Natural and Synthetic Colorants in Early Twentieth Century Russian Art

Problems of Transition and Coexistence

Evangelia A. Varella
Aristotle University of Thessaloniki, Greece
Introduction
colour is the thing without which the world would not be possible
Works of art, exhibited or stored, are susceptible to environmental factors, and alterations occur with the passage of time. To achieve a better and more effective preservation, the behaviour of all materials involved should be clarified.
The complex artistic patrimony of early twentieth century Russian art is amalgamating occidental modernist tendencies with Byzantine expertise, Mongol aesthetic suggestions, and folkloric proposals.

Monochromatic approaches are an outmost target, and hue is acquiring primordial importance, while brilliance and intensity are subjected to eager technical experimentations.
Painting palettes of this controversial period represent an effective model for examining the influence of environmental factors and historical processes to the chromatic profile originally sought by the artist; and for confronting preservation problems created by the coexistence of traditional and modern synthetic colorants.
The Role of Orthodox Iconography and Folkloric Art
Colorants used in Russian icon painting are combining Byzantine tradition to Central Asian proposals, and Renaissance influences.
Recipe collections compiled by local masters are already circulating in the 1400's, while antique and mediaeval treatises are systematically translated from the early seventeenth century on.

Describing sophisticated lake preparations, recording on imported products, adjusting raw materials to indigenous possibilities, experimenting with the binding media – the manuscripts are clearly documenting of a long established craftsmanship.
Hand-coloured folk prints and polychrome wooden artefacts representing all traditions blooming in the immense country, are in general following Orthodox aesthetic principles and technical expertise.
The mineral palette embraces crude and burnt Sienna and umbra earths; baryte, zinc white, lithopone, ceruse; natural cinnabar and vermilion, red lead; Pozzuoli earth, several ochres – haematite, red bole, *caput mortuum*, Pompei red, and later Mars products; orpiment, massicot, Naples yellow, antimony cinnabar; iron chlorides, silicates and phosphates; lazurite, ultramarine; and a great variety of natural and artificial copper compounds – carbonates *e.g.* azurite and malachite, chlorides *e.g.* atacamite, sulphates, nitrates, sulphocarbonates, arsenates, silicates *e.g.* Egyptian blue, phosphates *e.g.* pseudomalachite, acetates, *e.g.* verdigris.
Although relatively rare, colouring lakes are traced as precious counterparts to inorganic pigments. Scale insects, red sandalwood, Brazil wood, madder, dyer’s bugloss, safflower; saffron, Persian berries, Indian yellow; tall cinquefoil; copper resinate; indigo or woad, and carbon black, are largely utilized in pure form or as ingredients of manifold composites.
In the late nineteenth century low cost synthetic colouring compounds are straightforwardly introduced in the traditional painting palette. More often are encountered chrome yellow, and Prussian blue; alizarin, Hansa yellow, and fuchsin.
Modernist Occidental Influences
At the same time, Russian artists are taking modernist colour perception into serious consideration. Impressionist and symbolist European masters are by the turn of the century satisfactorily represented in the Shchukin and Morozov collections, while the *First Golden Fleece Salon* is leading to a solid implementation of expressionist and cubist concepts.
At a scientific level, innovative circles are well acquainted with the approach developed in *Colour Science*, a fundamental treatise authored by W. Ostwald and translated in Russian in 1926. According to the essay, primary complementary colour pairs are red/sea green and yellow/ultramarine blue; furthermore orange/turquoise blue and purple/leaf green.

Ivan Kliun is an enthusiastic adherent to the theory; while Boris and Maria Ender are revising the inherent assumptions by recapitulating the experiments on colour pursued in the Petrograd/Leningrad *State Institute of Artistic Culture (GinKhuk).*
Following in his line of thought the *Theory of Colours* conceived by J.W. von Goethe, while consenting to the Newtonian reality of tonal priorities, V. Kandinsky – later head of the Moscow *Institute of Artistic Culture (InKhuK)* – is indirectly reintroducing the ancient concept of tetrachromy, by parenting yellow to the triangle, and materializing blue in the circle.
Avant-Garde Colours and Colorants
Individual *avant-garde* paintings are accurately reflecting the contradictory historical processes in early twentieth century Russia.
During the *ancien régime* industrial pigments are ordered to the main German, French and British suppliers; or locally produced by Central European and indigenous firms. By the turn of the century *Dosekin* is the most renowned relevant Russian company.

