

Detecting Forgery of an Oil Painting by Ivan Aivazovsky

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[Abstract]

Historical and antique oil paintings have been plagued with the threat of forgeries for a long time. The nature of art lends itself to forgery because a skilled and determined forger can mimic the techniques and styles of an artist to a level where even an expert can be duped. This research includes an examination and analysis of an oil painting signed with the name of the Russian painter, Ivan Aivazovsky, to detect if it is an original or just a professionally forged replica of the painting. The researcher used the following techniques: visual inspection by comparing the painting style and brush strokes of the painting to other paintings created by the same painter, and by studying the signature on this painting compared to the ones on other paintings for Ivan Aivazovsky. An anachronistic technique was also used to detect forgery of the painting, and this technique involved employing both XRD and EDAX. Fourier transform infrared (FTIR) was used to identify the binder of the ground layer and the varnish layer. The paint layer was examined using a microscope and the images were recorded on both black-and-white and color films. Microscopic examination was used in studying the different forms of decay found on the painting to detect if they were deliberately made for forgery purposes. The cohesion of the paint layers and the impact of ethyl alcohol on it, were also studied. The results of the study proved that the painting was not painted by the famous Russian painter Ivan Aivazovsky and that the signature is forged by a professional, skillful forger. The forger's attempt to give the painting an antique look was extreme and illogical; this was the first indication that the painting is forged. The forger also made the mistake of using pigments which were manufactured and used more than 30 years after the death of the Russian painter. The date of the painting under study is from 1950 to 1960, which is more than 50 years after the original painter's death.

1 Introduction

Ivan Konstantinovich Aivazovsky (1817-1900) was born in the town of Feodosia, Crimea (the Russian Empire) to a poor Armenian family. Aivazovsky became a famous Russian painter and, having arranged more than one hundred exhibitions in many European and American cities, brought great fame to Russian art. During the period of 1840-1844, Aivazovsky, as a pensioner of the Academy of Arts, spent time in Italy; he also traveled to Germany, France, Spain, and Holland. He painted many marine landscapes, which became very popular in Italy: "The Bay of Naples by Moonlight" (1842), "Seashore. Calm" (1843),

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“Malta Valetto Harbour” (1844). His works were highly appreciated by J. M. W. Turner, a prominent English landscape and marine painter^{1,2}.

The artist’s greatest achievement is “The Black Sea” (1881), showing the nature of the sea as eternally alive, and always in motion. Other important pictures of the late years are “The Rainbow” (1873) and “Shipwreck” (1876). Aivazovsky left more than 6,000 pictures of very different value. He was a member of the Academies of Stuttgart, Florence, Rome and Amsterdam. Aivazovsky died on the 19th of April 1900 leaving an unfinished picture he had begun that same day. Whatever lies ahead for Russian art there is no doubt that the creative legacy of Aivazovsky will always be a treasured part of its history³.

Art forgery has existed as long as there have been valuable and admired works of art to forge. By studying the techniques and styles of an artist, a skilled, determined forger can produce a copy that is extremely difficult to distinguish from an original. To make matters worse, the authentication of artwork is a subjective process relying heavily on the knowledge and experience of the art expert charged with the task. In addition, as technology and knowledge increases, and becomes more available to forgers, the ability to differentiate between the original authentic work and a forgery becomes increasingly difficult⁴. Nineteenth-century Russian paintings were much favored by the nouveau riche after the collapse of the Soviet Union. Ivan Aivazovsky and other 19th century landscape and seascape painters are currently the most forged.

The Russian art market is braving a wave of reports concerning criminal activity in the Russian art world. Dr. Vladimir Petrov of the Tretyakov Gallery in Moscow claimed that he had uncovered 120 Russian art fakes on the market in five months. Denis Lukashin, a Russian art consultant, has said that “as many as 70 percent” of Russian paintings in Russian art collections formed over the past two years are fakes. To get an idea of the growth rate of this steamroller of a market, the global figure for specialized Russian art sales in London and New York in 2000 was £7.6 million. However, there was discrimination at work⁵.

The embassy of Georgia in Cairo houses an oil painting signed by the Russian artist Aivazovsky; this painting reflects the unique painting style of the artist. The main theme of the painting is the theme of raging sea and huge waves (Fig. 1), a theme favored by Aivazovsky. This research aims at revealing whether this painting is original or fake. Several inspection and analysis methods were used for that purpose. Additionally, the technique used to build up the layer structure of the painting was accurately studied, a measure that helps very much in the detection of forgery. A survey on paintings of similar themes was made as well to locate originals of the same theme; also to find out if the forger combined different themes to produce this piece of work, a technique favored by many forgers. In this technique, the forger would copy the painter’s style and signature and then subjects his work to accelerated aging procedures.

1 T. H. C. Tafacamoba, NBAH KOHCTAHTNHOBHNY, AÑBA3OBCKHÑ, N3AATEABCTBO NCKYCCTBO, MockBa, 1965.

2 www.abcgallery.com.

3 www.agniart.ru.

4 K. Smith, K. Horton, J. R. Watling, and N. Scoular, Detecting Art Forgeries Using LA-ICP-MS Incorporating the in situ Application of Laser-based Collection Technology, Elsevier, Talanta, 67, 2005, pp. 402-413.

5 www.moodbook.com.

