Cronaca

THE MEDIEVALIST'S GADGET: HYPERSPECTRAL PHOTOGRAPHY AND THE PHANTOM SCRIBE

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Except for archaeologists, scholars in the Humanities are typically not concerned with material issues, and in their field, the very idea of a 'laboratory' seems quite odd unless it is in the context of experimental phonetics. Since they primarily deal with concepts, the purely material conditions to which these concepts are connected usually seems irrelevant. Rather the situation recalls Rick's answer to Ugarte in *Casablanca*, when the latter asks him: «You despise me, don't you?» and the former says, indifferently: «If I gave you any thought, I probably would». Even most art historians will look first for an allegorical explanation of any detail in a work of art rather than to confront its materiality and the related technicalities.

Nevertheless, for all of us in the humanities, from philologists and historians to cultural and gender studies researchers, the evidence we work with is mainly recorded in written texts, both manuscripts and printed books or documents. These records are not concepts, but rather material objects, and even the most idealistic solipsist would agree that there is at least a difference in perception between these two categories. They both are separate even as mere phenomena appearing to individual conscience and irrespective of the ontological *status* that could be ascribed to each one. Moreover, both manuscripts and printed books are the result of material procedures and conditions. Writing techniques are required to produce them and they are subject to physical damage. Consequently, in order to understand their production and inner con-

I wish to thanks Heather Bamford (PhD candidate at University of California at Berkeley) for her invaluable help in revising the English style of the present paper.

stitution, we must pay due attention to both material and conceptual aspects. Certainly, in order to reach the first goal, we have at our disposal material bibliography and codicology, but these usually constitute the realm of a few specialists, mostly paleographers and librarians. It is significant enough that the so called 'New Philology', even if it advocates for the primacy of scribal versions, is far more ready to give a conceptual interpretation of any variant or marginal addition than to take into the account the mechanics which could explain them.

This of course is not surprising when one notices that many analyses from approaches which are supposedly material positions derive (mainly through Heidegger) from a theory as idealistic and unempirical as Phenomenology. Nevertheless, it is not my present aim to make an argument against the hypertrophy of meaning, so typical in the Humanities ever since the formalization of exegesis methods by Church Fathers and Rabbinic Schools and even now, in contemporary Structuralist and Post-Structuralist Hermeneutics. Nor would I make a claim for any sort of naive positivism. I intend rather to show how the medievalist or, more widely, the textual scholar, can be helped by several tools when working with the materiality of cultural testimonies, specifically with manuscripts. Finally, this methodological topic clearly has some theoretical implications, as I will illustrate in the present study.

It is hardly surprising that the techniques I will describe were first adopted by classical scholars devoted to the study of palimpsests, the deciphering of which has challenged experts since the Renaissance. I am referring specifically to a research project sponsored by the European Community entitled *Rinascimento virtuale: Digitale Palimpsestforschung*, whose leader was the renowned specialist in Greek manuscripts professor Dieter Harlfinger, from the University of Hamburg.[1] Nor it is a wonder that the techniques themselves come from the field of art expertise and restoration (curatorship), in this case led by Forth Photonics, a Greek enterprise formerly devoted to biophotonics and optical molecular imaging focusing on the development of automated devices for the non-invasive optical detection, screening and guided therapeutics of cancerous and pre-cancerous lesions. Thanks to the joint efforts of palimpsest researchers and medical optics experts, a non-destructive and non-invasive technique has been developed, allowing the recuperation and virtual restoration of texts which are scarcely legible.

[1] For further information, the web site of the Project is accessible *on line* at http://www1.uni-hamburg.de/RV/

At the center of this new technique is the hyperspectral imaging system.[2] It not only enables the capturing of images in several narrow spectral bands in a wide spectral range, but also the recording of a full spectrum per image pixel (figure 1). This technology consists of

> a computer controllable hyper-spectral imaging apparatus, capable of acquiring spectral images of 5 nm bandwidth and with 3 nm tuning step, in the spectral range 380-1000 nm. The critical component of the apparatus is the innovative imaging monochromator, which enables the tuning of the imaging wavelength. This module is coupled with a two-dimensional detector array composing a tunable wavelength camera system. Electronic controllers are employed for detector and monochromator synchronization and driving, while the system calibration, image processing and analysis are performed with the aid of specially developed software. The system records light intensity as a function of both wavelength and location. In the image domain, the data set includes a full image at each individual wavelength. In the spectroscopy domain, a fully resolved diffuse reflectance and/or fluorescence spectrum at each individual pixel can be recorded.[3]