In post-revolutionary times materials are frequently deficient or mediocre, even though ingenious procedures are trying to meet the requirements.
the material we are working with are the colorants, and with it alone we create a real new world

we apply colours in practice not, for example, as the reflex of yellow on blue, but as an aggregate of greens of greater or lesser density

an artist uses paints, and paints are never of a pure colour; even cobalt blue differs from a pure blue passed through a prism

the question is if it is legitimate to do away altogether with infinite combinations, which distinguish cadmium yellow from cobalt violet; if it is permissible to draw the boundaries as closed as they are placed by the paint manufacturers
basic colours and colorants are red, black, emerald green, white, and cobalt blue; and complementary ones ultramarine and rarely citron yellow, and madder lake pink... pure cobalt is a dangerous hue... scarlet cinnabar is falling into red lead, or rather pure red lead, cobalt and white.

cinnabar and madder, Saturn and English red are favoured tonalities... cobalt green is hard; chrome green, ultramarine blue and madder lake red smooth; emerald green is a bad colour.
we create surfaces of hardened lava streams of vermilion, black red crepe varnish, and sky-blue cobalt.

Yellow is prepared with bleached umbra and red cadmium; dark olive green with umbra, orange cadmium and emerald green; pinkish brown with red cadmium, umbra and white; brown with natural umbra, white and light blue cobalt; and cold brownish red with natural lake umbra, blue cobalt and white.
Genuine and Current Chromatic Profile
Russian *avant-garde* artists were often forced by circumstances to use low quality materials, while the compatibility of traditional and novel pigments was not always well comprehended.

Particularly susceptible to injuries were paintings on paper, since cellulose undergoes natural ageing and decomposes, and can further interact with the actual paint layers, causing denaturation in components of both.
The Stalinist era was drastically rejecting modernist attitudes, and numerous precious works were stocked up in an inefficient way. Consequently the authenticity of their appearance is rather questionable.
The physicochemical research is proceeding by colorimetric and spectroscopic analysis of samples deriving from artificially aged experimental tables, prepared as watercolour and gouache layers on paper ground devoid of preparation. Respective binding media are gum Arabic or gum Arabic and chalk.

Comparison is made with authentic paintings belonging to the Costakis Collection, State Museum for Contemporary Art, Thessaloniki.
The colorants studied are red lead, orpiment and realgar, chrome yellow, verdigris, ultramarine blue, Prussian blue, Mars black; and combinations of orpiment and ultramarine blue, or chrome yellow and Prussian blue. Furthermore carmine lake, Brazil wood, madder and alizarin red, Indian yellow, indigo, van Dyck brown, carbon black; Hansa yellow, and fuchsine.

Recent interventions are faced with the study of quinacridone magenta red, as well as phthalocyanine greens or blues.
A systematic comparative review of all colorimetric, and spectroscopic data permits evaluating the colorants as to compatibility and stability towards extrinsic factors, and is proposing degradation routes at a molecular level, with the intention of contributing to the physicochemical elucidation and appropriate preservation of early twentieth century polychrome works of art.
The experimental tables were subjected for a total time of three months to the influence of moist heat (90°C, 60% relative humidity), and the influence of ultraviolet radiation (30°C, 50% relative humidity).

Colour measurements were performed during the accelerated ageing, and changes expressed using the colour space CIE 1976 (L*a*b*). The surface of both untreated and aged paint layers was as well microscopically observed.
In order to determine the degree, in which chemical and molecular alterations are related to colour changes, micro Raman and FT infrared spectra of paint layers before and after ultraviolet exposure were recorded.
90°C, 60% Relative Humidity

$\Delta E^*$ Changes of Watercolour and Gouache Paint Layers – Inorganic Colorants
Ultraviolet Radiation, 30°C, 50% Relative Humidity

ΔE* Changes of Watercolour and Gouache Paint Layers– Inorganic Colorants
**Red Lead** **Pb₃O₄**
When exposed to ultraviolet radiation, paint layers displayed a remarkable decrease in brilliance, redness and yellowness. The alteration occurred in slow rate during the first days, had a sharp increase in the middle of the procedure, and was then led to a plateau. It is apparently due to partial transformation to orange yellow litharge – tetragonal PbO.
Red Lead