2 Materials and Methods

The surface of the painting, texture of the paint layer, and the direction of brush strokes were studied through comparing the painting with an original painting from Ivan Aivazovsky. The damage forms found on the paint layer and on the back of the painting were accurately studied to detect whether it is an original or made on purpose to reflect the antique appearance. Handwriting analysis was performed wherein the painter's signature was subjected to comparison with a reference signature. This study was carried out using a Stereo Microscope Type Stemi DR 1663 Zeiss and a Canon camera (Canon, USA, Inc.). The images were recorded on a Kodak 200 black & white film (Eastman Kodak Company, NY). Additionally, several macro-images were taken with a Nikon COOLPIX 4500 digital camera. The cross section technique was carried out using the same stereo microscope.

Pigment materials of the paint layer and ground layer used in the painting have been sampled for laboratory analyses to determine their composition. Both XRD and SEM-EDAX analyses were used to detect the compounds and elements present in the pigments of the painting. X-ray diffraction (XRD) was performed on powder samples of the pigment materials, using a Philips (PW1840) diffractometer with Ni-filtered Cu-K α radiation. The samples were scanned over 5-70° 2 θ intervals, at a scanning speed of 1.2° min⁻¹. A quantitative estimate of the abundance of the mineral phases was derived from the XRD data, using the intensity of certain reflections and the external standard mixtures of minerals compared to the JCPDS standards of 1967. The detection limits of the method were ± 1 w/w %. SEM-EDAX analysis was performed using a FEI company device (version quanta 200), with specifications of: Kv: 24.98; tilt (0.00); take-off: (36.47); ampt (35.0); detector type (SUTW-sapphire); resolution (129.87). Moreover, the FTIR technique was employed to identify the resin used for the varnish layer and the binder used in the paint ground.

UV radiation was helpful in examining the pigments used in the paint layer and for the signature. This technique proved to be valuable in determining whether the pigments were all applied at the same time or not. It was also used to locate the position of the signature, whether it is above or below the varnish layer.

The effect of ethyl alcohol on a new paint layer is quite different than its effect on antique paint layers; and therefore ethyl alcohol 93% was used to differentiate between the two layers. Finally, a survey was done to determine whether the painting is officially registered under the name of the Russian painter. Similar paintings for Ivan Aivazovsky were studied to detect whether the forger cloned an original painting, used the main theme of an original, or combined the themes of several paintings to produce a new theme or topic and then forged the painter's signature.

3 Results and Discussion

3.1 Deterioration Phenomena

The surface of the painting, the texture of the paint layer, and the direction of the brush strokes were examined using a stereomicroscope to determine whether the forms of damage found are due to natural

aging or artificial aging done on purpose by the forger. A forger would have to paint in the manner of the artist he is imitating, through all stages of the creative process. He would have to use the same materials, the same tools, in the same order and most of all, he would have to work with the same decision and fluency⁶. Macro photographs were taken using a digital camera under normal light condition, ultraviolet radiation, and infrared radiation. Images were also recorded on color and black-and-white films. During the inspection of the sky region, cracks were found over brush strokes (Fig. 2); however, they are not similar to the cracks commonly found in oil paintings. These cracks appear as regular and parallel lines that pass across the brush strokes in a uniform pattern; and this form of damage is a compression in the paint layer made only by a special not pointed tool while the paint layer is partially soft and not totally dry (Fig. 3).

Similar cracks have been made in another area of the sky region and then a layer of thin paint was applied on top. Therefore, artificial cracks appear under this upper layer (Fig. 4). This form of damage can never occur naturally and can only be done using special tools known to forgers. In real cases, cracking which occurs in lower paint layers causes an evident separation in the lower paint layer and also in the upper paint layers currently or will occur in the future. Thus this hollow elongated compression in the paint layer is artificially made; the forger would then fill the hollow part with final brush strokes (Fig. 5).

The varnish layer was also found to fill the elongated compressions in the paint layer, and this is a valuable indication that these cracks were made before applying the varnish on the painting. Fig. 6 shows further evidence that this form of damage has been made after applying the paint layers and before applying the varnish layer. In real cases, cracks appear in the paint layer and varnish layer as local or overall vertical separation; and sometimes the color of the ground layer and the support are noticeable under these cracks. Fig. 7 shows the natural cracks on an original oil painting to differentiate between the naturally occurring cracks or craquelure and the artificial cracks made on purpose by the forger, as is the case in the painting under study.

These artificial cracks can only be realized using different examination methods (i.e. stereomicroscope), and inspection with the naked eye reflects the high forgery skills of forger (Fig. 8).

As for the signature area, it is possible that the artist signed the painting in the presence of forms such as peeling or scratching of the paint layer because there are abrasions in the form of compressions and the remains of the scratched color are accumulated at the end of the compression. The shape of the abrasion indicates that it was done while the paint layer was still soft and not totally dry. There is also a wide crack that runs parallel to the accumulated color; the crack even starts and ends with the accumulated color (Fig. 9).

The letters of the signatures cover this wide crack, the remains of the scratched color, and the smooth paint layer that appeared after the scratching process (Fig. 10). The sharp tool used for the scratching process has caused the lower paint layer to become smooth. After being scratched, the lower paint layer became the upper paint layer and this is the layer where the signature was made. Due to the smoothness of this layer, the letters fell off and only some remains are present (Fig. 11). Also present on the surface of the painting is a form known as flaking (Fig. 12). This aspect has affected the paint layer, the

6 J. Lang and A. Middleton, *Radiography of Cultural Material*, Elsevier Butterworth-Heinemann, Linacre House, Jordan Hill, Oxford, 2005, p. 128.

ground layer, and the wood support. Flaking of the wood support is not natural since attempts to obtain this aspect would result in multiple dents that appear as flaking, but the flaking in this painting is not the natural flaking found in oil paintings. Therefore, this aspect is evidence of the forger's attempt to give the painting an antique appearance.

