

# Assessing historical printed materials using the combination of historical information and imaging techniques. Case study: Greek postcards of the early 20th century

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## Abstract

This study investigates the combination of historical researches, multispectral microscopic imaging techniques and the color computational analysis of the historical postcards in order to retrieve information on the historical techniques and materials used in the printing of Greek postcards produced by Aspiotis' industry in the first years of the 20th century. The proposed methodology consists of in situ, innovative and non-invasive techniques that were applied in order to study these historical postcards. The collected historical information on the postcards gave significant information on the producing techniques and materials used during this process.

This methodology can provide us with information related to the printing techniques based on the printing texture. Moreover, the contemporary digital process into the graphic arts production leads the old production techniques to the oblivion and, thus, significant parts of the graphic art evolution can be lost. Both the retrieved historical information and the microscopic printing textures allow, firstly, the contemporary graphic arts industry to reproduce these works on better terms and, secondly, the historical research to enrich its knowledge about the production of historical graphic artworks. In addition, not only can the comparison of these aspects, that is, historical information and image-based techniques, give us information related to the manufacture techniques of postcards found in the Historical Archive of the National Bank of Greece, but also allow to determine the date of entry of these postcards.

## Introduction

Aspiotis' industry is a significant cultural industry in the more recent Greek history. "ASPIOTIS" has been the first and the largest graphic art industry in Greece since the last quarter of the 19th century (Vousoulinou, 2014; Agriantoni, 1986). The founder of the firm was Gerasimos Aspiotis and after his death in 1901, his son, Konstantinos took over the administration. Konstantinos Aspiotis was a well-educated and charismatic man who, before taking over the

Aspiotis' industry management, had studied in three different European countries (Austria, France and Switzerland), and had had an administrative experience acquired during his many years of sojourn and activity abroad. The company "ASPIOTIS", during the first period of the administration of Aspiotis' brothers, printed a series of postcards that were reproductions of works of art by well-known Greek artists of the time, who painted works of art

specifically for this purpose. Nowadays, many of these postcards are kept in the Historical Archive of the National Bank of Greece, as well as sample books containing postcards, posters with similar themes, and some paintings that were created for this purpose.

In recent years many studies have been conducted on postcards and their collections. Both in the past and in the present postcards played a communicative role between people and for this reason they were often a source of collection. Nguyen et al. (2021) applied statistical analysis on the printing patterns under a microscopic scale in order to identify forged printed documents. Lear (2008) used old postcards as a historical document and she connected them with the American history and the American culture during the 19th century. Koopman (2008) presented the relationship between postcards and the historical information that can be retrieved from them as important elements of enrichment in library studies. Bergman et al. (2005) presented an option for color image segmentation applied to printing quality assessment in offset lithographic printing by measuring an average ink dot size in halftone pictures. Karabelas (1999, 1998) studied many of the postcards produced by Aspiotis' industry and gave important information on the painters and paintings used in the postcards production in the 20th century and elements on the dating of postcards. Gascoigne (1995) tried to identify printing documents based on their texture of image.

The present research consists of a preliminary research on the historical postcards produced by Aspiotis' industry in the early 20th century (1900-1940). Its aim is, first of all, to present some series of postcards created in the early 20th century (Figure 1). Another issue of the

study is to retrieve information about the process and techniques that had been used by Aspiotis to produce postcards of such high quality.

The steps of the study followed three directions, the historical research, the application of imaging techniques and the computational analysis of the image taken by using imaging techniques:

- During the historical research, any historical information on the postcards produced by Aspiotis' industry was collected. This information has been collected from documents belonging to the Historical Archive of the National Bank of Greece, as well as historical evidence that other researchers made reference to, relative to Aspiotis' industry (Frantzeskakis, 1973)
- The microscopical multispectral imaging was applied on the historical postcards belonging, on the one hand, to the Historical Archive of the National Bank of Greece and, on the other hand, to a private archive in order that the producing techniques in postcards and the basic colors that were used will be studied and identified.
- Finally, the image analysis was used on microscopical images of the historical postcards in order to find elements of differences or similarities among postcards.