This «hyper-spectral imaging apparatus» is the MuSIS hyperspectral camera produced by Forth Photonics, which is sensitive in the spectral range from 365 nm (ultraviolet) to 1550 nm (near infrared) and can provide material information and accurate documentation of any kind of written record by means of a non-destructive analysis. Since the system is calibrated to the ambient light conditions, documentation essentially becomes independent of existing conditions, even with very low illumination, should it be necessary for purposes of preservation. The result is a spectral cube that is an image stack comprised of images spanning the entire spectrum (figure 2). In the case of the MuSIS-HS camera,

[2] A previous technique, the multispectral analysis, was developed by «Fotoscientifica» (Parma), cfr. D. Broia, C. Faraggiana di Sarzana, S. Lucà, *Manoscritti Palinsesti Criptensi: Lettura digitale sulla banda dell'invisibile. Test sperimentale condotto in collaborazione con l'Abbazia di S. Maria di Grottaferrata e con la Cattedra di Paleografia Greca dell'Università di Roma - Tor Vergata*, Ravenna, Parma, Università di Bologna, 1998, and D. Broia, C. Faraggiana di Sarzana, «Per una rilettura del palinsesto *Vat. Gr.* 2061A: saggio di ripristino digitale e di edizione diplomatica del *Nomocanone* alla luce del sistema RE.CO.RD®», *Bollettino della Badia Greca di Grottaferrata*, n. s., 53 (1999), pp. 67-78, who provide a detailed report on technical and practical questions.

[3] Costas Balas, Vassilis, Nicolas and Antonis Papadakis, Eleftheria Vazgiouraki, George Themelis, «A novel hyper-spectral imaging apparatus for the non-destructive analysis of objects of artistic and historic value», *Journal of Cultural Heritage*, 4 (2003), pp. 330-337 (quotation on p. 330).

a full stack consists of thirty images. This means that for any picture taken of a given manuscript sample, the hyperspectral camera shoots thirty photographs, each one sensitive only to a specific wavelength, from ultraviolet to infrared (figure 3). Owing to the fact that different materials absorb some wavelengths of the whole spectrum and transmit others, such a procedure allows us to see at a distinct spectral point specific kinds of elements and not others. That proves very useful when the text of a manuscript is darkened by a stain, because the underlying writing would be visible at a particular band of the spectrum where the stain becomes 'transparent', so to speak. In general, the shots sensitive to ultraviolet light allow for the enhancement of faded ink, while those sensitive to infrared light are usually more useful for studying the writing surface. Hyperspectral imaging provides the capability of acquiring and determining the optimum imaging conditions for a given case. However, further digital enhancements of the images are often required in order to achieve the appropriate differentiation between the distinct strata composing the object, which in the case of manuscripts are the writing surface, the ink or other pigment employed by the primary scribe and, finally, any other product later added over them.

An excellent test case is provided by the unique manuscript of *Cantar de mio Cid*, at the Spanish National Library (ms. Vitr. 7-17), which I had the chance to examine, together with two other members of my research team, on May 2007.[4] As it is well known, from at least the later sixteenth century to the start of twentieth, this manuscript has suffered from the application of chemical reagents.[5] The reactants enhance the faded ink, rendering it, for a time, easier to read. Later, however, a black stain appears where the chemical product had been applied. As a result, at present there are several passages that are almost or wholly illegible. For example, we can see the damage which the last page of the poem has suffered, here shown under ultraviolet light in figure 4.

Moving to the verso of folio 23 (figure 5), we can see that due to the effect of reactants, line 21 of this page (v. 1124) is hardly legible, even in this high resolution digital photograph taken under direct white light.

[4] Thanks to the combined efforts of the Biblioteca Nacional de España itself, the CiLengua (a division at the Fundación San Millán), and the official Spanish Research Project «Genesis y transmisión de la material cidiana en la Edad Media y el Siglo de Oro».

[5] See Alberto Montaner Frutos, «Ecdótica, paleografía y tratamiento de imagen: El caso del *Cantar de mio Cid*», *Incipit*, XIV (1994), pp. 17-56. In this paper I explained the problems of legibility of the manuscript and the use of a less powerful tool, the surface exploring video-microscope, in an attempt to resolve them.

On the other hand, in the conventional facsimile editions only some isolated strokes are barely visible (figure 6).[6] In this case, the photograph sensitive to 540 nm wavelength (greenish-yellow light) offers the best visualization of underlying image, but still is not enough (figure 7). Here, the Resolve program, a specific Manuscript Image Analysis Utility powered also by Forth Photonics proves useful. After selecting three points of interest corresponding to 'Upper Script' (in this case, actually the stain of reagent), 'Lower Script' and 'Background', the program employs mathematical and statistical approaches that aim to determine the relative abundance of materials depicted in hyperspectral imagery based on the materials' spectral characteristics. This procedure allows for the increase of the difference of brightness and contrast between the three aforementioned levels, and then for the recovery of the hidden text. As a result, the hidden text 'Hyremos ver' is now clearly visible (figure 8).

