

## COLORS ANALYSIS AND TECHNOLOGICAL ERRORS IDENTIFIED IN PRINTING OF ROMANIAN POSTAL STAMPS

Mihai PĂUNESCU<sup>1</sup>, Mihai MARUȘCIAC<sup>2</sup>, Emilia BĂLAN<sup>3</sup>

**Rezumat.** Hârtiile de valoare de tip bancnote, timbre, acțiuni etc. sunt produse tipografice care se realizează prin tehnologii speciale care trebuie să asigure protecția lor împotriva falsificării. Pentru verificarea elementelor lor de siguranță s-a proiectat și executat un aparat digital comparator. Acesta conține două microscopice digitale montate în paralel, care se pot deplasa simultan pe axa Oz, și un suport, reglabil și gradat, pentru poziționarea mostrelor pe axele Ox și Oy. Microscopicele se calibrează la începutul studiului din punct de vedere optic și spectral în limita toleranței impuse. Câmpul vizual al microscopelor este luminat controlat, cu un iluminant standard, pentru a asigura corectitudinea și consistența măsurărilor. În această lucrare, standul experimental este utilizat pentru a analiza comparativ culorile și dimensiunile mărcilor poștale românești în vederea identificării erorilor tehnologice apărute în timpul tipăririi lor.

**Abstract.** Papers of value such as banknotes, stamps, stocks etc. are typographical products which are executed using special technologies which should ensure their protection against forgery. In order to verify their security elements, a digital comparative instrument has been designed and manufactured. This contains two digital microscopes mounted in parallel which can move simultaneously on the Oz axis and an adjustable and graded support for positioning the samples on the Ox and the Oy axes. The microscopes are calibrated from an optical and spectral standpoint at the beginning of the study based on the imposed tolerances. The visual field of the microscopes is illuminated in a controlled manner according to a standard light source, to properly ensure the correctness and consistency of the measurements. In this article, the experimental devise is used to record and analyze comparatively the colors and dimensions of the Romanian postal stamps to identify the technological printing errors.

**Keywords:** printing, stamps, errors, fake, colors, conductivity

DOI <https://doi.org/10.56082/annalsarscieng.2021.2.63>

### 1. Philatelic history

The securities papers like postal stamps are typographical products that are made using special technologies. Philately, being a cultural-educational subject, deals

<sup>1</sup>Eng., affiliation: Faculty of Industrial Engineering and Robotics, Robots and Production Systems Department, University POLITEHNICA of Bucharest, Romania, (E-mail: [mhpaunescu@yahoo.com](mailto:mhpaunescu@yahoo.com))

<sup>2</sup>Eng., PhD student, Doctoral School of Faculty of Automatics and Computer Science, Technical University of Cluj-Napoca, Romania (E-mail: [mihaim@transilvae.ro](mailto:mihaim@transilvae.ro))

<sup>3</sup>Assoc. Prof., PhD Eng., Faculty of Industrial Engineering and Robotics, Robots and Production Systems Department, University POLITEHNICA of Bucharest, Romania, (E-mail: [emilia.balan59@yahoo.com](mailto:emilia.balan59@yahoo.com))

with the determination, collection and study of philatelic pieces, research, establishing typographic procedures and determining stamp errors, varieties, forgeries [1], [2].

The printing periods of the Romanian stamps are [3], [4]:

- 1858 – the “Aurochs’ head / Cap de bour” issues;
- 1862 – the “The United Principalities / Principatele Unite” issues;
- 1864 - 1872 – the "lithographs" were printed; lithography uses as support for the image a special porous stone, on which the images are marked;
- 1872 - 1908 – the period of the so called “post-classic” issues: “Paris”, “Bucharest”, “Pearls / Perle”, “Eagles / Vulturi”, the “Wheat Ear / Spic de grâu”; the printing form was made of individual, mobile, interchanged frames (Fig. 1);
- 1909 - 1927 – in this period the plates were made of compact blocks (fixed frames); the blocks consisted of 25 frames or 100 frames each;
- 1926 - 1948 – this was the era of the intaglio printing; the printing form was a cylinder engraved by autotype;
- starting with  $\approx 1960$  – the offset printing period.



Fig. 1. Wood matrix support [5].