Figure 1: Postcards reproducing paintings by Bokatsiabis, a famous Greek painter of that time, are shown in the lower right corner of the respective paintings. Historical Archive of the National Bank of Greece

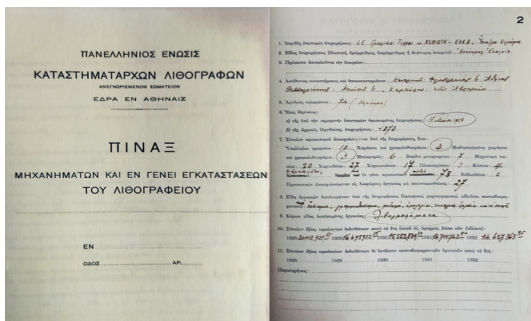


Figure 2: The first pages of a list of machines from the Union of Lithographers in Greece in 1927. Historical Archive of the National Bank of Greece.

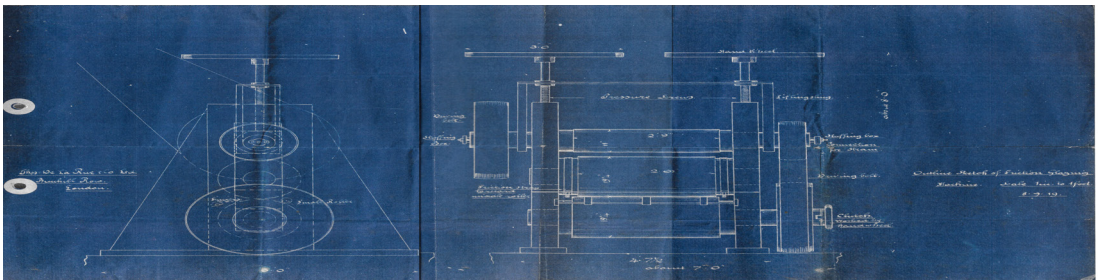


Figure 3: The blueprinting of a machine made by the firm "Thomas de la Rue & Company" from London. Historical Archive of the National Bank of Greece

The historical postcards studied were:

- The postcards of an unknown date belonging to the Historical Archive of the National Bank of Greece
- The postcards belonging to a private archive with dates written on them

Postcards of Historical Archive of National Bank of Greece



Figure 4: Postcards with unknown sending date. Historical Archive of the National Bank of Greece



Figure 5: Postcards with known sending date

In Figure 4 some postcards from the Historical Archive of the National Bank of Greece are presented and in Figure 5, postcards from a private archive. These postcards from the private archive have the date they were sent written on them. Although this date is not the production date, it should be seriously taken into account as a reference date.

## Methods

Methods for the three aspects of analysis are presented: historical researches, multispectral imaging techniques, and computational visual analysis.

### Historical Researches

Historical information on the historical postcards produced by Aspiotis' industry has been collected from historical documents belonging to the Historical Archive of the National Bank of Greece, as well as historical evidence referred to by other researchers relative to Aspiotis' industry and especially, information on the producing techniques and materials used during this process.

Historical information retrieved from the Historical Archive of the National Bank of Greece consists of various historical issues during the existence period of Aspiotis' industry, such as, contracts, blue printings of machines, lists of machines that belonged to the industry from the Union of Lithographers in Greece, letters written by technicians of the industry and text evidence from people having worked in the industry.

A typical example of the historical researches on Aspiotis' industry is the contract of 1912 (Figure 6), signed between Aspiotis and the Greek State which makes reference to the production of play cards, which were produced in addition to the postcards analyzed in the present research. This contract is in the Historical Archive of the National Bank of Greece and mentions to the following:



- Konstantinos Aspiotis was the person responsible for the continuing production of the play cards printed from 1901 (the year of his father's death) until 1904, as we can see on the right in the middle image. Moreover, he was responsible for de novo production of play cards until 1912.
- In this contract, we are also presented with various technical information about the printing process of play cards, such as the use of four colors in printings of play cards (at least since 1904), as we can see on the lower right image where the use of four basic colors in the printing of play cards is written.

