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READING INVISIBLE INK: DIGITAL IMAGING OF P.DUK.INV. 716

aus: Zeitschrift für Papyrologie und Epigraphik 127 (1999) 127–130

Reading Invisible Ink: Digital Imaging of P.Duk.Inv. 716

P.Duk.inv. 716 is among a lot of papyri acquired by the Special Collections Library at Duke University in 1979.[1] The poor legibility of P.Duk.inv. 716 has made it virtually unpublishable. Recently, however, Weinberg and Johnson introduced digital imaging methods (procedure described below) that make the first four lines, hitherto invisible to the unaided eye,[2] (Fig. 1) easily legible. The new readings allow us to place the text in its historical context. The method of the text's decipherment merits its prompt publication.

Imaging technology, equipment and procedure

The original papyrus, sandwiched between two glass plates,[3] was illuminated with a tungsten-halogen fiber-optic light source, modified to permit insertion of band-pass interference filters into the light path. Images were acquired with a 12-bit cooled CCD camera (Princeton Instruments) which employed a Kodak KAF CCD chip (1317 x 1035 pixels). An f2.8 MicroNikkor lens was used fully open for focusing, and stopped down to f8 for data collection. Images were captured and processed using IP Lab software (Scanalytics), on a Macintosh PowerPC host computer. Data were collected using filters of several wavelengths, including 540 nm (green, close to the maximum sensitivity of the human eye), 620 nm (deep red), 800 nm (near infrared), and 900 nm (infrared, approaching the longest wavelength to which the chip is sensitive). A long-pass gelatin filter was also tested (Kodak Wratten #29), which blocks wavelengths shorter than ~620 nm.

With monochromatic green illumination (Fig. 2) the papyrus was sharply defined, but the image was dominated by the texture of the papyrus, with the ink only marginally visible. At progressively longer wavelengths, details of the physical texture of the papyrus became progressively vaguer, with corresponding enhancement of the writing. Best results were with 900 nm illumination (Fig. 3). With further digital processing, the image could be considerably sharpened (Fig. 4). Similar results could be obtained with Adobe Photoshop, using the "Unsharp" filter followed by "Adjust Levels." Only slight global improvements beyond this image could be obtained by further image processing, but interactive "tweaking" of the image (in IP Lab or Photoshop) could make specific characters more visible. Results with the gelatin filter were almost as good as with the 900 nm bandpass filter, presumably reflecting the predominantly infrared output of tungsten light sources.

The improved visibility of the text in the final images (Figs 3 and 4) is likely to arise from several factors: a) surface texture reflectance is reduced at longer wavelengths; b) by penetrating deeper into the sheet without reflection, infrared light may be more sensitive to traces of ink that have soaked into the matrix of the papyrus; c) small differences in reflectance are more readily detected by instruments than the unaided eye, thus allowing interactive adjustment of contrast and luminance of the captured image to make previously hidden details visible; and d) digital signal processing can sharpen details blurred by time, by physical damage, and by imperfections in the image acquisition process itself.

Similar results could be obtained with considerably less costly components than used here. Narrow-band interference filters attenuate the light severely, thus requiring a highly sensitive camera, but with a

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[1] See Duke University Special Collections Library, *Duke Papyrus Archive* [*DPA*], <http://scriptorium.lib.duke.edu/papyrus/texts/acquisitions.html> 1999.

[2] See *DPA*, <http://scriptorium.lib.duke.edu/papyrus/records/716.html> 1999, for 72-, 150- and 300dpi scans and a catalogue record.

[3] For techniques employed in conservation of the Duke papyri see *DPA*, <http://scriptorium.lib.duke.edu/papyrus/texts/conserving.html> 1999.

gelatin filter, sufficient light is provided by a standard tungsten-halogen lamp to eliminate the need for a cooled camera. In addition, gelatin filters with a longer wavelength cutoff than the #29 are available. While we used the filter on the light source, it may be more convenient to attach it directly to the camera lens. Twelve bit megapixel CCD cameras are now available for considerably under $8,000. We estimate that a full megapixel acquisition system could be set up for approximately $12,000, and a 2K x 2K system for less than $20,000.

The Papyrus

The text runs with the fibres of the pale tan papyrus in a fine hand, with thin, stick-like but confident strokes. The hand is very neat and the letter forms distinctly block-like. Right, left and top margins are preserved, but the entire lower half of the papyrus has been torn away. The upper portion, including the bulk of the first four lines is effaced and still carries gesso. The remaining gesso was left during preservation as it could not be removed without destroying more of the already abraded and easily flaked ink.

The decipherment of the first four lines, now possible through the aid of digital photography, enables us to put the text in its proper historical context. The text belongs with two, and possibly three, other papyri in the Special Collections Library that concern the affairs of Petosiris, a priest of the god Horos.[4] Petosiris was the Hawk-feeder (ἱερακοβοσκός) at a shrine in the village of Oxyrhyncha in the Fayum district of Egypt.