The next case is an even more damaged point in the manuscript, the 24th line of folio 6, corresponding to line 269 (figure 9), which Menéndez Pidal transcribed as «Fem ante uos yo τ u*e∫tr*as ffijas yffantes ſon τ de dias chicas».[7] Both in the manuscript and in the facsimile editions (figure 10), the last word is illegible, covered by a stain of reagent. According to Menendez Pidal 'Con reactivo se lee *chicas*', what is the text offered by all editors, myself included. Here again, the hyperspectral camera allows us to reveal the hidden text. The most useful shot is that sensitive to 620 nm wavelength (orange light), but it is necessary to be accustomed to the letter of the manuscript in order to recognize the text (figure 11). For an untrained eye a further processing is needed and again the use of Resolve's 'analysis 3 algorithm' is useful. That allows for the confirmation of Menéndez Pidal's reading. Nevertheless, the word is not properly *chicas*, as meaning requires, but *chias*, since -*c*- is absent (a typical scribal error due to the similarity of cursive gothic *i* and *c*) and -*s* is superscript, to avoid being too close to the edge of the parchment (figure 12).

Of course, hyperespectral analysis is not a panacea. When the text has been deeply erased or, in general, has suffered very significant damage, there is no way to recover it. Even if there are traces of writing, at times they cannot be properly deciphered, as in verse 1668 (f. 34v), which contains an erased word (figure 13). The implementation of Resolve

[6] The best available facsimile is *Poema de Mio Cid*, which includes a volume of studies by H. Escolar *et al.*, Burgos, Ayuntamiento, 1982, 2 vols.; reprinted 1988.

[7] Ramón Menéndez Pidal, *Cantar de Mio Cid: Texto, gramática y vocabulario*, Madrid, Bailly-Baillière e hijos, 1908-1911; reprinted with additions, Madrid, Espasa-Calpe, 1944-1946, 3 vols. (quotation in vol. II, p. 917).

allows only for the recovery of some loose strokes which are not directly readable (figure 14), although comparison with the context shows that *madre*, whose small capital must have been the abbreviation *Mª*, followed by *del* eliminated by the second scrape, under rewritten *maria,* was probably written there. Despite these limitations, the hyperespectral imaging and associated devices constitute a powerful tool whose help in reading and editing damaged manuscripts is invaluable.

In addition to the capability of text recuperation, the new technique also has other uses which have even more interest for my goal in the present study. The use of hyperspectral imaging and information obtained by imaging in a multitude of narrow spectral bands has several advantages. Capitalizing on the fact that different materials will emit different, and quite often distinct, spectral signatures, the MuSIS systems provide unique material identification capabilities. A spectral signature is available for each pixel point in the image, providing the information required for an accurate material identification. In the figure 15[8] we can see the procedure: from the actual letter (A) a hyperspectral stack of images (B) is taken, allowing us to draw the reflectance vs. wavelength curve of the pigment employed in writing this letter. Comparison with a sample of the same curve traced for several widespread red pigments (C) reveals that the one used for painting the capital T is vermilion.

This tool has an interesting use for a textual scholar, namely the possibility of distinguishing between several written interventions in a manuscript. For example in folio 19 verso of *Cantar de mio Cid*, what appear to be three different hands are present, the original one (which appears very light in the image), and two others which are darker. Due to the slash of the final *-a* of *preaua* (figure 16), the text on the folio appears to be the work of several scribes. Nevertheless, their reflectance vs. wavelength curves are very similar, flatter than the curve of the original writing and with a remarkable inflection at 750 nm (figure 17). That shows that the material composition of the ink is the same for the two additions and identifies them as made by the same hand. After running the Resolve program, the resulting image confirms this conclusion, since nearly all other elements are faded and only the later additions remain on the screen (figure 18).

Folio 3 verso (figure 19) is an even more difficult case, in which several written interventions of the same scribe are found, in addition to

[8] Adapted from Balas, Papadakis, Vazgiouraki, Themelis, «A novel hyper-spectral imaging...», cit., p. 335.

other, entirely different hands. The paleographic analysis can determine which letters are the work of the scribe and which are not, but it can be scarcely helpful when the later have fairly similar strokes. On the other hand, it does not provide useful tools for distinguishing between the various interventions of a single hand. On the contrary, the hyperspectral analysis does not allow the scholar to identify hands. It is extremely accurate, however, for identifying inks. Thus, the combination of both paleographic and hyperspectral variables proves to be very enlightening. Figure 20 shows the difference between spectral reflection curves of the original text of the copyist, with more (A, A' and A") and less ink in the pen (A'", A'^{v}), and its interventions in the first (B) and in the second (C) *recognitiones*, or control revisions of copied text, besides the addition of the other aforementioned hand (D).