Moreover, a thick layer of paste on the back of the painting and then numerous regular and uniform cracks were made. Several abrasions were also made in different areas. For further deception, a piece of paper was glued to the paste layer (Fig. 13) and then paint was applied on top (Fig. 14), after framing the painting in a valuable frame (Fig. 15). X-ray diffraction analysis has revealed that the color used to paint the back of the painting is raw umber. Raw umber gives wood a tone that is similar to old dark wood. This color tone has been commonly used for this purpose. After removing the painting from the frame, it was observed that forger had forgotten to paint some areas of the sides of the painting and the light color of the wood indicates that the wood was cut very recently, and is much newer than 100 years.

3.2 Comparing Signatures

A signature is a result of an instant message from the human brain which orders the hand to write according to the specific path that the brain is accustomed to perceive. Accordingly, the hand is accustomed to follow that path. To identify the characteristics of the forged signature, one must first know the characteristics of the original signature. If the original characteristics do not match those of the examined signature, then in that case one should suspect that the signature is not original. Signatures were generally forged very carefully, so carefully in fact that they have deceived several experts⁷.

One of the most important characteristics of original signatures is "flow" as there is no reason to hesitate or stop during the flow of the brush during the signing process. Furthermore, original strokes are done with confidence (Fig. 16). On the other hand, the strokes done by a forger, who is more concentrated on imitating the signature but at the same time fears making mistakes, are not smoothly done. Fig. 17 shows that the signature on the painting under study is not smooth as there is some sort of zigzagging in the letters.

The examination of the signature of the Russian artist in his original paintings also revealed that he signed the paintings with a brush (Fig. 18). On the other hand, the signature found on the painting under study was not done by brush. The colors were first mixed on a palette; and then, using some sort of tool, which was perhaps a palette knife or even a brush, the colors were applied without touching the surface of the painting with the tool. The tool carrying the paint was dragged along the letters allowing the paint to fall in place without touching the surface with the tool. This technique has resulted in unsmooth writing due to the shaking of the artist's hand, particularly in the letters with straight lines such as the letter "A" (Fig. 19). The dragging technique also led to poor adherence of the signature to the paint layer (Fig. 20), despite the roughness of the surface which makes any pigment adhere easily to it.

7 S. R. Lines, Examination of a "Velasco" Signature on an Oil Painting, *Journal of Forensic Sciences*, Vol. 51, No. 4, 2006, pp. 929-933.

The hand path of some letters in the signature under study and the hand path of the same letters in original signatures found either on original paintings or in the Dictionary of the International Artist, were compared⁸. The result of this study revealed that in the original signature the two side lines that form the letter "A" were done using a brush in one continuous movement without lifting the brush away until both sides were done. The two side lines are connected in the upper meeting point. The horizontal line that completes the letter "A" starts from the right-side line and ends at the left-side line in a smooth and natural way. This horizontal line overlaps both the right- and left-side lines in most original paintings, and in some cases the horizontal line is found to cross outside the two side lines as is the case in the Russian artist's official signature which is found in the Dictionary of International Artists (Fig. 21).

After examining the signature on the painting under study, it was found that the two side lines of the letter "A" are not connected (Fig. 22). This separation indicates that they were not done in one continuous movement and that the artist stopped in between. As for the horizontal line of the letter "A," it clearly shows the hesitation of the artist. It also confirms that the method of application used is the dragging method as the shaking hand stopped at the left side line for a period during the dragging of the color to write the horizontal line of the letter. Consequently, this has caused an accumulation of the paint in the middle of the left-side line as is apparent through microscopic inspection (Fig. 23).

It was also observed that the artist was unable to complete the horizontal line but stopped before reaching the right-side line. The microscopic examination revealed the presence of two uncompleted horizontal lines and not one. Both lines were written by starting at the left-side line. The presence of the two lines is probably due to the psychological pressure faced by the artist. His first attempt was not satisfying and so he tried again. Both horizontal lines start at the same point on the left side line. The lower horizontal line ends with some zigzagging indicating the tension of the artist, especially in the first letter, which shows most of tension (Fig. 24).

The technique used to sign the painting and the hand path both indicate that the hand did not move according to the specific path that the brain is accustomed to perceive. The spaces between the letters in the original signature are much smaller (Fig. 25) than the spaces between the letters in the signature under study (Fig. 26). All of the above evidence reveals the forgery of the signature.

In brief, graphoanalysis of the signature under study and comparison studies which involved comparing the characteristics of the mother signature and the signature under study, all revealed that the latter signature is not the result of an instant message from the human brain which orders the hand to write according to the specific path that the brain is accustomed to perceive. It only shows that it is the work of an artist under the pressure of imitating an original signature.

Moreover, the horizontal line of the letter "A" in original signatures starts at the right-side line and ends at the left-side lines, overlapping both side lines (Fig. 27). But in this case study, the horizontal line starts at the left-side line and stops before reaching the right-side line (Fig. 28). This also indicates the forgery of the signature.

⁸ E. Bénézit, *Dictionnaire critique et documentaire des peintres sculpteurs dessinateurs et graveurs des tout les temps et de tous les pays par un groupe d'écrivains spécialistes français et étrangers*, Tome I, GRÜND, 1999, p. 126.

3.3 Similar Paintings

Investigations of paintings of unknown origin often call on a diverse range of consultants. From the arts, provenance studies (where an art historian judges the painting's history relative to known facts about the artist) are coupled with connoisseurship (where an art expert compares a visual inspection of the painting with the catalog of known paintings)⁹. After searching in the paintings of the Russian painter Ivan Aivazovsky, this painting was not found registered under his name. However, several paintings of similar themes were found. This might indicate that the forger combined different ideas from each painting to carry out his work. The difference between the painting under study and original paintings is that the sea waves in the painting under study were done using the impasto technique (Fig. 29).