Scientists of the philatelic community want a transfer of technology, a modeling, through the increased use of visualization tools, photographs, diagrams, drawings, graphics, etc., so that the study of postal stamps is understandable to all people. The unusual requirement is the need to communicate to regular people highly technical information in order to help them understand the basic elements, ideas, conclusions and applications of scientific results.

This is crucial if you want an efficient transfer of technology in the hobby area. The suggested methods include a moderation of the technical complexity and an increased use of visualization tools [1].

The education, experience and aptitude of each individual determine the level of interest of the person for science. To establish this documentation framework, the philatelic science takes into account these three different skills of people:

- high aptitude for pure science, which involves scientific investigation, referring to years of study and training;
- ability for technology and engineering: inventing new devices or improving already existing devices;
- aptitude for individual study.

## 2. Characteristics of postal stamps

The postal stamp can be defined as a valuable print of small sizes of different forms (rectangular, oval, triangular or square) [1].

The characteristics of postal stamps (one of them presented in Fig. 2) are [3]: the design, the color, the printing ink, the paper, the adhesive, the lacing, the stamp and the protective elements (the watermark, elements visible with ultraviolet rays).



**Fig. 2.** The “Wheat Ear” postal stamp.

a) front

b) back

The color is an element that can influence the value of postal stamps when we are in the presence of errors, these being printed in a different color or shade than the original postal stamp. The colors of the postal stamps must be light-resistant, not sensitive to heat or moisture and must not prevent the visibility of the stamp. The visible field of the human eye includes the radiation of red, orange, yellow, green, indigo blue and purple. The human eye is adapted to perceive all the colors of the rainbow of the solar spectrum to which black and white are added. The problem of color is also found in the elements of paper, adhesive, stamp and pattern. The identification of an atypical color at a certain authentic mark is a criterion for establishing the philatelic value.

Printing ink is an essential factor in printing postal stamps, being a product which is usually liquid or viscous, black, colored or white. The ink is spread on the active, printable surface of the printing form, by direct contact or by being pressed on the material on which it is printed, so it's transferred to the surface.

Each postal stamp printing process corresponds to a type of ink whose properties vary depending on the printing speed, the quality of the paper, the need to withstand various agents, UV radiation, etc. The main properties required for printing inks used to print postal stamps are: density, adhesion, color, consistency, fineness and fixation after printing. The basic materials used in the printing ink are carbon black, pigments, tinting dyes, binders, driers, etc. Dyes and pigments are the main sources of color by absorption [6].

Postal stamps are generally made of paper; other materials such as aluminum, copper, silver or gold foil, with silk and cotton textiles being used in exceptional cases. Depending on the raw material from which the paper is made, we can identify postal stamps made of cellulose, textile waste, paper waste, reed pulp or mixed, including several of the raw materials listed above.

According to the manufacturing method, the handmade paper obtained by artisanal processes and the industrially produced paper are distinguished. The handmade paper is characterized by thickness non-uniformity that can be highlighted using a micrometer.

Paper, as a support material, ages and changes its appearance by yellowing or discoloring and it is affected by storage and use. The ink, paste and pencil lead on postal stamps also undergo perceptible changes over time in both color and chemistry. The change in color of the paper over time is influenced by the composition of the paper and the storage conditions. One of the methods of analysis is the measurement of the electrical conductivity of the paper which leads to the identification of the different quality of the composition.

The adhesive is a sticky substance applied on the back of the postal stamps to make it easier to fix them on envelopes, by wetting. The adhesive can be glossy, matte, smooth, rough, coloured or colourless. The first adhesive used was potato starch. Subsequently, most postal stamps were based on dextrin, bone glue and gum Arabic.

The lacing needed to separate the stamps arose shortly after the appearance of adhesive postal stamps, because their separation was difficult to achieve, sometimes leading to damage. Three processes are used to separate postal stamps from the sheet: perforating, stamping and cutting. The perforation is sometimes the only distinguishing feature between two stamps when compared. The instrument for measuring the size of the perforation is called an odontometer.

---

From the point of view of execution, the perforations are divided into three categories: • drilling in-line – it is performed with a linear needle device that perforates the sheet successively horizontally and then vertically; • the comb perforation – it is obtained with a device whose needles are placed in the shape of a comb and ensures a precise lacing; • the box perforation – it is made with the help of a steel plate with needles on the contour of the stamp.