As the above cases illustrate, hyperspectral analysis not only has material and concrete consequences, but also theoretical ones. Indeed, the need of such an assistant reveals the true complexity of manuscript constitution and the often insurmountable problems which anyone must confront when reading them. Moreover, it makes us become conscious that, even if one codex has no problems of legibility, it doesn't mean it is without textual problems. I am not now referring to problems of *constitutio textus*, but more simply to problems about what word we must read on the page: the first written by the scribe, the one he corrected, or, the one modified by another person?

It is for this reason that I wonder whether there is such thing as a 'scribal version', because the rendering of a text in a single manuscript can involve, as we have seen, several hands. At times these hands can be very distant from one another in time and differentiating between them is not always easy. It is important to note that the very act of pointing out the differences is a kind of interpretation: is this not the opposite of the Edenic state in which the 'scribal version' must be read? If we must interpret the manuscript, why not interpret the text itself, that is, make a true edition and not just a transcription?

What I hope to communicate here is that there are not unconditioned readings and that a direct consultation of the manuscripts, as opposed to the supposed fake of the editions, is no guarantee of authenticity. On the other hand, doing a naive reading which disregards the complexity of the phenomenon and not employing the available tools, such as the hyperspectral camera, is, at the very least, useless. However, if we can resort to new techniques and use experimental methods to help us, it is assumed that there is a criterion of priority which allows us to order the inter-

ventions in a hierarchical manner. If such a criterion exists at the material level, why not admit that it can also exist at a conceptual one? Thus, why not admit that the text has a coherence in itself and that we can also use criteria of inner cohesion when making judgments about variants? Indeed, I'm not speaking about authorial preferences, but about the mechanisms of a literary artifact, which underlay the text surface just as the writing stands under the stain of reagents. Better yet, we might describe it as a textual stimulus that produces, as a reader response, a cognitive reaction in the form of a mental object provided with an internal coherence which makes it possible to distinguish between its own components and the elements added or modified in transmission, in the same way that we can do, thanks to hyperspectral analysis, with the different hands and inks on the surface of the written page. Accordingly, if we really deal with texts and not with mere sets of letters, we cannot limit ourselves to reading isolated testimonies and grant the scribe too great of a role in literary production. For if the author is dead, the scribe is only a phantom.

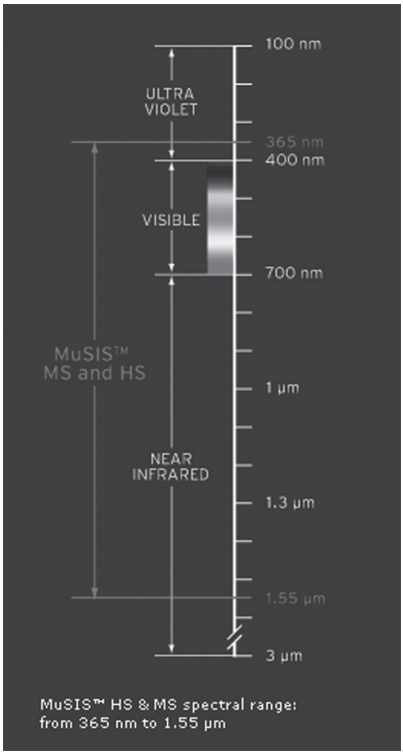

FIGURE 1
Range spectrum covered by the analysis of hyperspectral camera Musis (reproduced courtesy of Forth Photonics)

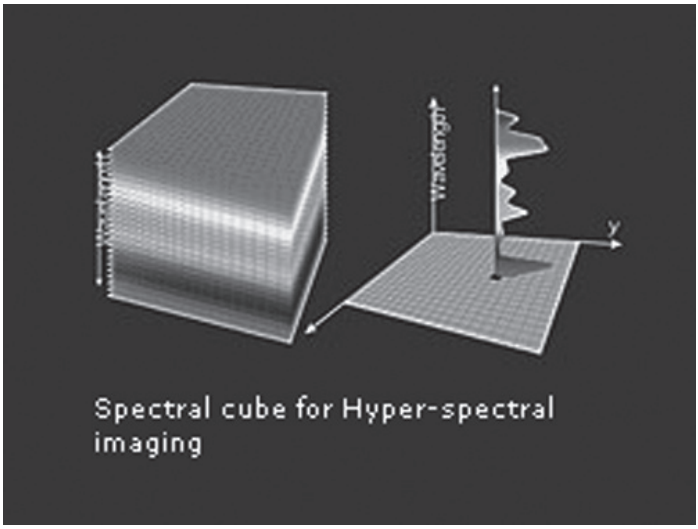

FIGURE 2
Characteristics of a spectral cube stored together with the resulting image and spectral curve for a given pixel (reproduced by courtesy of Forth Photonics)