Another typical example is the newspaper "Vradini" (Figure 7), in which it could be read that in Aspiotis' industry, it was the first time in Greece that postcards depicting paintings of well-known Greek painters had been printed using the three basic colors, as well as, that in Aspiotis' industry there are 33 departments covering the various printing procedures.



Figure 7: The newspaper "Vradini" of 1929. Historical Archive of the National Bank of Greece.

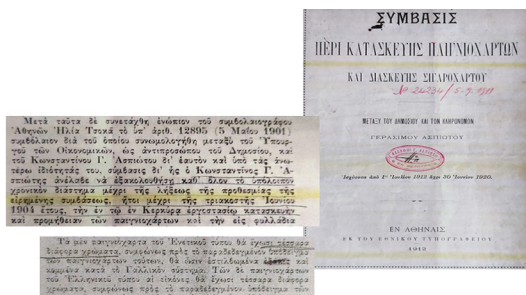


Figure 6: The contract of 1912. Historical Archive of the National Bank of Greece

### Multispectral imaging techniques

The aim of the microscopical multispectral imaging was to retrieve the traces of the used printing process and the spectral information of the colors in use. The researchers took microscopical images in four different bands of the electromagnetic spectrum:

- in the Visible band from 420-780nm
- in the Ultraviolet, at the length of 395 nm
- in the Infrared, at the length of 975nm
- in the band between 400-420nm, where the phenomenon of fluorescence observable.

All microscopical images were taken using DinoLite digital microscope in different magnifications of 30 times, 70 times and 180 times.

In Figure 8 a typical example of multispectral microscopical imaging is presented. On the

left, there is the original postcard with the no 153<sup>1</sup> derived from the Historical Archive of the National Bank of Greece, and on the left in two lines, there are its microscopical images. From left to right, the images in the columns were taken in the magnifications of 30 times, 70 times and 180 times.

In Figure 9, there is another type of example. At the bottom, in the center, the original image of the postcard with the no 113 derived from the Historical Archive of the National Bank of Greece can be seen. On its right, there is a magnification of 30 times shown a man's face who is dancing. In the upper line, we can see images in a magnification of 180 times, in the four different bands of the electromagnetic spectrum. From left to right, we can see the image in the visible band, in the band between 400-420nm, in the length of 395 nm and, finally, in the length of 975 nm.

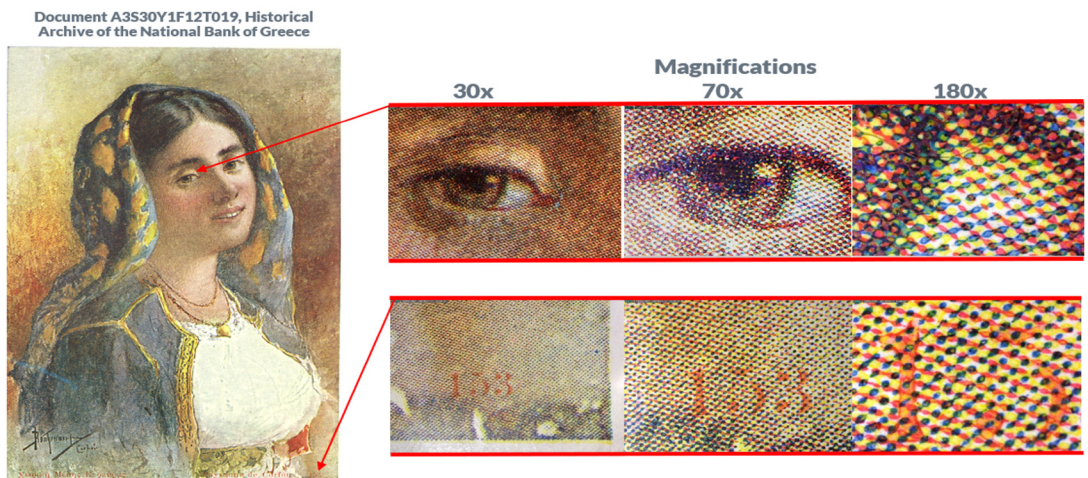


Figure 8: A typical example of a microscopical imaging of a postcard with the no A3S30Y1F12T019<sup>2</sup>