The watermark, a security element, is a distinctive or inscribed sign consisting of drawings, figures, lines, formed in the paper mass or printed on it. There are main watermarks obtained directly on the sieve of the papermaking machine and artificial watermarks executed on the finished paper.

The essays are drafts of postal stamps, typographic tests, created to see what the brand would look like in various variants that can undergo changes in design and color. That is why essays can have different designs as opposed to color samples that have an identical design (Fig. 3).



**Fig. 3.** Color essays of “Wheat Ear” - 1 Lei and 2 Lei (comparison and contrast photographs).

Errors are postal stamps that have different characteristics, details related to the image, color, overprint, lacing, paper, watermark, etc., compared to those of the authentic mark. These differences are found in the same position in the print sheet in all print run or only in a part of the print run. Errors can be caused by the composition of the printing plate and are transmitted to the entire print run or may occur during the printing process.

The identification of postal stamps is based on the knowledge the examiner has about the combined elements that give uniqueness to a philatelic piece. The identification of the printing process used to print a postal stamp is usually facilitated by the clarifications made with reference to each of the postal issues in the philatelic catalogues. If some of the characteristics of the postal stamps presented above do not conform to the authentic stamps, philatelists generally use the generic term philatelic forgery.

### **3. Scientific examination of postal stamps**

In achieving the goal of detecting philatelic forgeries it is necessary to combine scientific rigor with the accumulated knowledge of postal history and philately of the philatelic collectors, researchers and experts [3].

Lithographic counterfeiting involves, as a preliminary step, the graphic reproduction of the authentic postal stamp on the lithographic stone.

In the case of the authentic postal stamps the sides are parallel while when comparing a fake and an authentic postal stamp they will form a certain angle due to the different conditions and the machine with which their separation was made.

If the authentic postal stamp is monochromatic and photogravure is used for printing, on the microscopic research are found chromatic differences because the counterfeit postal stamp will never reproduce the full range of semitones specific to authentic postal stamps.

The examination of the philatelic pieces can be done by:

- comparative examination – it is performed by confronting two or more objects in order to establish the differences [3];

- juxtaposition – it consists in placing the postal stamps as close as possible to each other so that they can be observed in the same time;

- overlapping – it consists in placing the photos of the postal stamps one on top of the other in lacing, surface occupied by the graphics, graphic elements or color; this is achievable with a comparator microscope and a computer, that gives the possibility of optical overlapping of the images; an examination like this has the advantage of establishing any differences with efficiency and rigor too;

- joinder – it is the process by which photos of compared postal stamps are joined together in order to verify the linear continuity of the edges; cropped photos whose fragments are juxtaposed can be used to render neighborhood areas; the comparator microscope or the computer can be used [3];

- visual examination - it may be performed both in incident light and through transparency of the paper;

- optical examination – it may be done with a magnifying glass, optical microscope, electron microscope, comparator microscope etc.; the comparator microscope has an optical system consisting of two lenses and a single eyepiece; in order to obtain the precise results during the examination with the comparator microscope the following rules must be considered: the identity of characteristics of the two objectives, the objects subjected to the comparative examination should be placed in the same position, the lighting should be made with a light source of the same type and with the same intensity;

- examination in ultraviolet radiation - by producing fluorescence these highlight the places on the postal stamp where it was acted upon by erasure;

---

- examination in infrared radiation - the applicability of the research is reduced to the detection of the text removed by erasure, more precisely to the highlighting of the remains from the pre-existing graphics [3];

- examination by spectrophotometric methods – it allows the measurement of color spectral parameters by illuminating materials printed with monochrome radiation; spectrophotometers have a software that allows the simultaneous display, side by side, of the colors of the printed materials comparing them precisely, in order to highlight any chromatic differences [3]; another method of accentuating the differences in hue among the printing materials, consists in operations of superimposing the images or increasing the color saturation; this method is required when the spectrophotometric research becomes difficult due to the very small surface on which the printing materials are deposited.