90°C, 60% Relative Humidity

$\Delta L^* = -6.7$
$\Delta a^* = -3.5$
$\Delta b^* = -7.7$
$\Delta E^* = 10.8$

$\Delta L^* = -8.0$
$\Delta a^* = -6.3$
$\Delta b^* = -9.8$
$\Delta E^* = 14.1$
Red Lead

Ultraviolet Radiation, 30°C, 50% Relative Humidity

$\Delta L^* = -5.1$
$\Delta a^* = -8.3$
$\Delta b^* = -8.6$
$\Delta E^* = 13.0$

$\Delta L^* = -10.3$
$\Delta a^* = -16.5$
$\Delta b^* = -13.1$
$\Delta E^* = 23.5$
Ultraviolet Radiation, 30°C, 50% Relative Humidity

Raman Spectra of Untreated and Artificially Aged Red Lead Paint Layers
[676.4nm, 0.3mW; Litharge Peaks Indicated with an Asterisk]
**Orpiment** $\text{As}_2\text{S}_3$

Ultraviolet radiated layers displayed a gradual decrease in redness and yellowness, and an increase in brilliance.

The untreated pigment contains realgar – $\alpha\text{-As}_4\text{S}_4$, which in the aged layer tends to yield pararealgar and arsenolite – $\text{As}_4\text{O}_6$. Fading of red realgar and simultaneous formation of yellow pararealgar and white arsenolite elucidates the changes in the initial hue. Sensitivity to ultraviolet radiation can be attributed to the biphasic state of the orpiment/realgar pigment, and its distribution in finer particles on the paper.
Orpiment

90°C, 60% Relative Humidity

\[ \Delta L^* = -13.7 \]
\[ \Delta a^* = -17.2 \]
\[ \Delta b^* = -30.4 \]
\[ \Delta E^* = 37.6 \]
Orpiment

Ultraviolet Radiation, 30°C, 50% Relative Humidity

\[ \Delta L^* = 9.3 \]
\[ \Delta a^* = -15.1 \]
\[ \Delta b^* = -18.9 \]
\[ \Delta E^* = 26.0 \]

\[ \Delta L^* = 13.2 \]
\[ \Delta a^* = -18.6 \]
\[ \Delta b^* = -28.0 \]
\[ \Delta E^* = 36.1 \]
90°C, 60% Relative Humidity

Raman Spectra of Untreated and Artificially Aged Orpiment Paint Layers
[676.4nm, 0.3mW; Orpiment Peaks Indicated with an Asterisk]
Raman Spectra of Untreated and Artificially Aged Orpiment Paint Layers

[676.4nm, 0.3mW; Realgar Peaks Indicated with an r/Pararealgar Peaks with a p/ Arsenolite Peaks with an a]
**Verdigris** Cu(CH₃COO)₂·H₂O
When watercolour layers are exposed to moist heat, tenorite – CuO is formed. Reduction to cuprite – Cu₂O is stimulated by the reducing sugars of gum Arabic, and accelerated by ultraviolet radiation.

Cuprite formation is taking place to a much smaller extent in the gouache layer; given that calcium is acting as an inhibitor in the reaction of copper with the carbohydrate units of gum Arabic, the presence of chalk could be credited with the relative stability of gouache.
Verdigris
90°C, 60% Relative Humidity

ΔL* = -17.9
Δa* = 47.1
Δb* = 15.8
ΔE* = 52.8

ΔL* = -25.1
Δa* = 42.8
Δb* = 19.5
ΔE* = 53.3
Verdigris

Ultraviolet Radiation, 30°C, 50% Relative Humidity

ΔL* = -0.3
Δa* = 20.8
Δb* = 18.4
ΔΕ* = 27.8

ΔL* = 6.2
Δa* = 14.8
Δb* = 15.4
ΔΕ* = 22.2
Raman Spectra of Untreated and Artificially Aged Verdigris Paint Layers

[488nm, 0.25mW; Chalk Peaks Indicated with a \( c \)]
Ultraviolet Radiation, 30°C, 50% Relative Humidity

Raman Spectra of Untreated and Artificially Aged Verdigris Paint Layers
[488nm, 0.25mW; Cuprite Peaks Indicated with an *; Chalk Peaks with a c]
**Prussian Blue** $\text{Fe}_4[\text{Fe(CN)}_6]_3$

Ultraviolet radiated layers demonstrated an initial raising, a subsequent decline, and a final restitution of brilliance values. Raman spectra recorded equally an initial shift of the cyan group to lower frequencies, followed by broadening.