<sup>1</sup> Numbering of Aspiotis' Library

<sup>2</sup> Numbering of the Historical Archive of the National Bank of Greece

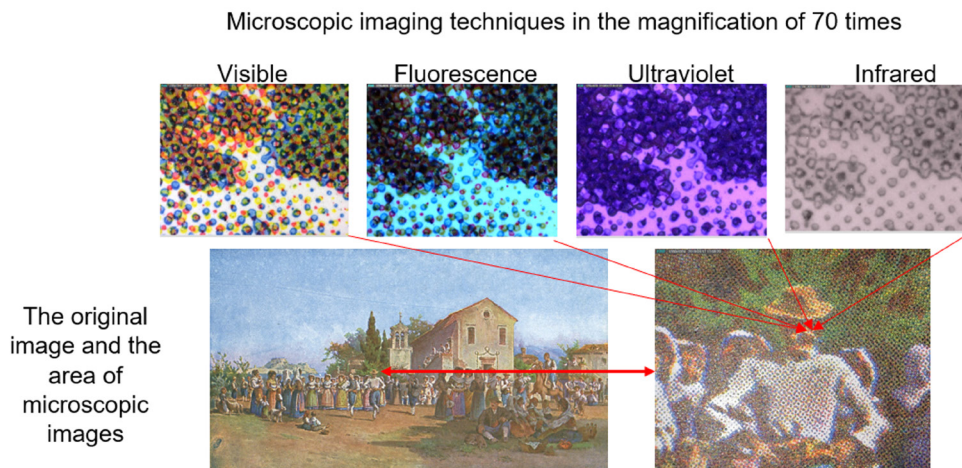


Figure 9: A typical example of a microscopical imaging

In the fluorescence image (400-420nm) it is observed that pseudochromes have been created according to the fluorescence or not and their reflectivity of the colors. In the ultraviolet image, the colors present different absorptions and, finally, in the infrared image, the blue and black color present a slight difference of the absorption of this length while the red and yellow color do not have any absorption in the infrared band.

### Computational visual analysis

Computational visual analysis is a non-invasive technique and can be based on color analysis, a method used in the postcards printing. In this study it was examined if a relationship in the use of the basic colors on the historical postcards can exist and if this relationship can provide knowledge about the postcards on which no information is written. It was considered that the comparison of the three basic colors of the historical postcards with known and unknown dates could enrich our knowledge on them if we compared them to each other. Therefore, the image-based analysis was

applied to two types of these postcards: to those with no date of sending (postcards come from the Historical Archive of the National Bank of Greece) and to those that the date of sending is known (postcards from a private collection).

The computational analysis has two directions:

- First, the computational characteristics of the basic colors of the postcards with known and unknown dates were tried to be found.
- Secondly, these features were compared in the two different types of postcards to see if they matched

Thus, in the case that the colors matched each other, it could be considered that the postcards were produced in a similar period of time; otherwise, they were produced in a different period of time.

Computational techniques were based on the following steps:

- The color segmentation of the microscopical images. During segmentation the microscopical images were segmented into the three basic colors (Gonzalez, 2004).
- The HSV values<sup>4</sup> of the basic colors were measured. Taking into consideration these measurements, hue, saturation and values of the HSV system we created histograms for each measurement of each color from the basic ones.
- Statistical measurements were applied to these histograms, such as the mean, the standard deviation, etc. The mean values of these measurements in HSV system gave valuable results for the comparison of the basic colors of historical postcards.
- All colors should be on a white support.
- The thickest areas of color with the greatest density were chosen, because, according to the Kubelka - Munk law (Kubelka et al. 1931), the color reflectivity of a layer is influenced as little as possible by the support reflectivity when the color layer is thicker.
- Areas were chosen not displaying a local glazing, especially, when these areas have a large dense of color.
- Another important point to take into account is that the selected color areas should contain only one color that does not overlap another one.