The photos used in the research methods are of several types:

- illustration photo – it is a “mirror” of the general external features, dimensions and format of the examined postal stamp; this type of photo has the role of the reference point for the characteristics of the postal stamp that are perceptible to our sense organs; a postal stamp is photographed as a whole, so that its dimensions are clearly fixed [3];

- comparative photo – it has a major importance in the optical examination of postal stamps; the uniformity of these type of photos is obtained by bringing all the specimens that are compared to the same size, position and intensity of contrast;

- contrast photo – it is based on the difference in color, brightness and opacity.

- colors separation photo – it is based on the extremely small differences between the shades of the same color, imperceptible to the naked eye [3].

Nowadays, the main elements that characterize the valuable Romanian postal stamps are:

- lacing perforation – it represents in the international numbering system, the number of “teeth” or perforations per 2 cm (e.g., A = 13½, B = 11½);
  - color – it is analyzed in the following order: the main color, the center color, the other colors, polychrome (several colors);
  - watermark – it is made in the process of making paper by pressing the dry pulp; the watermark is between I to XVIII;
  - adhesive – it is used: starch, gum Arabic and so on.
-



Fig. 4. Series “Wheat Ear” with watermark PR II, II, IV, V.

In Fig. 4 it is presented the series “Wheat Ear” published in 1893/1898:

1 Bani - brown; 1½ Bani - black; 3 Bani - reddish brown; 5 Bani - blue; 10 Bani - green; 15 Bani - red; 25 Bani - purple; 40 Bani - green-blue; 50 Bani - orange;

1 Leu - light brown and pink;

2 Lei - orange and brown.

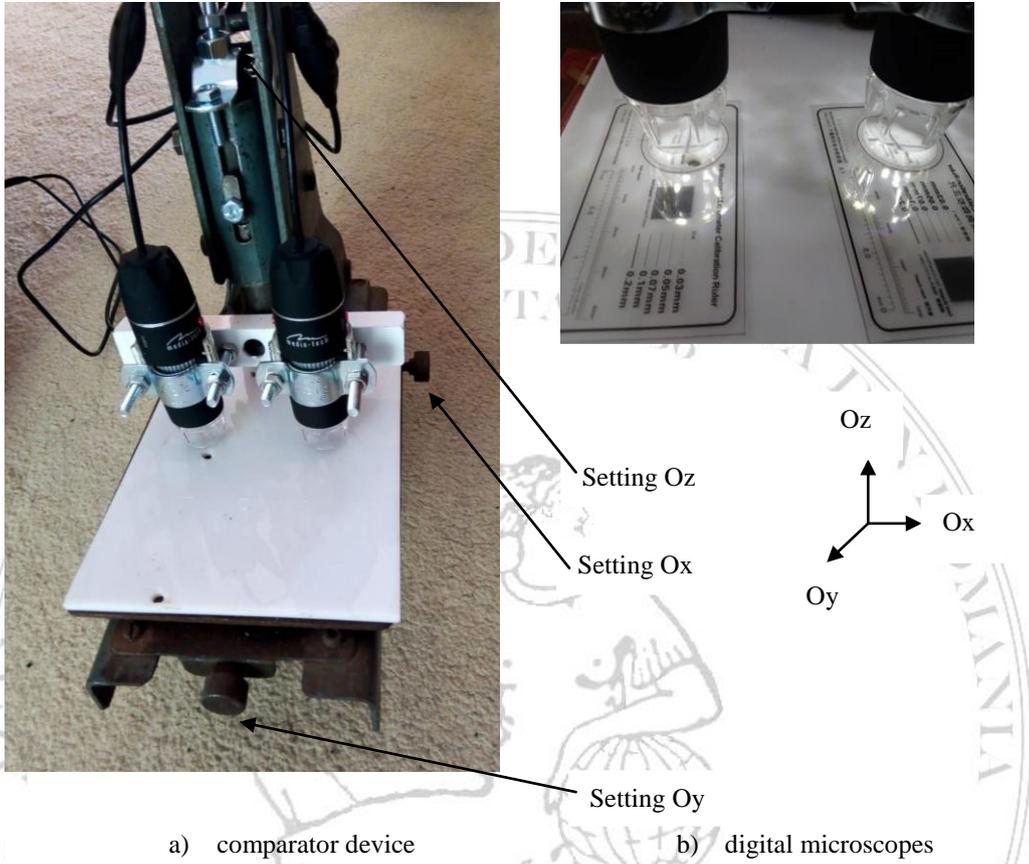
#### 4. Experimental research

The color of the postal stamps constitutes an important and problematic characteristic, not being related to a precise cataloging of a color palette or of a code.

