13.3 minutes matching Sample 48 which was also recorded at 13.3 minutes.

Sample 49:

Sample 49 was not numbered but is likely 150/160N 0/10E NW #13. Dark purple wool from the design in the center was unidentified. Results were recorded at 10.005 minutes.

Sample 50:

Red/purple wool from 160/170N 10/20E SW #39A was identified as indigo based on the second run of the indigo standard. The indigo standard, Sample 51, was recorded at 13.3 minutes matching Sample 50 which was also recorded at 13.3 minutes.

Sample 51:

Sample 51 is the indigo standard with a peak recorded at 13.3 minutes.

Sample 52:

Sample 52 is a Tyrian Standard. Results were recorded at 13.7 minutes

Sample 53:

Sample 53 was 50% Tyrian and 50% Indigo standard mix. This allowed for the identification of the two separate compounds (Figure 2).

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Sample 54:

Sample 54 was a mix of 25% Indigo standard and 75% Tyrian standard (100/300 μ L). This did not give the separate peaks that are given for Sample 53. There is an odd shaped peak at 13.331. (In this instance odd is meant that it peaks as normal, but when returning to the baseline on the right side there is a slight bump outward, though not enough to produce a separate result.)

Sample 55:

Sample 55 was a mix of 75% Indigo standard and 25% Tyrian standard (300/100 μ L).

This did not give the separate peaks that are given for Sample 53. There is a peak at 13.327 with a slight angle change near where the peak meets the baseline, though not enough to register a separate result.

Sample 56:

A rerun of the Indigo Standard. Results are at 13.3 minutes.

Sample 57:

A rerun of the Tyrian Standard. Results are at 13.7 minutes.

Based on these results, Samples 40, 41, 42, 43, 44, 45, 46, 47, 48, and 50 are indigo. Samples 49 is undetermined, but is neither Tyrian nor indigo. The mixture of the standards ensured that Tyrian and Indigo could be viewed separately in HPLC analysis. Sample 53 shows two peaks that are almost separated, consistent with peaks for pure indigo and pure Tyrian purple.

Figure 8: Photos of Samples from Run 5

Table 6: Dye Analysis Run 5

Sample	Location	Description	Results (in minutes)	Conclusion
Sample 40 (S40)	160/170N 10/20E SW #39G	Medium Purple Wool from Band	13.362	Indigo
Sample 41 (S41)	160/170N 10/20E SW #39G	Medium Purple Wool from Roundel	12.738	Indigo
Sample 42 (S42)	160/170N 10/20E SW #39G	Dark Purple Wool from Band (bottom)	13.359	Indigo
Sample 43 (S43)	160/170N 0/10W NW #7D.3	Medium Redish Purple Wool (vibrant)	13.363	Indigo
Sample 44 (S44)	160/170N 0/10W NW #7D.2.3	Medium Purple Wool	13.349	Indigo
Sample 45 (S45)	160/170N 10/20E SW # 38A	Medium Purple Wool from back of designs	13.336	Indigo
Sample 46 (S46)	160/170N 10/20E SW #46A.2	Medium Purple Wool	13.355	Indigo
Sample 47 (S47)	160/170N 0/10W NW #6F.2	Medium Purple Wool	13.335	Indigo
Sample 48 (S48)	160/170N 0/10W NW #6F.1	Medium Purple Wool	13.362	Indigo
Sample 49 (S49)	Not numbered; likely: 150/160N 0/10E NW #13	Dark Purple Wool	10.005	Undetermined

	(From display – piece with yellow fork)			
Sample 50 (S50)	160/170N 10/20E SW #39A	Red/Purple Wool	13.356	Indigo
Sample 51 (S51)	N/A	Indigo	13.309	N/A
Sample 52 (S52)	N/A	Tyrian	13.742	N/A
Sample 53 (S53)	N/A	50% Indigo 50% Tyrian (200µL)	13.325 and 13.691	N/A
Sample 54 (S54)	N/A	25% Indigo 75% Tyrian (100/300µL)	13.331	N/A
Sample 55 (S55)	N/A	75% Indigo 25% (300/100µL)	13.327	N/A
Sample 56 (S56)	N/A	Indigo	13.315	N/A
Sample 57 (S57)	N/A	Tyrian	13.733	

G. Data and Analysis – Run 6:

The sixth run tested 24 threads from 21 different textiles and 3 standards. Results for samples 58 –81 were based on the results of the standards T1, I1, and IT1. Results for the Tyrian standard were recorded at 15.8 minutes and 14.9 minutes for the indigo standard. Results and

descriptions are summarized in Table 7. Images of the samples can be seen in Figure 9 following the analysis.