In Figure 10, an example of the image segmentation of microscopical image into the three basic colors of the postcard is presented. During the segmentation selection, the areas were chosen to be segmented with the one of the basic colors; for instance, red, blue or yellow<sup>5</sup>. Each color was separately chosen in order to segment because we wanted to analyze each color separately. Furthermore, this color area where the color reflectivity is not affected by the support reflectivity or is affected as little as possible was selected to segment. Thus, some criteria were created followed in each selection for the color segmentation, such as:



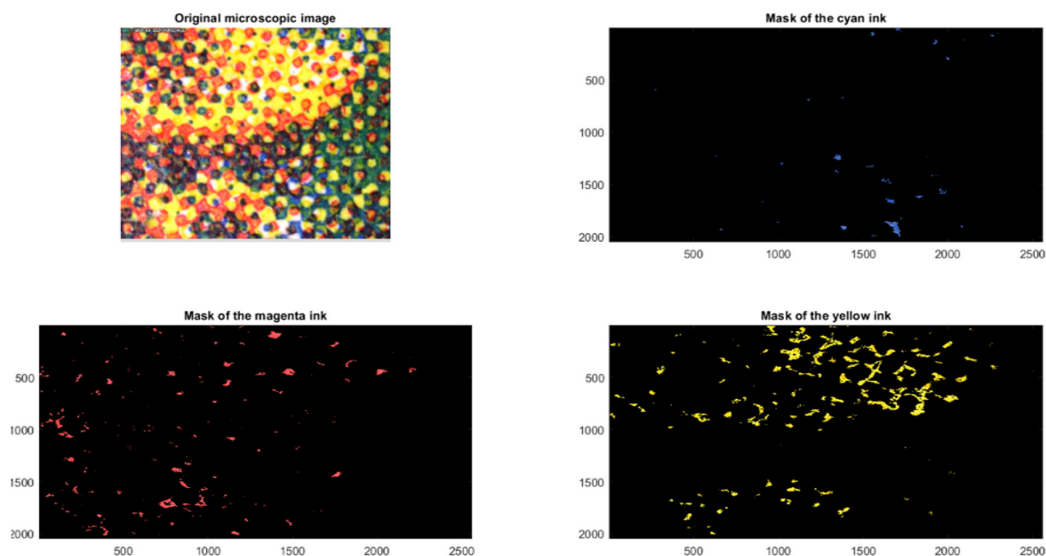


Figure 10: Image segmentation into three basic colors

After the segmentation the RGB images were transformed into the HSV system and they measured the hue, saturation and value (Kokla et al., 2010; Kokla et al., 2008). Figure 11 presents two examples of group histograms of basic colors, one for a postcard on the left with a known sending date, and one on the right with an unknown date. These histograms are based on the measurements of the HSV system.

From right to left we can see measurements of each basic color, such as blue, red and yellow and from top to bottom we can see the measurements of hue, saturation and value of

each of the basic colors in the HSV system. The x-axis shows the values of each color in the HSV system and the y-axis shows how many of these measurements exist in each studied image. We can see that there are few differences between the basic colors of the two types of postcards, such as the values of blue, whereas the other characteristics of the basic colors present similar measurements.