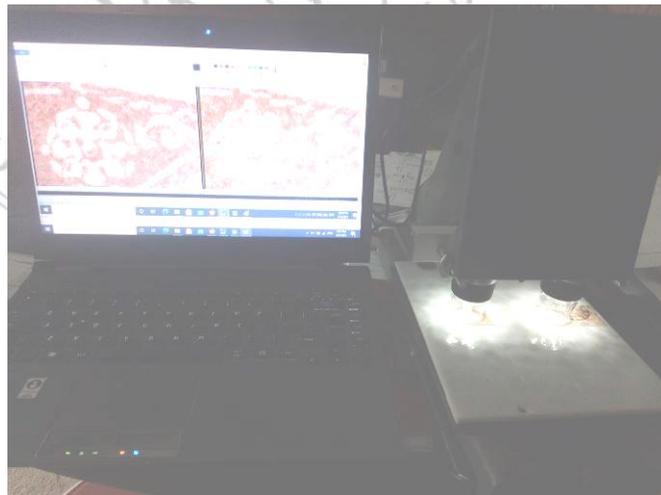
To identify and analyze the colors, a digital comparator device was designed with two calibrated microscopes that can move on the Ox, Oy and Oz axes. The microscopes are digital, with USB, 2 MP image sensor, JPEG or BMP image format, with image magnification up to 500x, resolution of 1600×1200 dpi, 600 lx brightness. They have their own calibrated lights (Fig. 5).

The image is captured and sent to a computer, where (with the aid of Active Webcam and Adobe Photoshop) two distinct images appear on the monitor screen, enabling us to make a comparison, an overlap and a juxtaposition of the two images (Fig. 6).

In order for the captured image by the digital microscopes to be executed correctly in terms of dimensions, exact position, a microscope calibration card was created (Fig. 7).



**Fig. 5.** Digital comparator device.



**Fig. 6.** Comparator device and monitor ensemble (in the darkroom).

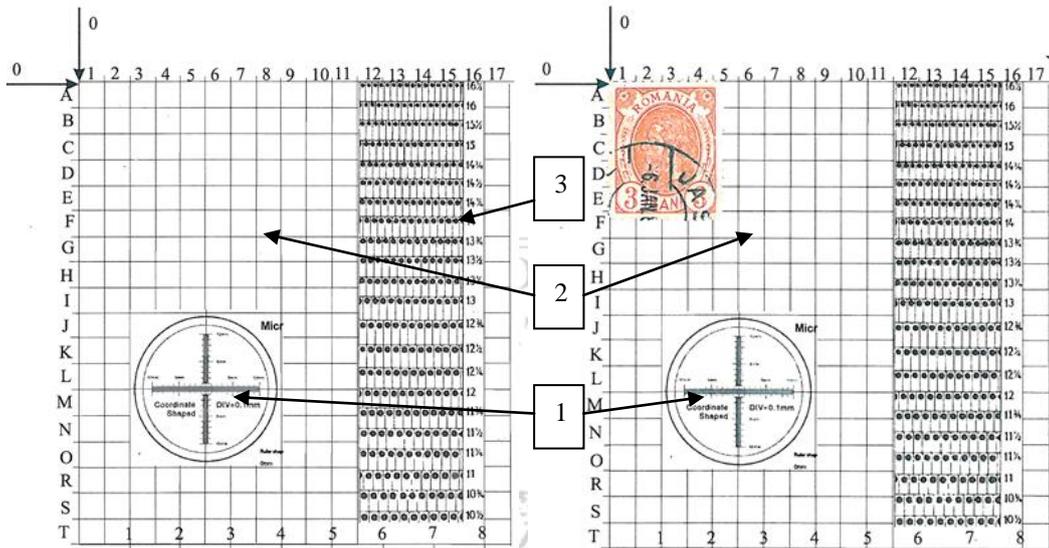


Fig. 7. Positioning and calibration card.