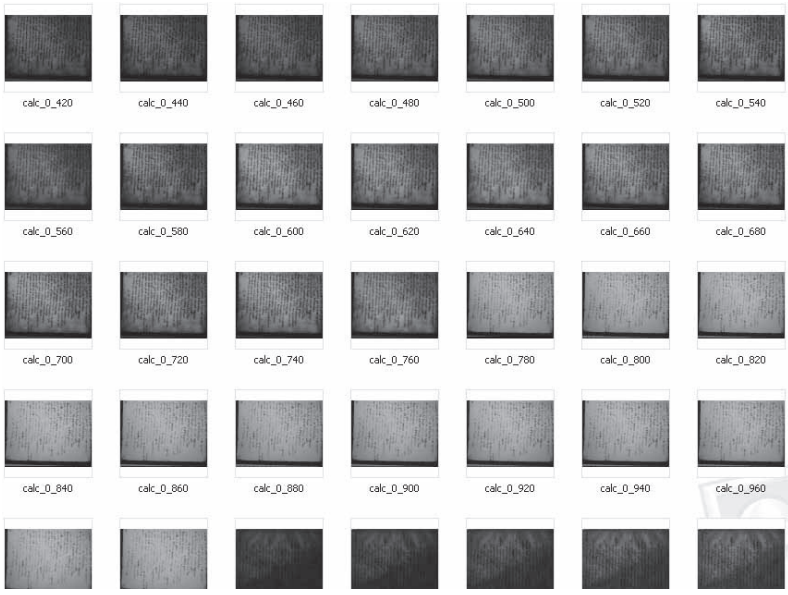

FIGURE 3
Sample of a hyperspectral set of thirty shots, one in every hundred nanometers along the preset spectral range (from f. 63r of *Cantar de mio Cid*)

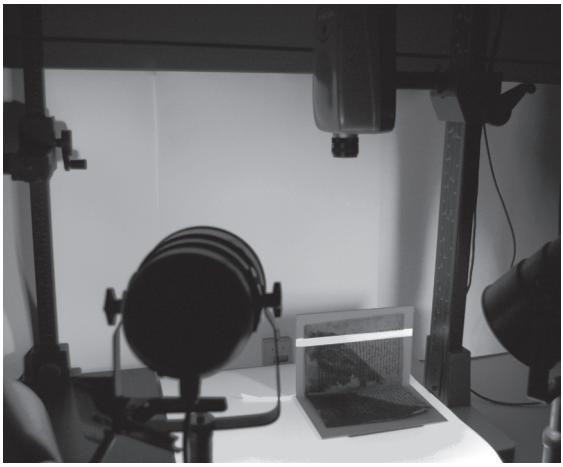

FIGURE 4
The last sheet (f. 74r) of *Cantar de mio Cid* under ultraviolet light

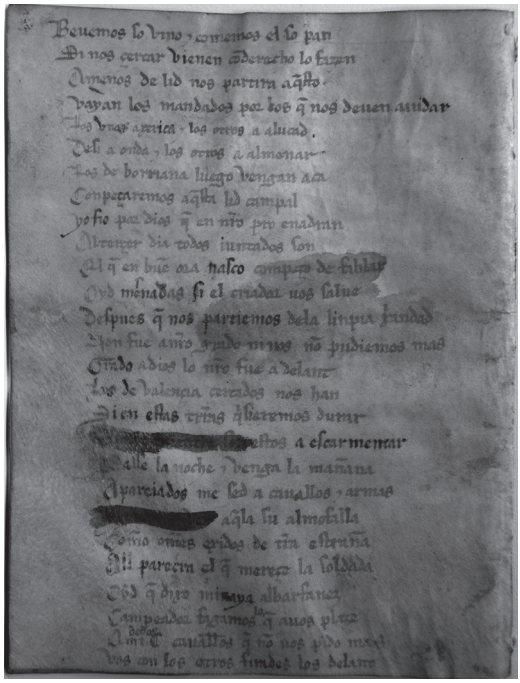

FIGURE 5
Cantar de mio Cid, f. 23v, showing the effect of reactants (photography of the actual manuscript)