On the other hand, the sea waves in all original paintings examined by the researcher were done by applying a smooth paint layer (Fig. 30). The strokes of the brush in original paintings reflect the smoothness of the flow, but the brush strokes in the case of the painting under study reflect the tension of the artist. The waves' region particularly shows the tension of the artist because the brush strokes are not connected. The same region in the original paintings was done smoothly. The brush strokes are connected and the waves appear as if they were real. Although the painting under study was accurately done, it still does not reflect the main characteristics of Aivazovsky's work.

4 Crosssection

Study of cross sections of the ground and paint layers reveals the painter's technique; the structure of the paint layers, the mixture of the pigment grains, the density of the colors, and the layer structure of the painting. The construction of the layers helps to determine the school the painting belongs to¹⁰. In this painting the cross-section technique was used to identify the layer structure and the artistic style used. The cross section of the green sample (Fig. 31) revealed that the artist had applied four layers of the paint layer over a thick ground layer of a red pigment that has hematite as its main component, with lead white and chalk also appearing in this layer. This sample confirms that the artist used the multi-layer technique which is one of the methods used in oil paintings. The sample which was taken from the blue pigment was examined as a cross section under the microscope (Fig. 32). The examination showed that the layer structure is of three layers: the upper layer is blue-black; the second is yellow, and the lower layer is brown. The sample taken from the white impasto area of the sea waves (Fig. 33) reveals the presence of a fine dark upper layer of varnish which is followed by white layer that is very thick; the final lower layer is very thin and it is green. From these results, one can conclude that the painting is composed of a wood support; a ground layer composed of three layers, and a paint layer carried out using the multi-layer and impasto

9 R. P. Taylor, et al., *Authenticating Pollock Paintings Using Fractal Geometry*, Pattern Recognition Letters, Elsevier, 28, 2007, pp. 695-702.

10 E. E. Vasilescu, *Examples of Application of Some Modern Techniques of Icon and Fresco Restoration and Conservation*, European Journal of Science and Theology, 4 (3), 2008, pp. 39-48.

techniques.

5 Binder and Varnish Samples

Two samples were analyzed using FTIR to identify the binder which was used with the filler in the ground layer and the resin in the varnish layer. Functional groups and wave numbers of the varnish and the binder were measured, and the bending of the dammar resin was cited on the FTIR charts. Based on the results, the dammar varnish has been proved to be the varnish layer (Fig. 34), but natural glue was not detected and an artificial polymer was found to be used as an alternative (Fig. 35). The use of the artificial polymer clearly shows that the painting is not original because artificial polymers were discovered many decades after the death of the famous Russian painter, Ivan Aivazovsky.

6 Pigment and Ground Samples

6.1 Green Pigment Sample

XRD analysis of the green pigment sample from the sea area of the studied object proved that the pigment material is green earth “celadonite” [Fe, Al, Mg, K, hydrosilicate] (standard No. 17-521)¹¹. The sample also contains: graphite [C] (standard No. 12-212), zinc oxide [ZnO] (standard No. 05-0664), halite (standard No. 5-0628), and hematite [α Fe₂O₃] (standard No. 13-534). For ochres, the major component is hematite. In highly prized ochres traces of muscovite and quartz add “sparkle” to the ochre¹². Lead carbonate hydroxide [Pb₃ (CO₃)₂ (OH)₂] and calcite [CaCO₃] (standard No. 5-0586) are found also in the sample. The EDAX analysis of the sample proved that it contains: about 92.55% carbon, 00.54% iron, 00.19% potassium, 00.33% magnesium, 00.54% aluminum, 01.00% silicon, 01.33% sodium, 00.22% chloride, 01.23% zinc, 00.51% calcium, and 01.57% lead (Fig. 36).

6.2 Blue Pigment Sample

Based on the XRD analysis, the blue pigment material used in the painting is phthalocyanine blue [C₃₂H₁₆N₈Cu] (standard No. 04-0836), mixed with graphite [C]. The analyzed sample also contains ochre yellow [iron oxide hydroxide] (standard No. 13-92) and raw umber [iron oxide hydroxide] (standard No. 13-87). The EDAX analysis of the same sample proved that it contains 96.20% carbon, 00.40% iron and 03.40% copper (Fig. 37).

6.3 White Pigment Sample

11 JCPDS, Joint Committee on Powder Diffraction Standards, Index to the Powder Diffraction File, American Society for Testing and Materials, Pennsylvania, 1967.

12 D. Creagh, A. Lee, V. Otieno-Alego, and M. Kubik, Recent and Future Developments in the Use of Radiation for the Study of Objects of Cultural Heritage Significance, *Radiation Physics and Chemistry*, 78, 2009, pp. 367-374.

The polymorphs anatase, rutile and brookite cannot be identified by Raman microscopy, nor can other TiO species, though they can by X-ray diffraction (XRD)¹³. XRD analysis performed on white pigment material in the area of waves proved that it is titanium white “rutile” [TiO₂] (standard No. 4-0551) and zinc oxide [ZnO] (zincite). The sample also contains: lead carbonate hydroxide, graphite [C], halite (standard No. 5-0628) and quartz. The EDAX analysis of the same sample proved that it contains about 54.0% carbon, 5.0% titanium, 06.0% zinc, 22.0% lead, 11.0% sodium and 2.0% silicon (Fig. 38).