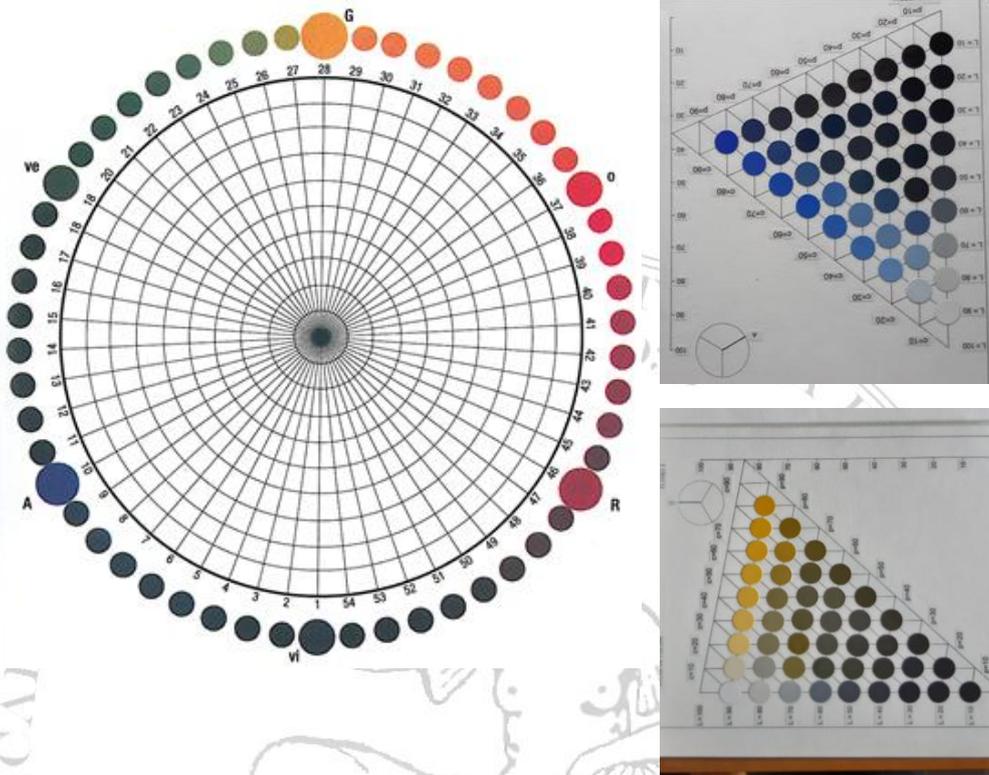
This contains:

- micrometric scale on the OX and OY axes in the calibration and adjustment circle (Fig. 7, pos. 1);
- a grid of 5 mm by 5 mm, in which the postal stamps are positioned starting from the upper left corner (Fig. 7, pos. 2, e.g., A1, E5);
- a table with different types of lacing stamps for the analyzed stamps, a scale in mm for measuring the stamp contour (Fig. 7, pos. 3).

The color code of the Romanian chromatic system SCR 5969 was used to catalog the color spectrum of the stamps. At the base of the system are the three primary colors R, Y, B (R, G, A in Fig. 8) [7].

The color has a special importance in identifying the type of value papers known as stamps. In the field of chromatic education of stamps the Romanian chromatic system SCR 5969 is used.

The realization of the system was performed by spectrophotometric measurements at the Centre for Interdisciplinary Research of Chromatic Phenomena in Timisoara (Fig. 9 and Table 1).



**Fig. 8.** The Romanian chromatic system SCR 5969 [7].

**Table 1.** Spectrophotometric measurements [7]

The name of the chromatic tone	Wave length [nm]	Value luminosity [%]
Red	630	50
Yellow	575	85
Blue	485	35
Secondary colors		
Orange	530	60
Green	595	70
Purple	410	30