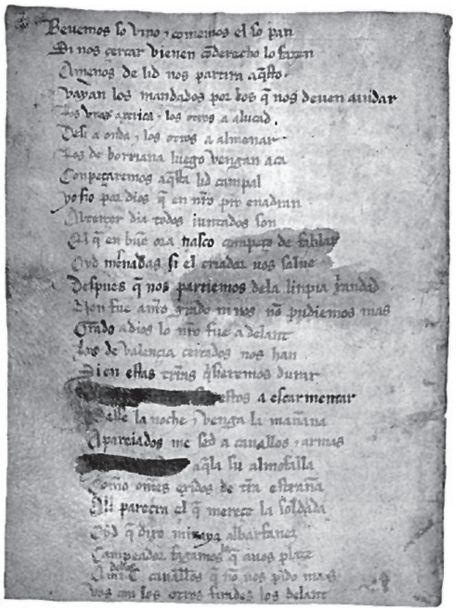

FIGURE 6
Cantar de mio Cid, f. 23v, as it appears in a conventional facsimile edition

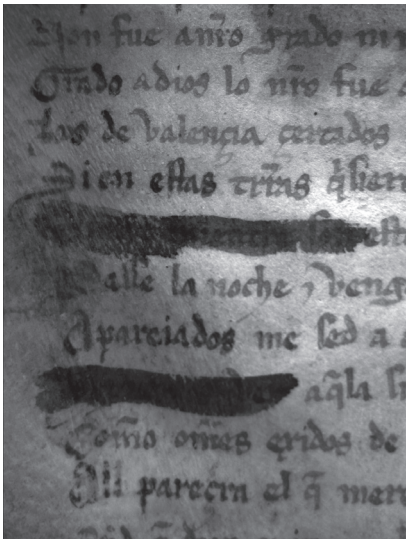

FIGURE 7
Detail of *Cantar de mio Cid*, f. 23v, as it appears in the shoot sensitive to 540 nm wavelength

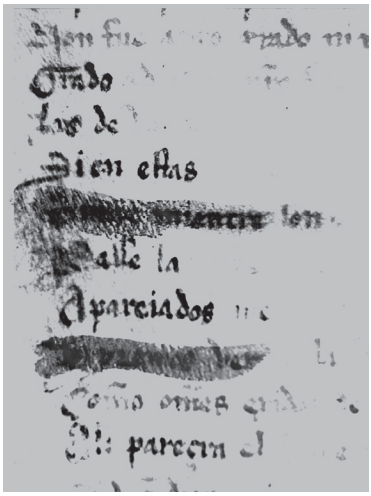

FIGURE 8
Detail of *Cantar de mio Cid*, f. 23v, after applying the 'analysis 3 algorithm' of Resolve program

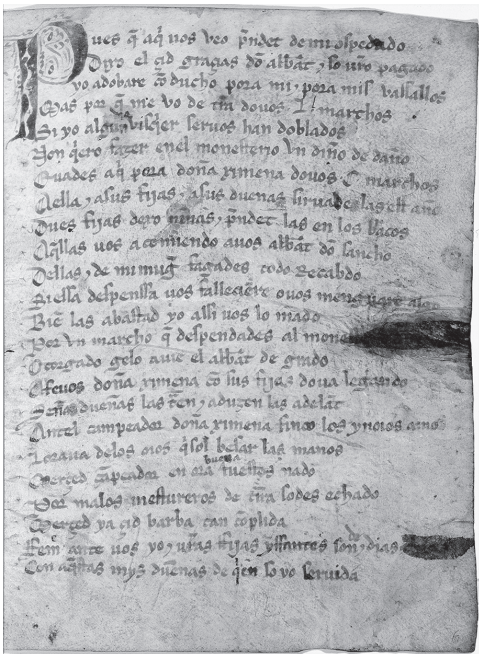

FIGURE 9
Cantar de mio Cid, f. 6r (photography of the actual manuscript)

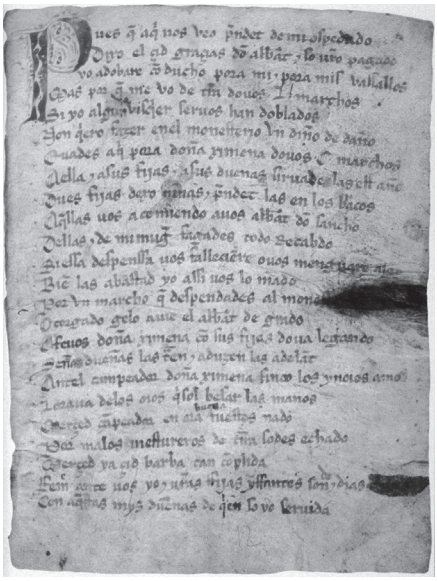

FIGURE 10
Cantar de mio Cid, f. 6r, as it appears in a conventional facsimile edition