Sample 58–60:

Samples 58–60 were a rerun of 200/210N 30/40E SW #50 (Samples 1 and 2). Light purple wool from Sample 58 was identified as indigo based on the third run of the indigo standard. The indigo standard, Sample I1, was recorded at 14.9 minutes matching Sample 58 which was also recorded at 14.9 minutes. The indigo standard also matched Sample 59, which was the dark purple wool in the [page 234, table 9.7] [page 235, table 9.7 continued] [page 236, figure 9.9] [page 237] textile, and Sample 60, which was a mix of the light purple wool and the dark purple wool from this textile. This clearly distinguished that both purples in this textile are indigo.

Sample 61:

Medium purple wool from 160/170N 10/20E SW #22B.3 was identified as indigo based on the third run of the indigo standard. The indigo standard, Sample I1, was recorded at 14.9 minutes nearly matching Sample 61 which was recorded at 15.0 minutes.

Sample 62:

Medium purple wool from band from 160/170N 10/20E SE #17.1 was identified as indigo based on the third run of the indigo standard. The indigo standard, Sample I1, was recorded at 14.9 minutes nearly matching Sample 62 which was recorded at 15.0 minutes.

Sample 63:

Dark purple wool from border design from 160/170N 10/20E SW #17A.1 was identified as indigo based on the third run of the indigo standard. The indigo standard, Sample I1, was recorded at 14.9 minutes matching Sample 63 which was also recorded at 14.9 minutes.

Sample 64:

Dark purple wool from *clavus* from 150/160N 0/10E NW #25.1 was identified as indigo based on the third run of the indigo standard. The indigo standard, Sample I1, was recorded at 14.9 minutes matching Sample 64 which was also recorded at 14.9 minutes.

Sample 65:

Medium purple wool from 150/160N 0/10E NW #21 (Figure 130) was identified as indigo based on the third run of the indigo standard. The indigo standard, Sample I1, was recorded at 14.9 minutes matching Sample 65 which was also recorded at 14.9 minutes.

Sample 66:

Medium purple wool from tapestry square from 150/160N 0/10E NW #25.2 was identified as indigo based on the third run of the indigo standard. The indigo standard, Sample I1, was recorded at 14.9 minutes nearly matching Sample 66 which was recorded at 15.0 minutes.

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Sample 67:

Dark purple wool from *clavus* from 150/160N 0/10E NW #25.2 was identified as indigo based on the third run of the indigo standard. The indigo standard, Sample I1, was recorded at 14.9 minutes nearly matching Sample 67 which was recorded at 15.0 minutes.

Sample 68:

Dark purple wool from design from 160/170N 10/20E SW #17C.3 was identified as indigo based on the third run of the indigo standard. The indigo standard, Sample I1, was recorded at 14.9 minutes nearly matching Sample 68 which was recorded at 15.0 minutes.

Sample 69

Red/purple unspun wool from 150/160N 0/10E NW #13 was identified as indigo based on the third run of the indigo standard. The indigo standard, Sample I1, was recorded at 14.9 minutes nearly matching Sample 69 which was recorded at 15.0 minutes.

Sample 70:

Red/purple wool from band from 160/170N 10/20E SW #21B.1 was identified as indigo based on the third run of the indigo standard. The indigo standard, Sample I1, was recorded at 14.9 minutes nearly matching Sample 69 which was recorded at 15.0 minutes.

Sample 71:

Dark purple wool (discolored) from band from 160/170N 10/20E SW #21B.4 was unidentified. Results were recorded at 10.48 minutes.