Reduction to Berlin white – $\text{K}_2\text{Fe[Fe(CN)}_6]\text{]}$ is probably taking place, stimulated by the reducing sugars of gum Arabic, and accelerated by ultraviolet radiation. Restitution could be based on the inhibition of any further reduction, as gum Arabic is decomposing. Berlin white is hence partly re-oxidised to Prussian blue.
Prussian Blue

Ultraviolet Radiation, 30°C, 50% Relative Humidity
Raman Shifts of the Cyanide Group Stretch Peaks in Prussian Blue During Accelerated Ageing [76.4nm, 0.1mW]

Ultraviolet Radiation, 30°C, 50% Relative Humidity
90°C, 60% Relative Humidity

\[ \Delta E^* \] Changes of Watercolour and Gouache Paint Layers – Organic Colorants
Ultraviolet Radiation, 30°C, 50% Relative Humidity

$\Delta E^*$ Changes of Watercolour and Gouache Paint Layers – Organic Colorants
Carmine Lake

Colour alterations observed in ultraviolet radiated carmine layers are due to partial loss of the lake complex structure, as well as to crack formation on the surface.

In the infrared spectra, a destabilization of the complex, in which the alum salt is linked through the carbonyl group, could be detected.
Carmine Lake
Carmine Lake

90°C, 60% Relative Humidity

\[ \Delta L^* = -2.3 \]
\[ \Delta a^* = -7.2 \]
\[ \Delta b^* = -3.8 \]
\[ \Delta E^* = 8.5 \]

\[ \Delta L^* = -1.5 \]
\[ \Delta a^* = -7.2 \]
\[ \Delta b^* = -3.9 \]
\[ \Delta E^* = 8.3 \]
Carmine Lake

Ultraviolet Radiation, 30°C, 50% Relative Humidity

\[
\Delta L^* = -2.6 \\
\Delta a^* = -4.8 \\
\Delta b^* = -3.5 \\
\Delta E^* = 6.5
\]

\[
\Delta L^* = 7.9 \\
\Delta a^* = -8.1 \\
\Delta b^* = -8.8 \\
\Delta E^* = 14.4
\]
Ultraviolet Radiation, 30°C, 50% Relative Humidity

FT-IR Reflectance Spectra of Carmine Lake Layers before and after Ageing
Brazil Wood
Under ultraviolet radiation, main parameter contributing to the total colour difference is L*, confirming that the fugitive behaviour of the dye is playing the predominant role in colour change.

The infrared spectra are implying that even a 350 nm radiation is sufficient for inducing oxidation of phenolic brazilin to aromatic carboxylic brazilein.

A small rise in brilliance under the effect of moist heat is pointing at a dye loss on the paper substrate.
Brazil Wood

Ultraviolet Radiation, 30°C, 50% Relative Humidity

ΔL* = 6.4
Δa* = -0.7
Δb* = -0.8
ΔΕ* = 6.5

ΔL* = 11.1
Δa* = 0.7
Δb* = 0.5
ΔΕ* = 11.1
FT-IR Reflectance Spectra of Brazil Wood Layers before and after Ageing

Ultraviolet Radiation, 30°C, 50% Relative Humidity
Alizarin
Colour fading, observed in alizarin layers subjected to moist heat ageing, is due to alterations in the intramolecular hydrogen bonding between the carbonyl and the hydroxyl group, as well as to high crack formation on the surface.
Alizarine
90°C, 60% Relative Humidity

\[ \Delta L^* = 0.3 \]
\[ \Delta a^* = -6.2 \]
\[ \Delta b^* = -5.2 \]
\[ \Delta E^* = 8.0 \]

\[ \Delta L^* = -3.6 \]
\[ \Delta a^* = -7.7 \]
\[ \Delta b^* = -10.2 \]
\[ \Delta E^* = 13.3 \]
90°C, 60% Relative Humidity

FT-IR Reflectance Spectra of Alizarin Layers before and after Ageing
**Indian Yellow**

The colorant was fairly susceptible to moist heat ageing. On the surface of both watercolour and gouache layers, formation of dark areas is explaining the decrease of all colour parameters.