The results of the SEM-EDAX reveal the use of two pigments which were both manufactured after the death of the Russian painter, Ivan Aivazovsky, whose signature is found on the painting. These pigments were used by painters after the death of Aivazovsky; after 30 years of his death in the case of phthalocyanine blue, and 20 years in the case of titanium white.

Phthalocyanine blue was first developed as a pigment in the mid-1930s. Its brilliant blue is frequently used in paints and dyes. It is highly valued for its superior properties such as light fastness, tinting strength, covering power and resistance to the effects of alkalis and acids¹⁴.

The white of TiO₂ is a well-known modern colorant since 1919. Mass-production of the artist-quality oil pigment only began in the early 1920s. The mineral anatase and rutile are two forms of TiO₂ and are related to kaolin deposits. The level of TiO₂ in kaolin which is used as white pigment from analyses around the world is concentrated to 1% by weight¹⁵.

6.4 Ethyl Alcohol (Solubility Test)

An ethyl alcohol solubility test was performed to identify the solubility of the paint layer and the varnish layer in ethanol. It has been noted that the removal of the varnish layer was not easy and at the same time it was not difficult either; the same situation occurred in the case of the paint layer. A test was done on one of the edges of the painting. The results of this test indicate that the age of the painting is from 25 years old to not more than 75 years old¹⁶. It is mentioned that ethyl alcohol has a vast effect on drying the paint layer and varnish layer; however, recent paintings (25 years old or less) are more affected by the use of ethyl alcohol compared to older paintings (to over 25 years to 75 years old).

This test confirms that the age of the painting is certainly less than 100 years old. Based on the results of the previous examinations and analyses and the researcher's long experience in detecting forgery, the researcher dated the painting to between 1950 and 1960.

The color of the varnish is yellow in tone and appears transparent below the frame (Fig. 39). This

13 R. J. H. Clark, Q. Wang, and A. Correia, Can the Raman Spectrum of Anatase in Artwork and Archaeology be Used for Dating Purposes? Identification by Raman Microscopy of Anatase in Decorative Coatings on Neolithic (Yangshao) Pottery from Henan, China, *Journal of Archaeological Science*, 34, 2007, pp. 1787-1793.

14 P. Gregory, *Journal of Porphyrins and Phthalocyanines (JPP)*, Vol. 4, Issue 4, 2000, via worldscinet.com.

15 Th. Katsaros, I. Liritzis, and N. Laskaris, Is white Pigment on Appelles' Palette a TiO₂-rich Kaolin? New Analytical Results on the Case of Mellan-earth, *Mediterranean Archaeology and Archaeometry*, Vol. 9, No. 1, Greece, 2009, pp. 29-35.

16 R. Mayer, *The Artist's Handbook of Materials and Techniques*, New York, 1978, p. 386.

confirms that the varnish of the painting, which was identified as dammar, is the original varnish of the painting and that all materials used to produce the painting including the varnish were used and applied on the painting during the same period and are not materials used for restoration purposes. This conclusion is based on the results of different examination techniques, particularly ultraviolet radiation inspection.

7 Conclusions

According to the results of the previous analyses and investigation techniques, the picture under study, which is displayed at the Embassy of Georgia in Cairo and signed with the name of the Russian painter, Ivan Aivazovsky, was forged. This has been proven through performing several examinations, analyses, and tests such as SEM-EDAX, and XRD.

The results revealed that two pigments used in this painting were manufactured and used for the first time by artists 30 years after the death of Aivazovsky in the case of phthalocyanine blue, and 20 years after his death in the case of titanium white. Russian artist Ivan Aivazovsky died in 1900.

Furthermore, after comparing the signature found on this picture with those found on original paintings by Aivazovsky, it was found that the signature is forged as well. This study included techniques such as graphoanalysis. The mother signature was compared to that on the painting to study the writing pattern. This investigation revealed that the signature found on the painting under study does not reflect the characteristics of spontaneous writing that is a result of an instant message from the human brain which orders the hand to write according to the specific path that the brain is accustomed to perceive. The flow of the signature does not match that of the original official signature of the Russian Artist. On the contrary, the signature reflects the hesitation of the person who forged the signature.

Moreover, in original signatures, the horizontal line in letter "A" starts from the right-side line and ends at the left-side line; it also overlaps both side lines that make up the letter A. On the other hand, in the case of the signature under study, the horizontal side line starts from the left line and does not reach the right-side line, but stops just before reaching it. This is further evidence indicating the occurrence of forgery.

The cross-section technique revealed that the paint layer is layered in a uniform pattern and each layer is separate. There is no sign of overlapping, and this may be the result of a slow appliance of the layers. Then again, the painting technique used which involved the use of different separate tones produces an overlapping structure of the paint layer, and this is opposite to what the cross sections reveal. The lack of spontaneity indicates that this work was done by a forger and that the painting is not original.

Further evidence indicating forgery come from the results obtained from the FTIR analysis. FTIR was employed to identify both the binder used with the filler in the ground layer and the resin in the varnish layer. Natural glue was not detected and an artificial polymer was found to be used instead. On the other hand, artificial polymers were discovered after the death of the Russian artist.

Another difference between the original painting and this painting is the technique used to execute the sea waves. Waves in the painting under study were done using the impasto technique; however, in the original paintings, the artist did not use this technique. Alternatively, he applied a smooth paint layer. Additionally, brush strokes are discontinuous and therefore indicate hesitation. On the other hand, original

paintings show a smooth flow of pigments.