Sample 72:

Medium purple wool from band from 160/170N 10/20E SW #39D.2 was identified as indigo based on the third run of the indigo standard. The indigo standard, Sample I1, was recorded at 14.9 minutes nearly matching Sample 72 which was recorded at 15.0 minutes.

Sample 73:

Dark purple wool from band from 2000 Season 170/180N 20/30E SE #13.3 was identified as indigo based on the third run of the indigo standard. The indigo standard, Sample I1, was recorded at 14.9 minutes nearly matching Sample 73 which was recorded at 14.5 minutes.

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Sample 74:

Medium purple wool from embroidery from 160/170N 0/10W NW #6J.2 was identified as indigo based on the third run of the indigo standard. The indigo standard, Sample I1, was recorded at 14.9 minutes matching Sample 74 which was also recorded at 14.9 minutes.

Sample 75:

Dark purple wool from 160/170N 0/10W NW #6J.1 was identified as indigo based on the third run of the indigo standard. The indigo standard, Sample I1, was recorded at 14.9 minutes matching Sample 75 which was also recorded at 14.9 minutes.

Sample 76:

Discolored purple wool and warps of an unknown color from 160/170N 0/10W NW #6Sample2 was identified as indigo based on the third run of the indigo standard. The indigo standard, Sample I1, was recorded at 14.9 minutes matching Sample 76 which was also recorded at 14.9 minutes.

Sample 77:

Dark purple wool from 160/170N 0/10W NW #6Sample5.1 was identified as indigo based on the third run of the indigo standard. The indigo standard, Sample I1, was recorded at 14.9 minutes nearly matching Sample 77 which was recorded at 15.0 minutes.

Sample 78:

Medium purple wool from embroidery from 150/160N 0/10E NW #13B1 was identified as indigo based on the third run of the indigo standard. The indigo standard, Sample I1, was recorded at 14.9 minutes nearly matching Sample 78 which was recorded at 15.0 minutes.

Sample 79:

Dark purple wool from 200/210N 30/40E SW #9.2 was identified as indigo based on the third run of the indigo standard. The indigo standard, Sample I1, was recorded at 14.9 minutes nearly matching Sample 79 which was recorded at 15.0 minutes.

Sample 80:

Dark purple wool from 200/210N 30/40E SW #9.1 was identified as indigo based on the third run of the indigo standard. The indigo standard, Sample I1, was [page 240] recorded at 14.9 minutes matching Sample 80 which was also recorded at 14.9 minutes.

Sample 81:

Dark purple wool from band from 200/210N 30/40E SW #22.3 was identified as indigo based on the third run of the indigo standard. The indigo standard, Sample I1, was recorded at 14.9 minutes matching Sample 81 which was also recorded at 14.9 minutes.

Based on these results, Samples 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 72, 73, 74, 75, 76, 77, 78, 79, 80, and 81 are indigo. Sample 71 is undetermined, but is neither Tyrian nor indigo.

Figure 9: Photos of Samples from Run 6

Table 7: Dye Analysis Run 6

Sample	Location	Description	Results (in minutes)	Conclusion
Sample 58 (S58)	200/210N 30/40E SW #50	Light Purple Wool	14.979	Indigo
Sample 59 (S59)	200/210N 30/40E SW #50	Dark Purple Wool	14.991	Indigo
Sample 60 (S60)	200/210N 30/40E SW #50	Light/Dark Purple Mix (1 strand of each)	15.027	Indigo
Sample 61 (S61)	160/170N 10/20E SW #22B.3	Medium Purple Wool	15.041	Indigo
Sample 62 (S62)	160/170N 10/20E SE #17.1	Medium Purple Wool (from band)	15.040 (and 10.472)	Indigo
Sample 63 (S63)	160/170N 10/20E SW #17A.1	Dark Purple from border design	14.983	Indigo
Sample 64 (S64)	150/160N 0/10E NW #25.1	Dark Purple from Clavi	14.987 (and 10.442)	Indigo
Sample 65 (S65)	150/160N 0/10E NW #21	Medium Purple Wool	14.985	Indigo
Sample 66 (S66)	150/160N 0/10E NW #25.2	Medium Purple from Tapestry Square	15.007	Indigo
Sample 67 (S67)	150/160N 0/10E NW #25.2	Dark Purple from Clavi	15.033 (and 10.471)	Indigo