The text published here is the beginning of a petition by Petosiris to Phanias, strategos of the Arsinoite nome. In the related Duke texts, which appear to represent a second redaction of the same petition, Petosiris complains of the depredations of one of Phanias's subordinates. This agent of the strategos has, among other acts, arrested Petosiris' nephew in an incident that was evidently related to the collection of grain. Petosiris writes the strategos asking that the youth be released so that the two may return to their cultic duties.

Phanias is attested in numerous documents from Tebtynis as strategos of the Arsinoite between 140 and 137/6 BC, and perhaps as late as 135/4 BC.[5] Together, the Tebtynis texts and the other texts in the Duke collection suggest that in 140/39 BC the Nile flood was inadequate in segments of the Arsinoite nome and that Phanias played a part in resolving conflicts resulting from the diminished harvest. This petition may have been prompted by one such conflict.

Text

P.Duke inv. 716 10.1 x 9.5 cm. ca. 140–137/136 BC
<http://scriptorium.lib.duke.edu/papyrus/records/716.html> Arsinoite

Φανίαι τῶ̣[ν π]ρώτω̣ν̣ φίλω̣ν̣ καὶ
στρατηγῶ̣[ι κα]ὶ ἐπὶ τῶν προσόδων
παρὰ Πετ[οσί]ρ̣ιος τοῦ {Πετο}
4 Πε̣τ̣ο̣σίριος [ἰ]ερακοβοσκοῦ τῶν
ἐ̣ξ̣ ̓Οξυρύγχων τῆς Πολέμωνος
μερίδος. …

For complete text, translation and commentary see J.D. Sosin, "Abduction at the Threshing Floor: P.Duk. inv. 714-716," pages 131-140 in this volume.

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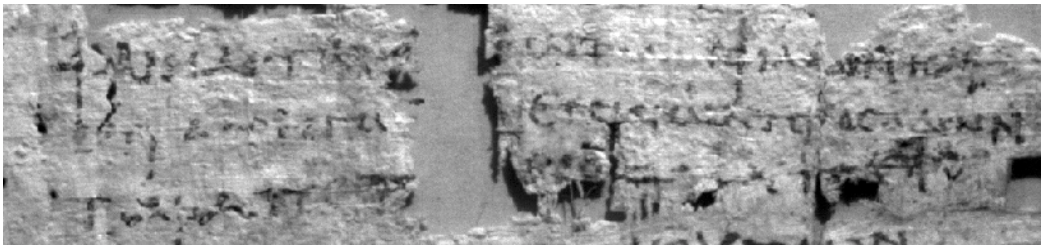
[4] For P.Duk.inv. 714–715 see J.D. Sosin, "Abduction at the Threshing Floor: P.Duk. inv. 714-716," pages 131-140 in this volume; see *DPA*, <…/papyrus/records/714.html>, <…/papyrus/records/ 715.html> 1999; 713 is a highly fragmentary text, whose first two lines, at least, can be read and restorerd confidently: Φανίαι τ̣ῶ̣[ν πρώτων φίλων καὶ] | στρατ̣[ηγῶι καὶ ἐπὶ τῶν προσόδων].

[5] *P.Tebt*. I 61b.351–378 (140/39 BC) [≈ I 72.349–380]; *P.Tebt.* III.2 959 (140 BC); *P.Tebt.* III 785, 786, 787 (ca. 138 BC); *P.Tebt.* I 61b 46 (137/6 BC) [≈ I 72d. 205]; *PSI* XIII.1310.1, 9 (135/4 BC).

Figure 1: 300dpi scan of P.Duk.inv. 716. Enlarged portion in box [lines 1–3].

Figure 2: monochromatic green illumination [P.Duk.inv. 716.1–3].



Firgure 3: 900 nm filter and modest digital sharpening [P.Duk.inv. 716.1–3].

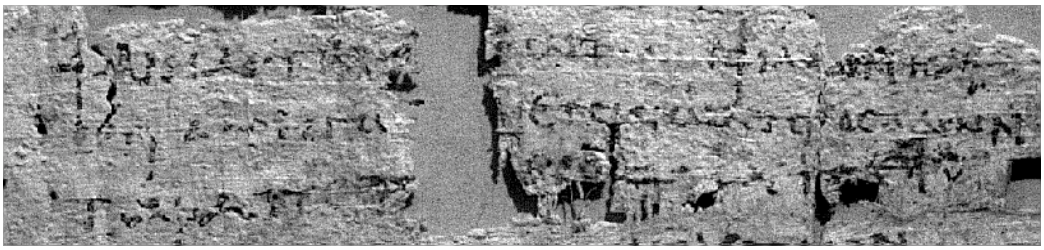


Figure 4: 900 nm filter with digital enhancements [P.Duk.inv. 716.1–3].

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