Inspection of the surface of the painting using a stereomicroscope, digital camera, ultraviolet radiation, and infrared radiation revealed that the damage forms found in the painting were done by the forger to give the painting an antique appearance. Solubility tests confirm that the age of the painting is certainly less than 100 years old. Based on the results of the previous examinations and analyses and the researcher's long experience in detecting forgery, the researcher dated the painting to between 1950 and 1960.

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Fig. 1 The painting signed by the Russian artist Aivazovsky



Fig. 2 Artificial parallel lines of cracks pass across the brush strokes



Fig. 3 The compression cracks in the paint layer made by a special tool (Black-and-white image)



Fig. 4 The thin paint layer was applied on top of artificial cracks

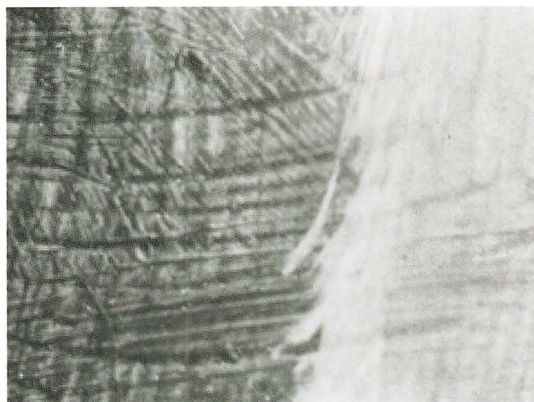


Fig. 5 The forger filled the hollow part with final brush strokes (Black-and-white image)

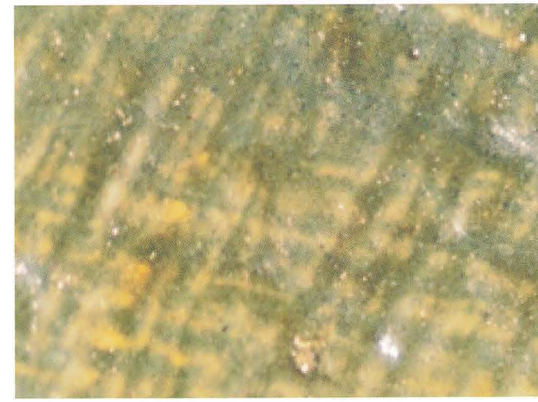


Fig. 6 The varnish layer fills the elongated compressions in the Paint layer

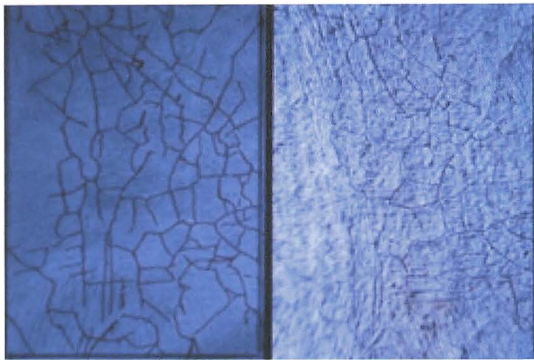


Fig. 7 The natural cracks on an original oil painting Both sides?



Fig. 8 The naked eye reflects the high forgery skills of the forger

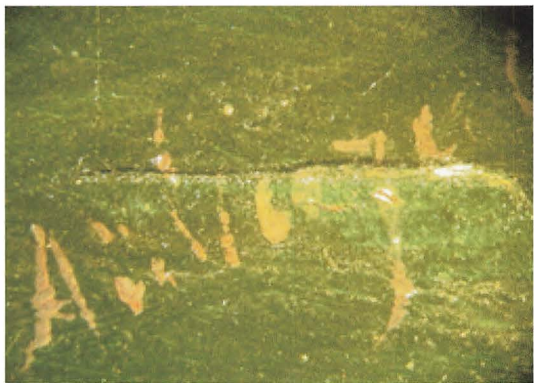


Fig. 9 The wide crack runs parallel to the accumulated color

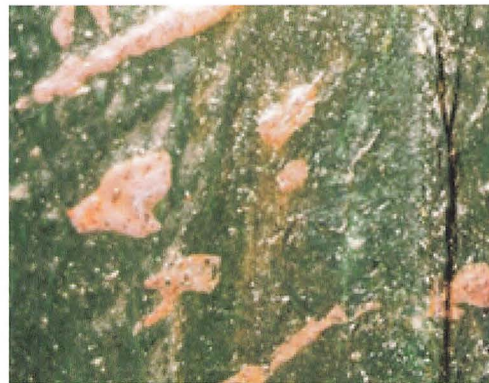


Fig. 10 The letters of the signatures cover the wide crack



Fig. 11 The letters fell off and only some remains are present on the smooth layer