Sample 68 (S68)	160/170N 10/20E SW #17C.3	Dark Purple from design	15.031	Indigo
Sample 69 (S69)	150/160N 0/10E NW #13	Red/Purple Wool	15.037	Indigo
Sample 70 (S70)	160/170N 10/20E SW #21B.1	Red/Purple Wool from band	15.046	Indigo
Sample 71 (S71)	160/170N 10/20E SW #21B.4	Dark Purple (discolored) from band	10.481	Undetermined
Sample 72 (S72)	160/170N 10/20E SW #39D.2	Medium Purple from band	15.013	Indigo
Sample 73 (S73)	2000 Season 170/180N 20/30E #13.3	Dark Purple from band	14.569	Indigo
Sample 74 (S74)	160/170N 0/10W NW #6J.2	Medium Purple Wool Embroidery	14.987	Indigo
Sample 75 (S75)	160/170N 0/10W NW #6J.1	Dark Purple Wool	14.993	Indigo
Sample 76 (S76)	160/170N 0/10W NW #6Sample2	Discolored Purple Wool (+ warps of unknown color)	14.991	Indigo
Sample 77 (S77)	160/170N 0/10W NW #6Sample5.1	Dark Purple from band	15.028	Indigo

Sample 78 (S78)	150/160N 0/10E NW #13B1	Medium Purple from embroidery	15.033	Indigo
Sample 79 (S79)	200/210N 30/40E SW #9.2	Dark Purple Wool	15.040	Indigo
Sample 80 (S80)	200/210N 30/40E SW #9.1	Dark Purple Wool	14.979	Indigo
Sample 81 (S81)	200/210N 20/40E SW #22.3	Dark Purple from band	14.986	Indigo
T1	N/A	Tyrian Standard	15.885	N/A
I1	N/A	Indigo Standard	14.974	N/A
IT1	N/A	25% Indigo 75% Tyrian (100/300µL)	14.986 and 15.865	N/A

H. Data and Analysis – Run 8:

The eighth run tested 87 threads from 76 different textiles and 3 standards. Results and descriptions are given in Table 8.

Samples 82 –90 and Samples 92 –165 are likely indigo, though all results are undetermined due to the inconsistent application of the standard. All samples, excepting Sample 91, are thought likely to be indigo given their physical comparison with samples from Runs 1 –7 as well as the relative consistency within the run (results common at 14.5, 15.0, and 15.5, with the indigo standard at 15.000 minutes, and no results as high as the Tyrian standard at 15.877).

[beginning of table 9.8] [page 241, continuation of table 9.8] [page 242, continuation of table 9.8] [page 243, continuation of table 9.8] [page 244, continuation of table 9.8] [page 245, continuation of table 9.8] [page 246, continuation of table 9.8] [page 247, continuation of table 9.8]

Table 8: Dye Analysis Run 8

Sample	Location	Description	Results	Conclusion
Sample 82 (S82)	200/210N 20/40E SW #22.5	Medium Purple Wool	15.495	Undetermined (likely Indigo)
Sample 83 (S83)	200/210N 20/30E SE #18.2	Dark Purple from band	15.476	Undetermined (likely Indigo)
Sample 84 (S84)	200/210N 30/40E SW #21.1	Dark Purple from band	15.492	Undetermined (likely Indigo)
Sample 85 (S85)	200/210N 30/40E SW #51.1	Dark Purple Wool	14.410	Undetermined (likely Indigo)
Sample 86 (S86)	200/210N 30/40E SW #21.2	Dark Purple from band	15.494	Undetermined (likely Indigo)
Sample 87 (S87)	160/170N 0/10W NW #6.1	Medium Purple from Tapestry Design	15.477	Undetermined (likely Indigo)
Sample 88 (S88)	160/170N 0/10W NW #6.4	Medium Purple from Embroidery	15.472	Undetermined (likely Indigo)
Sample 89 (S89)	150/160N 0/10E NW #13A1	Medium Purple from Embroidery	15.507	Undetermined (likely Indigo)