The physical nature of the chromatic alteration – deterioration of the smooth surface, changes in particle aggregation, crack formation – was proven by the lack of differentiation in the infrared spectra.
Indian Yellow

90°C, 60% Relative Humidity

\[ \Delta L^* = -3.0 \]
\[ \Delta a^* = -5.6 \]
\[ \Delta b^* = -4.8 \]
\[ \Delta E^* = 8.0 \]
**Hansa yellow PY3**

Under high temperature and humidity, important decreases in both brilliance and yellowness are observed. A warm and moist environment is causing extended crack formation, responsible for reducing reflectance values.

Lessening of yellowness may be due to gradual sublimation of the colouring agent.
Hansa Yellow

90°C, 60% Relative Humidity

$\Delta L^* = -8.7$
$\Delta a^* = -0.4$
$\Delta b^* = -19.2$
$\Delta E^* = 21.1$
Fuchsine
As a solid, fuchsine forms green-yellow crystals, turning to purple when dissolved in water. Exposure in ultraviolet light caused an immediate substantial decrease of b values in both watercolour and gouache layers.

Infrared spectra of ultraviolet radiated layers recorded amino group shifts due to the intramolecular charge transfer caused by ultraviolet excitation.
An increase in brilliance, observed after forty days of ageing, is justified on the basis of the more fugitive dye monomer. On the paint layer surface the paper was at occasions totally revealed.

The increase in brilliance and yellowness is related to the formation of bright yellow areas, probably due to aggregation of dye crystallites and the improvement of their reflecting surface. Further ageing induced intense crack formation, and subsequent re-darkening of the surface.
Fuchsine

Ultraviolet radiation, 30°C, 50% Relative Humidity

ΔL* = -4.5
Δa* = -0.4
Δb* = -14.1
ΔE* = 14.8

ΔL* = 3.2
Δa* = 0.3
Δb* = -14.0
ΔE* = 14.4
Ultraviolet Radiation, 30°C, 50% Relative Humidity

FT-IR Reflectance Spectra of Fuchsine Layers before and after Ageing

- fuchsin, watercolour
- fuchsin, gouache
In general, colouring agents – with the exception of alizarin, Indian yellow, and Hansa yellow – were stronger influenced by ultraviolet light than by high temperature combined to humidity.

Red lead, orpiment, verdigris, Prussian blue, carmine lake, and Brazil wood proved more sensitive; while chrome yellow, ultramarine blue – $3\text{Na}_2\text{O}.3\text{Al}_2\text{O}_3.6\text{SiO}_2.\text{Na}_2\text{S}$, alizarin, Indian yellow, Hansa yellow, and fuchsine exhibited a better stability.

Mars black – $\text{Fe}_3\text{O}_4$, indigo, van Dyck brown; quinacridone magenta red PR122, and phtalocyanine green or blue were hardly affected.
quinacridone magenta red PR122

phtalocyanine green and blue
The higher light sensitivity of gouache layers might be attributed to the lower concentration and smaller aggregation of pigment particles, since they are interpolating with chalk entities.
The comparative review of all data permits regenerating certain features of the chromatic profile, as originally created by the artist; is evaluating the colorants as to compatibility and stability towards extrinsic factors; and is proposing degradation routes at a molecular level.
The experimental tables were subjected to the ageing tests in a Voetsch VC0018 climatic chamber. They were exposed to Philips Cleo 20W fluorescence tubes, which emit highly concentrated ultraviolet radiation in the 300-400 nm range, peaking at 350nm. The samples were placed at a distance of 2 cm from the radiation source.