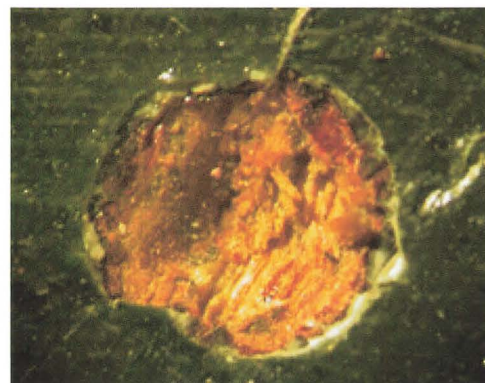


Fig. 12 Artificial multiple dents appear as flaking



Fig. 13 The piece of paper was glued to the paste layer



Fig. 14 The paint was applied on the top



Fig. 15 The painting in a valuable frame with confidence



Fig. 16 The original strokes are done

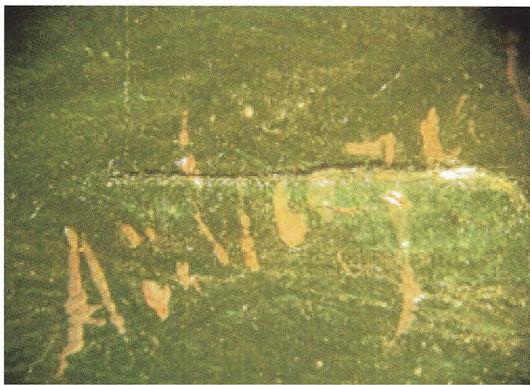


Fig. 17 The signature on the painting under study was not done by brush



Fig. 18 The Signature on the original painting was done by brush



Fig. 19 Unsmooth writing due to the shaking of the artist's hand



Fig. 20 Poor adherence of the signature to the paint layer



Fig. 21 The official signature in the Dictionary of International Artists



Fig. 22 The two side lines of the letter of "A" are not connected

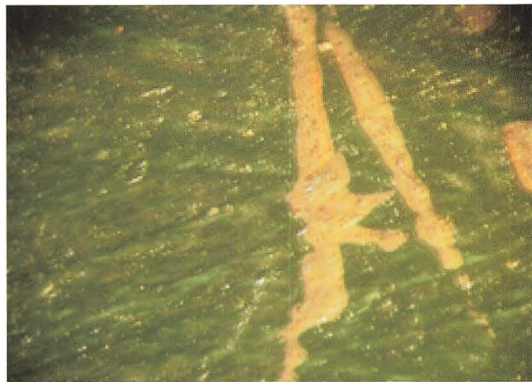


Fig. 23 Accumulation of the paint in the middle of the left-side line

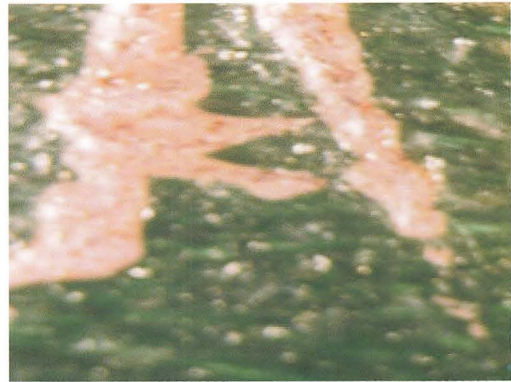


Fig. 24 Both horizontal lines start at the same point on the left-side line



Fig. 25 The spaces between the letters in the original signature are much small

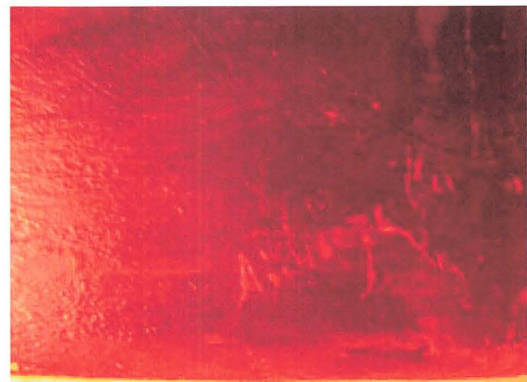


Fig. 26 The spaces between the letters in the signature under study are much bigger



Fig. 27 The horizontal line of the letter "A" in original signatures start at the right-side line