Sample 90 (S90)	150/160N 0/10E NW #13A1	Dark Purple (probably black) Wool	14.451	Undetermined (likely Indigo)
Sample 91 (S91)	150/160N 0/10E NW #13B1.2	Dark Purple from Embroidery	10.772	Undetermined
Sample 92 (S92)	150/160N 0/10E NW #13B1.2	Dark Purple/Red Mix (2 ply)	14.996	Undetermined (likely Indigo)
Sample 93 (S93)	150/160N 0/10E NW #13B1.2	Medium Purple from Embroidery	14.984	Undetermined (likely Indigo)
Sample 94 (S94)	150/160N 0/10E NW #13D1.2	Medium Purple Wool (loose)	14.996	Undetermined (likely Indigo)
Sample 95 (S95)	150/160N 0/10E NW #5G	Medium Purple from band	14.989	Undetermined (likely Indigo)
Sample 96 (S96)	150/160N 0/10E NW #5F.1	Medium Purple from band	14.555	Undetermined (likely Indigo)
Sample 97 (S97)	150/160N 0/10E NW #5F.2	Medium Purple from tapestry square	14.570	Undetermined (likely Indigo)
Sample 98 (S98)	150/160N 0/10E NW #5C.6	Medium Purple from tapestry design	14.996	Undetermined (likely Indigo)

Sample 99 (S99)	150/160N 0/10E NW #5C.13	Medium Purple from tapestry design	14.999	Undetermined (likely Indigo)
Sample 100 (S100)	160/170N 0/10W NW #45C.1	Medium Purple wool	14.997	Undetermined (likely Indigo)
Sample 101 (S101)	160/170N 0/10W NW #29.1	Medium Purple	14.584	Undetermined (likely Indigo)
Sample 102 (S102)	160/170N 0/10W NW #29.1	Dark purple	14.989	Undetermined (likely Indigo)
Sample 103 (S103)	160/170N 0/10W NW #19B	Medium Purple from band	14.987	Undetermined (likely Indigo)
Sample 104 (S104)	150/160N 0/10W NE #15B	Medium Purple	14.991	Undetermined (likely Indigo)
Sample 105 (S105)	150/160N 0/10W #2A.1	Medium Purple from tapestry design	14.980	Undetermined (likely Indigo)
Sample 106 (S106)	150/160N 0/10W #2A.2	Medium Purple from tapestry design	14.581	Undetermined (likely Indigo)
Sample 107 (S107)	150/160N 0/10W NE #24B.4	Dark Purple	14.990	Undetermined (likely Indigo)
Sample 108 (S108)	150/160N 0/10E NW #7B.1	Red/Purple Tapestry Design	14.557	Undetermined (likely Indigo)

Sample 109 (S109)	150/160N 0/10E NW #5L.1	Medium Purple from band	14.553	Undetermined (likely Indigo)
Sample 110 (S110)	150/160N 0/10E NW #5K.1	Dark Purple from tapestry design	14.026	Undetermined (likely Indigo)
Sample 111 (S111)	150/160N 0/10E NW #5K.1	Medium Purple Wool	14.573	Undetermined (likely Indigo)
Sample 112 (S112)	160/170N 0/10W NW #9B	Dark Purple from band (?)	14.711	Undetermined (likely Indigo)
Sample 113 (S113)	160/170N 0/10W NW #9B	Dark Purple from band (?)	14.696	Undetermined (likely Indigo)
Sample 114 (S114)	160/170N 0/10W NW #7G.1	Medium Purple from band	14.996	Undetermined (likely Indigo)
Sample 115 (S115)	160/170N 0/10W NW #7HFolder#1.1	Medium Purple	14.991	Undetermined (likely Indigo)
Sample 116 (S116)	160/170N 0/10W NW #7HFolder#1.2	Medium Purple from band	14.579	Undetermined (likely Indigo)
Sample 117 (S117)	160/170N 0/10W NW #7K.1	Medium Purple wool	15.002	Undetermined (likely Indigo)
Sample 118 (S118)	160/170N 0/10W NW #7K.2	Medium purple from neck opening	14.577	Undetermined (likely Indigo)
Sample 119 (S119)	160/170N 0/10W NW #7K.3	Medium Purple from band	14.991	Undetermined (likely Indigo)