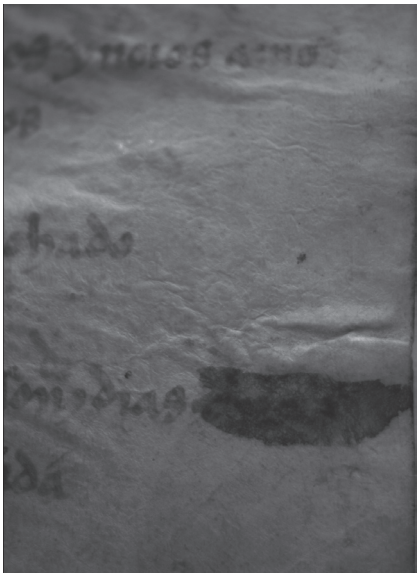

FIGURE 11
Detail of *Cantar de mio Cid*, f. 6r, as it appears in the shot sensitive to 620 nm wavelength

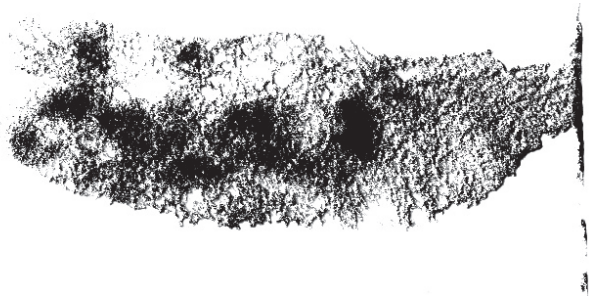

FIGURE 12
Detail of *Cantar de mio Cid*, f. 6r, after applying the 'analysis 3 algorithm' of Resolve program

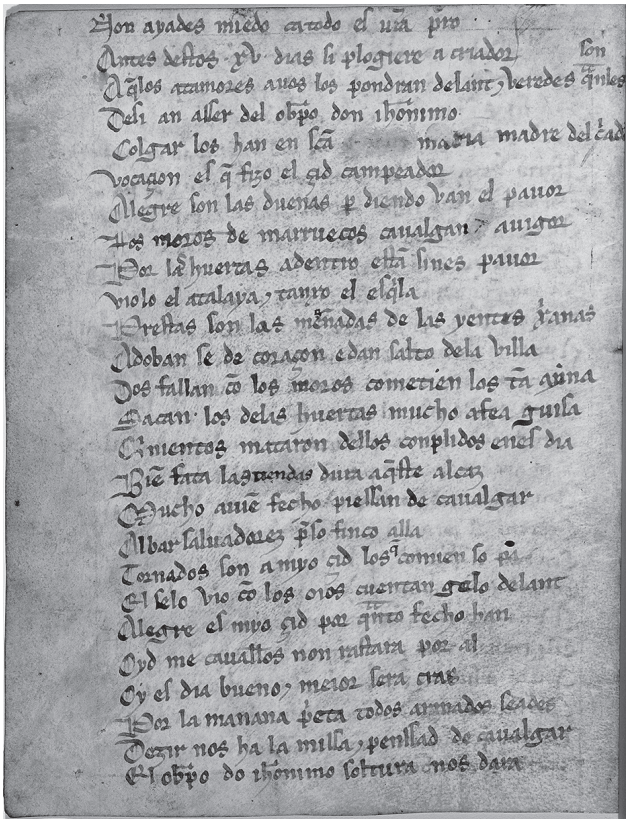

FIGURE 13
Cantar de mio Cid, f. 34v (photography of the actual manuscript)

FIGURE 14
Detail of line 1668 *Cantar de mio Cid*, at f. 34v, after applying the 'analysis 3 algorithm' of Resolve program

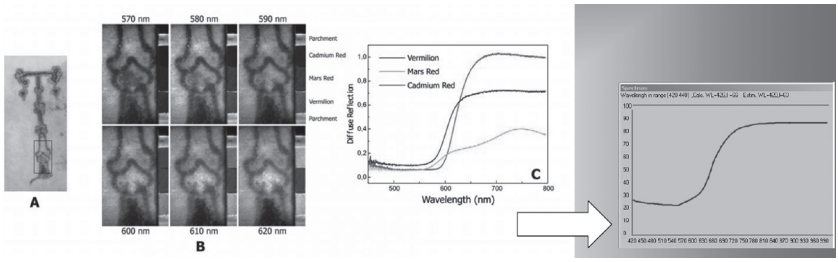

FIGURE 15
Analysis of pigments from the spectral curve (reproduced courtesy of Forth Photonics)

FIGURE 16
Cantar de mio Cid, f. 19v, as it appears in the shot sensitive to 660 nm wavelength