Fig. 28 The horizontal line starts at the left-side line in the case study

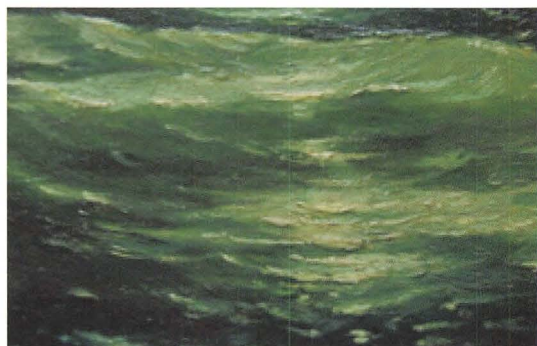


Fig. 29 The brush strokes are not connected in the case study



Fig. 30 The brush strokes are connected in the original painting

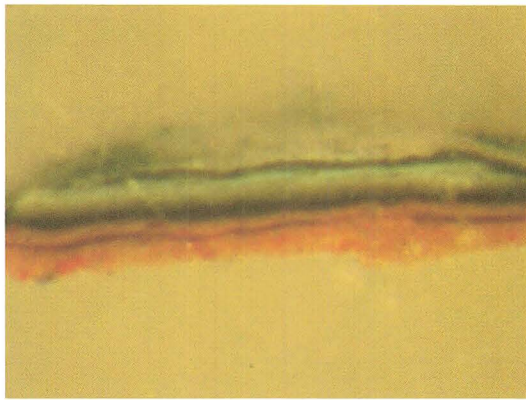


Fig. 31 Cross section of a green sample (four layers of the paint layer), 225x

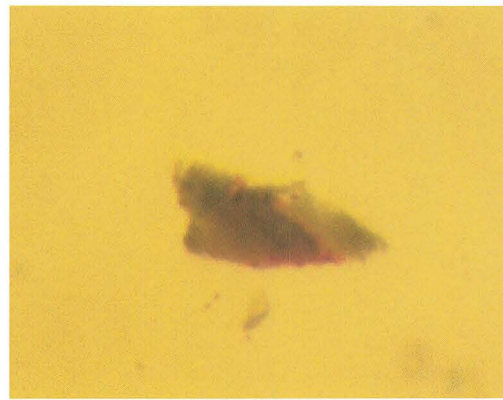


Fig. 32 Cross section of a blue sample (three layers of the paint layer), 175x

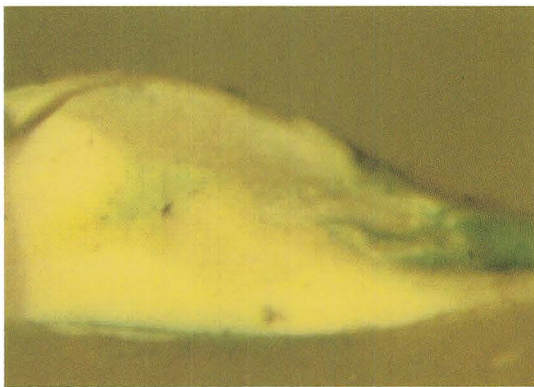


Fig. 33 Cross section of a white sample, 185x

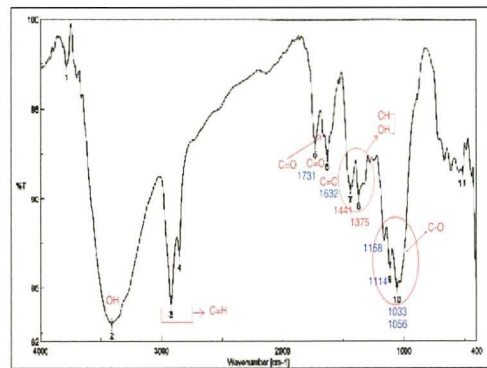


Fig. 34 FTIR spectrum of the varnish

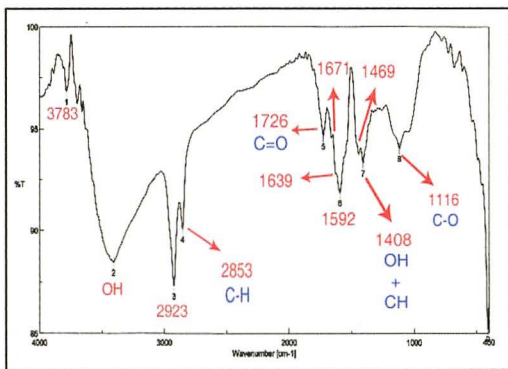


Fig. 35 FTIR spectrum of the ground binder

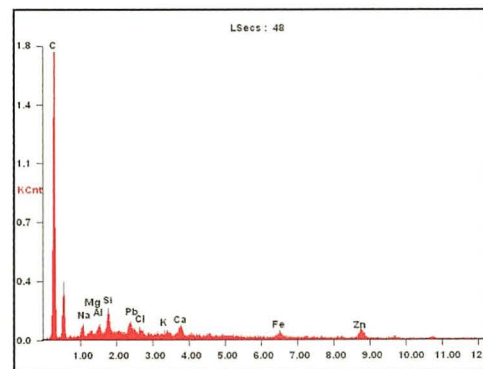


Fig. 36 EDAX spectra of the studied green sample

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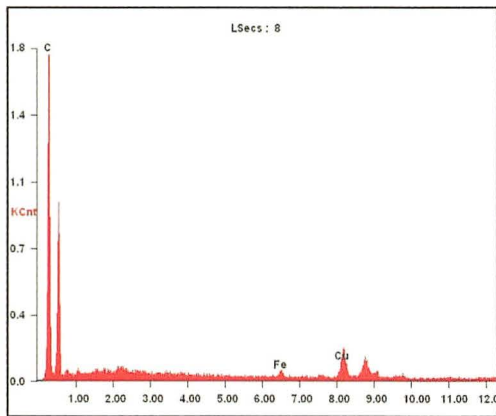


Fig. 37 EDAX spectra of the studied blue sample

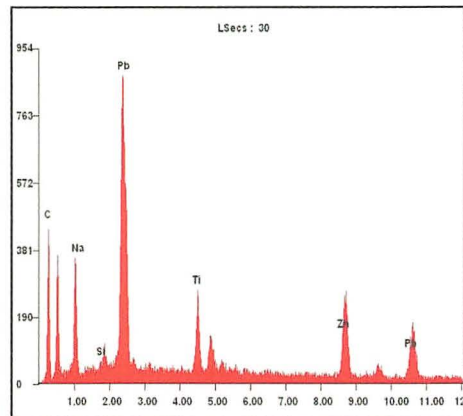


Fig. 38 EDAX spectra of the studied white sample

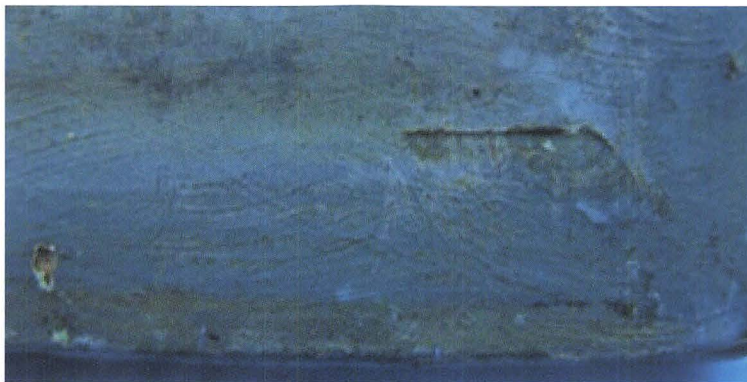


Fig. 39 All materials of the painting applied in the same period based on the results of ultraviolet radiation