Sample 120 (S120)	160/170N 0/10W NW #7L.1	Medium Purple from band	14.578	Undetermined (likely Indigo)
Sample 121 (S121)	160/170N 0/10W NW #8.1	Dark Purple from band	14.997	Undetermined (likely Indigo)
Sample 122 (S122)	160/170N 0/10W NW #8.2	Medium Purple from band	14.047	Undetermined (likely Indigo)
Sample 123 (S123)	160/170N 0/10W NW #8.2	Medium Purple from band	14.992	Undetermined (likely Indigo)
Sample 124 (S124)	160/170N 0/10W NW #6K.1	Medium Purple Wool	14.014	Undetermined (likely Indigo)
Sample 125 (S125)	160/170N 0/10W NW #7A.1	Medium Purple from braided design	14.587	Undetermined (likely Indigo)
Sample 126 (S126)	160/170N 0/10W NW #7A.2	Medium Purple from tapestry band	14.591	Undetermined (likely Indigo)
Sample 127 (S127)	160/170N 0/10W NW #7A.3	Medium Purple from tapestry band	14.699	Undetermined (likely Indigo)
Sample 128 (S128)	160/170N 0/10W NW #7BFolder#1.1	Medium Purple from braid band	14.598	Undetermined (likely Indigo)
Sample 129 (S129)	160/170N 0/10W NW #7BFolder#1.1	Medium Purple from tapestry band	14.587	Undetermined (likely Indigo)
Sample 130 (S130)	160/170N 0/10W NW #7CFolder#2	Medium Purple band	14.602	Undetermined (likely Indigo)

Sample 131 (S131)	160/170N 0/10W NW #1.1	Medium Purple band	15.018	Undetermined (likely Indigo)
Sample 132 (S132)	160/170N 0/10W NW #1.2	Medium Purple from roundel	14.280	Undetermined (likely Indigo)
Sample 133 (S133)	160/170N 0/10W NW #5C	Medium Purple from band	15.752	Undetermined (likely Indigo)
Sample 134 (S134)	160/170N 0/10W NW #6AFolder1.1	Medium Purple tapestry band	15.722	Undetermined (likely Indigo)
Sample 135 (S135)	160/170N 0/10W NW #6BFolder2.1	Medium Purple band	15.739	Undetermined (likely Indigo)
Sample 136 (S136)	160/170N 0/10W NW #6D.1	Medium Purple	15.312	Undetermined (likely Indigo)
Sample 137 (S137)	160/170N 0/10W NW #6E	Medium Purple Tunic	15.351	Undetermined (likely Indigo)
Sample 138 (S138)	160/170N 0/10W NW #6-3I.2	Medium Purple Wool	15.708	Undetermined (likely Indigo)
Sample 139 (S139)	160/170N 10/20E NW #3-4	Medium Purple Wool	15.754	Undetermined (likely Indigo)
Sample 140 (S140)	160/170N 10/20E NW #38	Medium Purple Band	15.748	Undetermined (likely Indigo)
Sample 141 (S141)	160/170N 10/20E NW #5	Dark Purple Design	15.732	Undetermined (likely Indigo)

Sample 142 (S142)	200/210N 30/40E SW #44.4	Medium Purple from Roundel	15.724	Undetermined (likely Indigo)
Sample 143 (S143)	200/210N 30/40E SW #43.3	Medium Purple Wool	15.699	Undetermined (likely Indigo)
Sample 144 (S144)	2000 Season SE #7	Medium Purple Roundel	15.682	Undetermined (likely Indigo)
Sample 145 (S145)	Unknown (warm edge)	Medium Purple Band	15.680	Undetermined (likely Indigo)
Sample 146 (S146)	Unknown (no address 5)	Medium Purple Tapestry Design	15.692	Undetermined (likely Indigo)
Sample 147 (S147)	Unknown (no address 1)	Medium Purple Band	15.693	Undetermined (likely Indigo)
Sample 148 (S148)	Unknown (no address 1)	Medium Purple Tapestry Design	15.697	Undetermined (likely Indigo)
Sample 149 (S149)	Unknown (no address 2)	Medium Purple Wool (unspun)	15.700	Undetermined (likely Indigo)
Sample 150 (S150)	200/210N 20/40E SW #22.4	Medium Purple Band	15.684	Undetermined (likely Indigo)
Sample 151 (S151)	200/210N 20/30E SE #36.1	Medium Purple Band	15.692	Undetermined (likely Indigo)
Sample 152 (S152)	200/210N 20/30E SE #38.2	Medium Purple Band	14.597	Undetermined (likely Indigo)