<sup>4</sup>In the HSV system, the hue corresponds to the colors varying from red to yellow, green, cyan, blue, and magenta, and then back to red. The saturation corresponds to the shades of gray, from unsaturated that contains shades of gray to fully saturated where no white component exists and the value corresponds to the color brightness, from darker to brighter. All measurements in the HSV system vary between 0 to 1 value (Image processing toolbox, Northwestern University, <http://www.ece.northwestern.edu/local-apps/matlabhelp/toolbox/images/color11.html>)

<sup>5</sup>The traditional basic colors (primary colors) in painting are red, yellow, blue and they have been used in color theory since 17th century. Since the second industrial revolution or else chemical revolution, many synthetic colors could be made including to synthetic dyes. Since the end of 19th century and especially, at the start of 20th century, based on the progress of physics and chemistry, new color theories were developed, creating various color spaces in an attempt to create colors similar or same with the colors found in nature. In the printings, the trichrome (cyan, magenta, yellow - CMY) was used and then the tetrachrome (cyan, magenta, yellow, black - CMYK). In this paper, the use of traditional basic color terms was preferred because postcards were printed in the early 20th century, when the discussion of the various color spaces began and the basic colors had not been defined in their entirety, as it was done later.

## Results

In the following subsections, the results from historical researches, multispectral imaging techniques, and computational visual analysis are presented.

### Historical Researches

The historical research provided us with useful results, such as the information about:

- The machines of the industry in the early 20th century. In another reference it is documented that the industry received two rotary offset printing machines made by Machinery and Altrincham in 1911. Some of the machines are presented in the Museum of the Historical Archive of the National Bank of Greece.
- The production line and other related work corresponding to the printing products. A great deal of this information was found in the newspaper of 1929.
- The use of basic colors in the color printing in the 1st decade of the 20th century.
- The influence of industry from the innovative European technologies and methods used in the product printing at the time. In

some letters found in the historical Archive it is mentioned that experts were called in to train Aspiotis' workers or the opportunity was offered to his workers to be trained in the new printing methods into the various respective printing industries in Europe with which he cooperated. In other historical evidence it was mentioned that Aspiotis' industry sometimes gave some printing works of products to those industries. Another important point that shows the research spirit that prevailed in the industry and simultaneously, the European influence, is that the industry employs a photographer-researcher called Nick Gazis.

### Multispectral microscopical techniques

The studied postcards with known and unknown sending dates have been printed using three or four basic colors. In Figure 12, some examples of the multispectral techniques are presented. On the left, there is the original postcard and the three images in different magnifications and bands of electromagnetic spectrum. These images show that this postcard has been printed by using the three basic colors. On the right, the postcard has been printed by

Histograms of the HSV values of cyan, magenta and yellow pigment

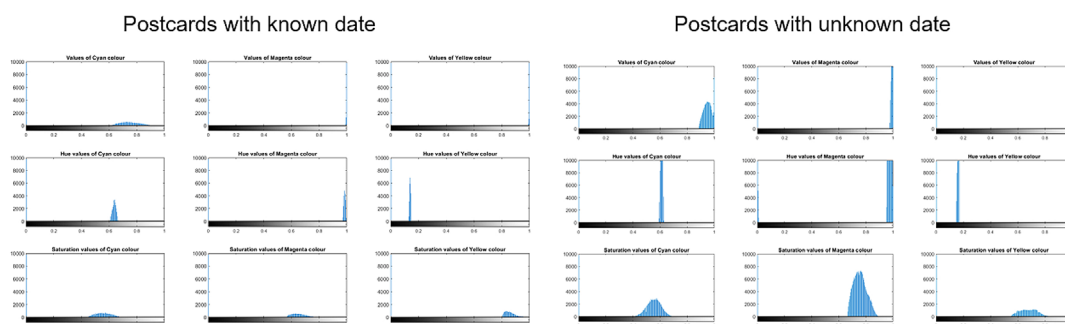
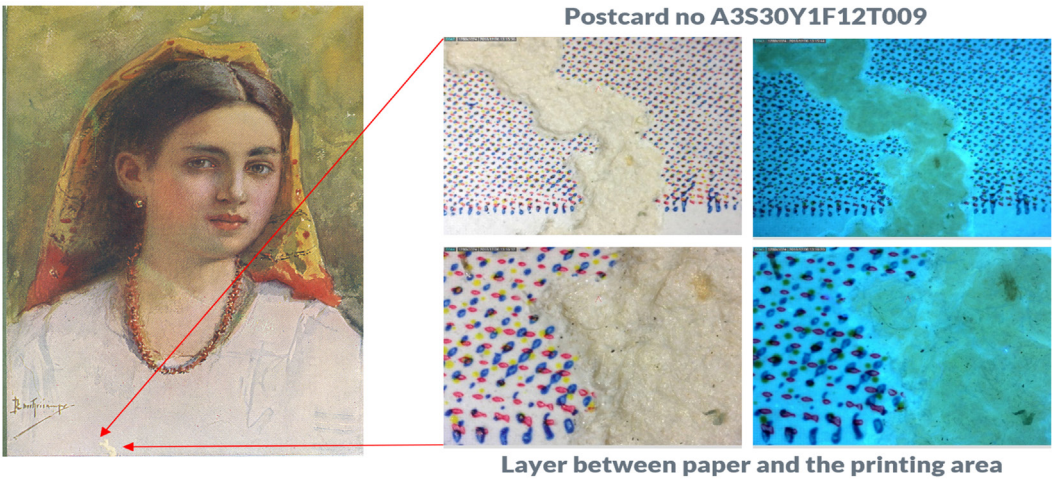