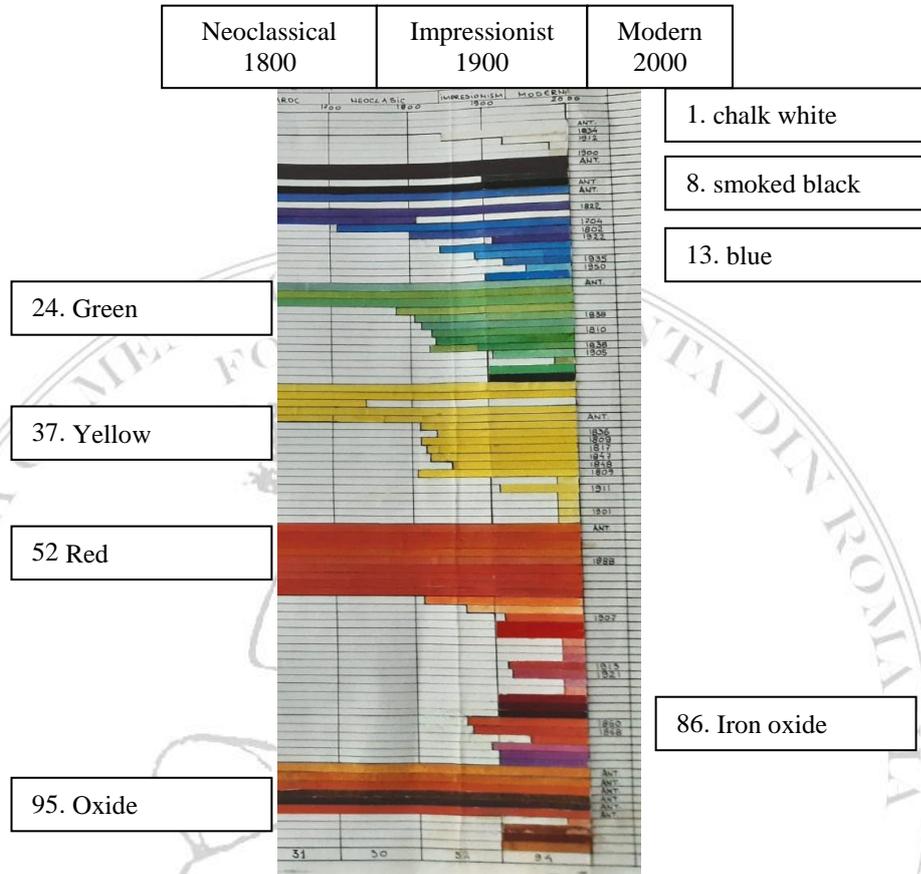
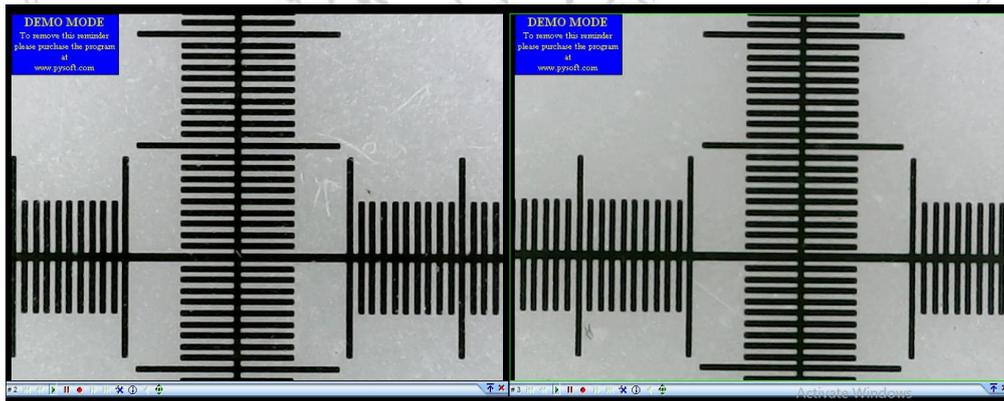