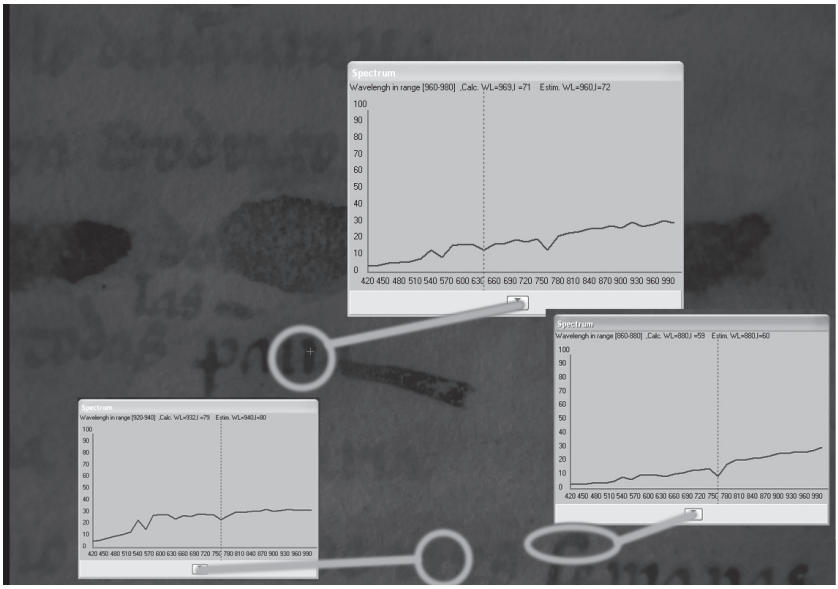

FIGURE 17
Spectral curves for the various inks used by the hands involved in the f. 19v of *Cantar de mio Cid*

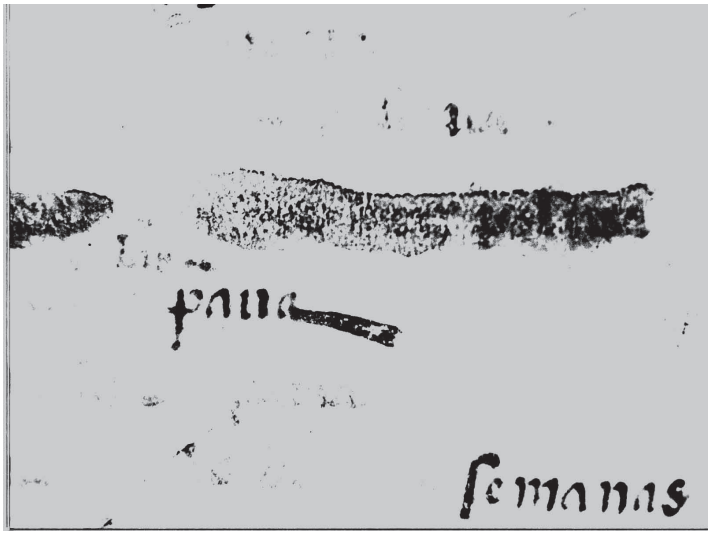

FIGURE 18
Detail of *Cantar de mio Cid*, f. 19v, after applying the 'analysis 3 algorithm' of Resolve program

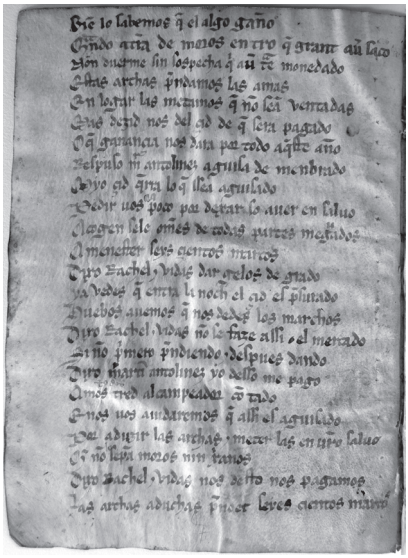

FIGURE 19
Cantar de mio Cid, f. 3v (photography of the actual manuscript)

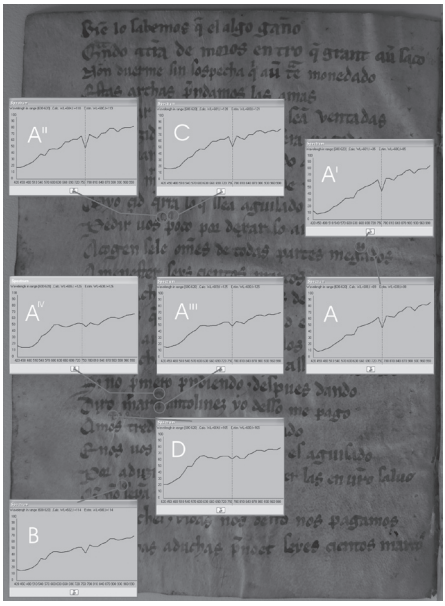

FIGURE 20
Spectral curves for the various inks used by the hands involved in the f. 3v of *Cantar de mio Cid*