Figure 11: Examples of color basic histograms

using four basic colors, where the black color and the blue color have different absorptions in the infrared band, as seen in the infrared microscopical image.



Figure 12: Examples of multispectral imaging for postcards with no A3S30Y1F12T55 and A3S30Y1F12T63<sup>6</sup>



Layer between paper and the printing area

Figure 13: An example of multispectral imaging for the postcard with no A3S30Y1F12T009<sup>7</sup>

<sup>1</sup> Numbering of the Historical Archive of the National Bank of Greece

<sup>2</sup> Numbering of the Historical Archive of the National Bank of Greece

A coating layer is between the paper base and the printed colors. In Figure 13, another type of example of multispectral imaging is presented. In this example, the microscopical imaging allowed us to determine the existence of a layer between the paper and the printing area. This layer fluoresces as we can see in the images of this band of the electromagnetic spectrum, which means that a coating exists among them. Some letters of Aspiotis' industry belonging to the Historical Archive refer to the purchase of barite.

Three printing techniques were determined, the halftone offset lithography, rotogravure and letterpress. Figure 14 presents some examples of diverse printing techniques used by Aspiotis' industry in the printing of the first postcards depicting artworks of famous Greek painters in the early 20th century. The techniques that have been retrieved in this study so far are the halftone, rotogravure and letterpress.

**Computational Visual analysis**

In Table 1 we can see the percentage of matching between postcards with a known and an unknown sending date for all HSV measurements. Each basic color from the unknown postcards was compared to the corresponding basic color from the known postcards. This comparison was realized for the Hue, the Saturation, and the Value in the HSV system. The color with the best matching (similarity) was yellow (85.7% for Hue, 85.7% for Saturation and 64.3% for Value). Most of the basic colors of postcards with known and unknown dates have been matched; therefore, it is considered that the matched postcards have been printed at the similar period of time, while it is considered that the other unmatched postcards have been printed during a different period of time.