Sample 153 (S153)	200/210N 20/30E SE #40.5	Dark Purple Bands	15.666	Undetermined (likely Indigo)
Sample 154 (S154)	200/210N 30/40E SW #43.4	Medium Purple Wool	15.691	Undetermined (likely Indigo)
Sample 155 (S155)	200/210N 30/40E SW #43.6	Medium Purple Bands	15.658	Undetermined (likely Indigo)
Sample 156 (S156)	200/210N 30/40E SW #43.5	Medium Purple Roundel	15.652	Undetermined (likely Indigo)
Sample 157 (S157)	200/210N 30/40E SW #43.7	Medium Purple Band	15.659	Undetermined (likely Indigo)
Sample 158 (S158)	200/210N 30/40E SW #49.2	Medium Purple Band	15.018	Undetermined (likely Indigo)
Sample 159 (S159)	200/210N 20/30E SE #44.7	Dark Purple Band	15.009	Undetermined (likely Indigo)
Sample 160 (S160)	200/210N 20/30E SE #44.8	Dark Purple Tapestry Design	15.017	Undetermined (likely Indigo)
Sample 161 (S161)	200/210N 20/30E SE #44.9	Dark Purple Roundel with Tapestry	15.022	Undetermined (likely Indigo)
Sample 162 (S162)	150/160N 0/10W NE #10A	Dark Purple Tapestry Roundel	15.154	Undetermined (likely Indigo)
Sample 163 (S163)	140/160N 50/60E NNW #7.1	Dark Purple Band	14.045	Undetermined (likely Indigo)

Sample 164 (S164)	140/160N 50/60E NNW #12.4	Dark Purple Wool	15.010	Undetermined (likely Indigo)
Sample 165 (S165)	150/160N 0/10E SE #3.4	Dark Purple Tapestry Design	14.992	Undetermined (likely Indigo)
T3	N/A	Tyrian Standard	15.877	N/A
I3	N/A	Indigo Standard	15.000	N/A
IT3	N/A	50% Indigo 50% Tyrian (200/200 μ L)	14.999 and 15.865	N/A

V. Conclusions:

The Fag el-Gamous cemetery has yielded an extensive collection of textiles. The majority of the textile fragments are plain or basket-weave linen, but there are a number of beautifully dyed wool pieces. Some of these textiles are visually very similar to textiles that were dyed with shellfish purple, but the wide variety of hues suggests that indigo (blue dye) and madder (red dye) were mixed to create purple in various proportions. Nearly all of the purple pieces analyzed in this study were determined to be made from indigo. Those not identified as indigo were determined to be neither indigo nor Tyrian. Tyrian purple is not present among any of the textile fragments analyzed in this study. This shows that the influence of “purple mania” did indeed reach as far as Fag el-Gamous, but “true purple” did not.

While it would be very interesting to find a textile dyed with Tyrian purple in this necropolis, it does not seem likely in this context. First, the Fayoum is removed from the main thoroughfares of trade. Geographically, the Fayoum is not close to the major ports and cities in Egypt. While trading certainly reached this far inland, it seems rather unlikely for this particular commodity to travel so far from its origin to a non-royal population. Second, those buried in the cemetery of Fag el-Gamous had rather poor burials, indicating that the inhabitants or those who buried them were of a lower socio-economic status in life,³⁴ and thus would not have had access to Tyrian purple-dyed textiles. The lack of Tyrian purple is consistent with what is currently thought about the people using this necropolis; they were not wealthy. Further excavation may improve upon this current understanding.

³⁴ See the article on the burial of the common man in this volume.