A Miniscan XE Plus spectrophotometer (HunterLab) was used for colour measurements during the accelerated ageing. The surface was studied under an Olympus Bx60 optical microscope with a JVC TK-C1381 camera and Leica MW Software. The total colour difference $\Delta E^*$ between the sample prior to light exposure and at each measurement during the ageing was calculated according to the equation: $\Delta E^* = \{ (\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2 \}^{1/2}$. 
Micro-Raman spectra were recorded using a triple grating spectrometer (Dilor XY) equipped with a CCD liquid-nitrogen cooled detector system. The blue (488 nm) line of an Ar ion laser and the red line (676.4 nm) of a Kr ion laser were used for excitation and the spectral resolution of the system was ~3 cm$^{-1}$. The laser was focused on the sample through the system’s microscope equipped with a standard objective lens 100x. The relevant power was kept at 0.1 - 0.3mW, in order to avoid damaging the underlying samples.

FT-Infrared spectra were recorded on a Perkin Elmer Spectrum GX II spectrometer equipped with a MCT detector. The spectra were collected in reflectance mode in the range of 4000-700 cm$^{-1}$, with a resolution of 4 cm$^{-1}$, an aperture of 100x100 µm, and 300 scans per measurement. Four spectra from different areas of each sample were recorded and the average spectrum was calculated.
As a conclusion, colour alterations due to environmental factors have been elucidated; and degradation routes have been proposed, with the intention of assisting museum conservators in every concrete case related to the broad spectrum of pigments, either actually studied or belonging to chemically related compound groups.
Physicochemical Investigation of Avant-Garde Paintings
The survey encompasses a series of samples taken from twenty-two watercolour and gouache paintings on paper, belonging to the Costakis Collection in the State Museum for Contemporary Art, Thessaloniki.

In an attempt to represent a significant number of art historical tendencies and theoretical concepts, as well as to consider a large variety of hues, the selection focused on Boris, Maria, Xenia and Yuri Ender, Ivan Kliun, Ivan Kudriashev, Salomon Nikritin, Konstantin Vialov, Alexander Volkov, and possibly Liubov Popova.
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<th>Artist</th>
<th>Inv. Number</th>
<th>Number of Samples</th>
<th>Colour of Samples</th>
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<td>[L. Popova]</td>
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List of Paintings [Costakis Collection, State Museum for Contemporary Art, Thessaloniki]
Colouring compounds identified include chalk, zinc white, vermilion, red ochre/Mars red, red lead; carmine lake, madder/alizarin; yellow ochre/Mars yellow, chrome yellow, and zinc yellow; emerald green, ultramarine blue, Prussian blue, and carbon black; as well as various well-established or unconfirmed mixtures.

Zinc white acts as a prevailing white colorant, being at the same time an excellent gouache filler, along with chalk.
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<th>Red Lead</th>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Yellow Ochre/Mars Yellow</th>
<th>Chrome Yellow</th>
<th>Zink Yellow</th>
<th>Chrome Green</th>
<th>Emerald Green</th>
<th>Ultramarine Blue</th>
<th>Prussian Blue</th>
<th>Carbon Black</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. Ender</td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>M. Ender</td>
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<td></td>
</tr>
<tr>
<td>X. Ender</td>
<td>*</td>
<td>*</td>
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<td>*</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Y. Ender</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I. Kliun</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>I. Kudriashev</td>
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<td></td>
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<tr>
<td>S. Nikritin</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>K. Vialov</td>
<td>*</td>
<td></td>
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<td>*</td>
</tr>
<tr>
<td>A. Volkov</td>
<td></td>
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<td>*</td>
</tr>
<tr>
<td>[L. Popova]</td>
<td>*</td>
<td>*</td>
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<td>*</td>
</tr>
</tbody>
</table>

**Distribution of Colorants by Painter [Sporadic Grains Indicated with an *]**
Raman Spectra of Samples Identified as Vermilion and Red Lead [676.4nm, 0.3mW]

Vermilion HgS

Red Lead Pb₃O₄

M. Ender, *Inv.Nr. C429/AB625*  
A. Volkov, *Inv.Nr. 281*

Raman Spectra of Samples Identified as Vermilion and Red Lead [676.4nm, 0.3mW]
Mars Red Fe$_2$O$_3$

I. Kliun, *Inv.Nr. C559*  
S. Nikritin, *Inv.Nr. 8-C9*

Raman Spectra of Samples Identified as Mars Red [676.4nm, 0.3mW]
Raman and FT-IR Reflectance Spectra of a Sample Identified as Alizarin [488nm, 0.3mW]
Raman Spectra of Samples Identified as Chrome Yellow and Emerald Green