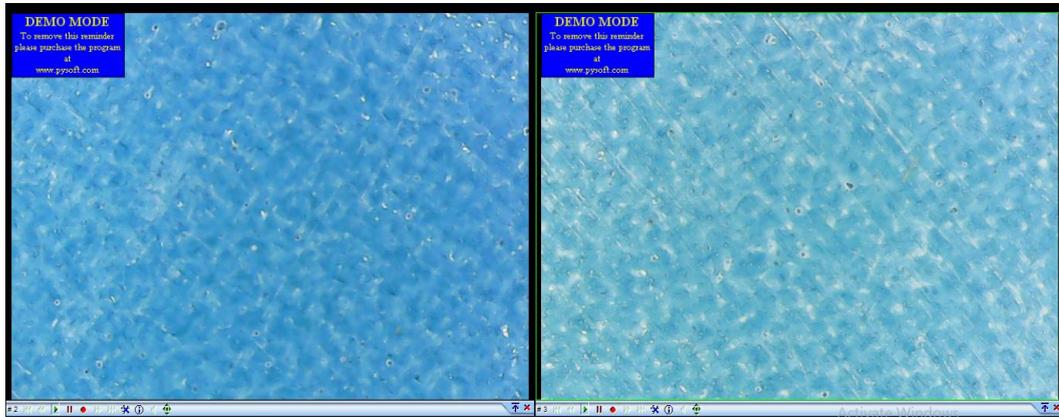
Fig. 9. Pigments evolution between 1800 to 2021 [7].



first microscope

second microscope

Fig. 10. Calibration of digital microscopes.



first microscope second microscope  
**Fig. 11.** Color verification with digital microscopes.



first stamp second stamp  
**Fig. 12.** Postal stamps comparison with digital microscopes.



stamp color card  
**Fig. 13.** Comparison of the stamp with color card.

The steps of experimental research of the chromatic analysis of postal stamps are:

1. the digital microscopes are calibrated from an optical and spectral standpoint at the beginning of the study based on the imposed tolerances; the visual field of the microscopes is illuminated in a controlled manner according to a standard light source, to properly ensure the correctness and consistency of the measurements (Fig. 10);
2. the postal stamp is placed on the calibration card, mounted in the same position established as a reference for the experimental determinations (it is used the grid A, B, ... and the 1, 2, ...);
3. the postal stamps are positioned on the table of the device in front of the digital microscopes so that their images can be compared (Fig. 11 and Fig. 12);
4. the color card is positioned on the table of the digital device in order to be compared with the color of the stamp (Fig. 13);
5. photographic captures of the monitor screen are made in order to perform the comparative analysis of the results.

In Fig. 14 it is presented a postal stamp which was analyzed from the chromatic point of view. The experimental characteristics of a postal stamp are:

1. pigment:
  - Background: dark gray (smoke black)
  - Medallion: permanent red (organic pigment)
2. spectrophotometric measurements:
  - Background: gray – luminosity = 39 %
  - Medallion: red – wave length = 588 nm; brightness = 44.71 lx



**Fig. 14.** The essay “Wheat Ear” analyzed.

3. Romanian Chromatic System (SCR 5969):
  - Background: gray – luminosity = 40 %
  - Medallion: red = no 38, wave length = 600 nm.

According to the measurements performed on the microscope we determined that the analyzed stamp is not a forgery.

The next step for this research is creating a database for Romanian stamps using this method of analyzing colors.

## 5. Conclusions

- The design and the execution of the device which compared using two digital light microscopes, calibrated with degrees of freedom on the OX, OY, OZ axes.
- Designing a digital microscope size calibration card with a gridded surface used for the determination of the exact images captured position that was compared.
- According to the measurements performed on the microscope (using the Romanian chromatic system SCR 5969) we determined that the analyzed stamp is not a forgery.
- The experimental device presented is a reliable method of research and analysis of securities papers known as stamps.

## REFERENCES

- [1] Herendeen, D. L., *Documenting Science in Philatelic Literature: A New Perspective* Institute for Analytical Philately, Computer Science, Smithsonian contributions to history and technology, **57**, pp. 35 – 45, (2013).
- [2] Alămoreanu, S., *Clasic și modern în examinarea documentelor suspecte*, (Alma Mater, Cluj-Napoca, Romania, 2003).
- [3] Poiana, I., *Falsuri și contrafaceri în filatelie*, (Alma Mater, Sibiu, Romania, 2006).
- [4] Kiriac, D., *Catalogul Mărcilor Poștale Românești*, (Casa Scânteii, București, Romania, 1974).
- [5] Williams, L. N., *Fundamentals of Philately*, (American Philatelic Society, USA, 1990).
- [6] Sofransky Z., *Geneza și evoluția cromaticii tradiționale în spațiul carpato-danubiano-pontic*, Teza de abilitare, Chișinău, Moldova, (2008).
- [7] Marian, A. M., *O istorie a ordonării culorilor*, (Artpress, Timișoara, Romania, 2011).