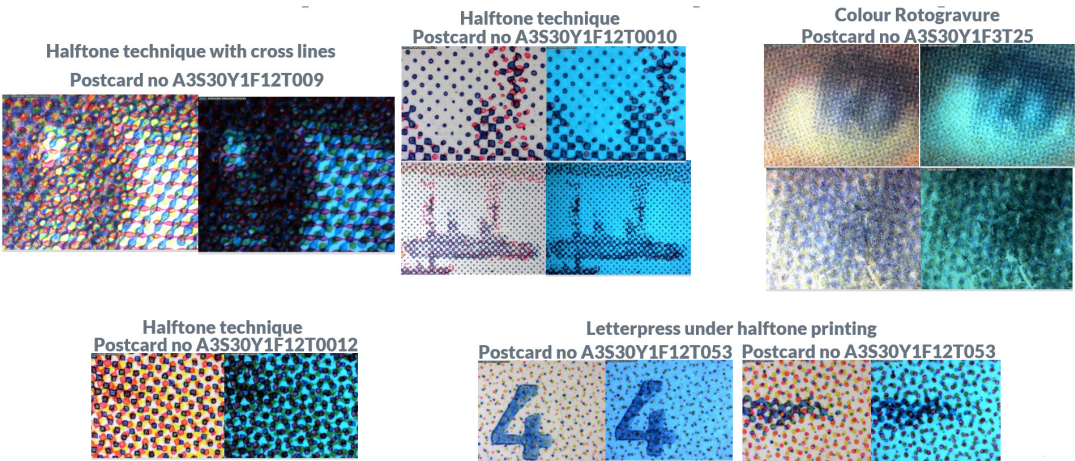


Figure 14: Various printing techniques were used by Aspiotis' industry. As a halftone technique is indicated the halftone offset lithography technique



Table 1. The percentages of matching of the basic colors of historical postcards

Percentages of matching of the basic colours of postcards			
	Hue	Saturation	Value
Blue	71.5%	50%	71.5%
Red	85.7%	35.7%	64.3%
Yellow	85.7%	85.7%	64.3%

Finally, in Table 2 the results of the comparison between measurements in the HSV system of the postcard no 113 with a known and an unknown sending date can be seen. Based on these results we can claim that these two postcards have been printed by using different basic colors and, therefore, they were probably printed in two different periods of time.

Table 2. Comparison between postcards no 113 with known and unknown sending dates

Comparison of HSV measurements between postcard no 113 with a known sending date and postcard no 113 with an unknown sending date from the Historical Archive of the National Bank of Greece									
Models postcards	Hue blue	Hue red	Hue yellow	Saturation blue	Saturation red	Saturation yellow	Value blue	Value red	Value yellow
no 113 <sup>8</sup>	-	X	-	-	-	X	-	-	-

<sup>8</sup> Numbering of Aspiotis' Industry

## **Conclusions - Further researches**

The first of the conclusions is that although this is a preliminary study of historical postcards, it shows that it can be used in order to find similarities and differences between postcards with known and unknown sending dates. Thus, this proposed methodology shows that the combination of historical and technological computational methods can allow us to approach the producing techniques and materials of historical postcards in the early 20th century.

Historical studies show that Aspiotis' industry was a Greek industry with European standards, which printed postcards using four basic colors since early of the 20th century. Also, these studies give us information about the facilities and equipment of Aspiotis' industry.

Based on the microscopic images, the printing techniques had been used in postcard printing can be distinguished. All postcards (with known and unknown sending dates) present similar printing techniques. These techniques also gave us more information about the construction of the cards, such as the use of a layer between the ink and the paper substrate and how many basic colors had been used to print each postcard. Some of the studied postcards have been printed by using three basic colors (blue, red, yellow), whereas some others by using four basic colors (blue, red, yellow, black).

Based on the image analysis, the basic colors of the postcards can be isolated in order to analyze. Each basic color of known (sending date) postcards was compared with the corresponding basic color of unknown (sending date) postcards. The similarity or differentiation of each basic color between known and unknown postcards can give information on the printing

period of time. If two comparable colors are similar, then we can assume that these colors have been printed in the same period of time. If not, they have been printed in a different period of time. According to this view, the comparison of basic colors of known and unknown (sending date) postcards can provide information on the determination of the period printing postcards. Most postcards with an unknown sending date present similarities to postcards with the known sending date.

We believe that the study should be continued and directed in two further directions:

- Firstly, the computational models should be created based on more postcards with known sending dates.
- Secondly, it should be examined if the characteristics of the basic colors from other bands of the electromagnetic spectrum beyond the visible can provide additional information on the production techniques and materials of the historical postcards.

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