Chrome Yellow PbCrO$_4$

Emerald Green Cu(C$_2$H$_3$O$_2$)$_2$·3Cu(AsO$_2$)$_2$

A. Volkov, *Inv.Nr. 281*

B. Ender, *Inv.Nr. C473*

Raman Spectra of Samples Identified as Chrome Yellow and Emerald Green [676.4nm, 0.3mW]
Ultramarine Blue $3\text{Na}_2\text{O}.3\text{Al}_2\text{O}_3.6\text{SiO}_2.\text{Na}_2\text{S}$


Raman Spectra of Samples Identified as Ultramarine Blue [676.4nm, 0.3mW]
Prussian Blue $\text{Fe}_4[\text{Fe(CN)}_6]_3$

Raman Spectra of Samples Identified as Prussian Blue [676.4nm, 0.3mW]

B. Ender, *Inv.Nr. C473*  
X. Ender, *Inv.Nr. C454*

Raman Spectra of Samples Identified as Prussian Blue [676.4nm, 0.3mW]
As a rule, a mixture of blue and yellow pigments – usually chrome yellow and Prussian blue – is credited with the creation of green areas. In several cases zinc yellow is added to Prussian blue, or yellow ochre to ultramarine blue.

Purple tints are habitually due to ultramarine blue mixed with vermilion, or with carmine lake and carbon black.

Carbon black is yielding brown with Mars red, and grey with zinc white.
<table>
<thead>
<tr>
<th>Painter</th>
<th>Red</th>
<th>Orange</th>
<th>Green</th>
<th>Purple</th>
<th>Brown</th>
</tr>
</thead>
<tbody>
<tr>
<td>X. Ender</td>
<td></td>
<td></td>
<td>Mars yellow, chrome yellow, Prussian blue</td>
<td>vermillion, Prussian blue</td>
<td></td>
</tr>
<tr>
<td>Y. Ender</td>
<td></td>
<td>zinc yellow, Prussian blue</td>
<td>zinc yellow, ultramarine, vermilion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I. Kliun</td>
<td></td>
<td></td>
<td>chrome yellow, Prussian blue</td>
<td>red ochre, ultramarine</td>
<td>red ochre, ultramarine, carbon black</td>
</tr>
<tr>
<td>I. Kudriashev</td>
<td></td>
<td></td>
<td>yellow ochre, ultramarine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K. Vialov</td>
<td></td>
<td></td>
<td>yellow ochre, ultramarine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Volkov</td>
<td>red lead, chrome yellow</td>
<td>chrome yellow, Prussian blue</td>
<td>chrome yellow, Prussian blue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[L. Popova]</td>
<td>red lead, madder lake</td>
<td></td>
<td></td>
<td></td>
<td>yellow ochre, carbon black</td>
</tr>
</tbody>
</table>

Distribution of Composite Colorants by Painter
Green Tints

Raman Spectra of a Sample Identified as Chrome Green [Chrome Yellow Peaks Indicated with a $c$, Prussian Blue Peaks with a $p$]; and of the Yellow Component of a Green Sample, Identified as Chrome Zinc Yellow [676.4nm, 0.3mW]

I. Kliun, Inv.Nr. AB326

Y. Ender, Inv.Nr. C472
Purple Tints

I. Kliun, *Inv.Nr. C555*

Raman Spectra of a Sample Identified as Vermillion and Prussian Blue; and of the Red Component of a Purple Sample, Identified as a Mixture of Carmine and Carbon Black [676.4 nm, 0.3 mW]
Brown and Grey Tints

I. Kliun, *Inv.Nr. C446*

I. Kudriashev, *Inv.Nr. AB739*

Raman Spectra of a Sample Identified as Mars Red and Carbon Black; and of a Sample Identified as Zinc White and Carbon Black [676.4 nm, 0.3 mW]
Systematization, Valorisation & Dissemination of e-Learning Courses in Conservation Science

Lifelong Learning Programme/Erasmus/Virtual Campus

**Partners:**
Aristotle University of Thessaloniki (coordinator)
University of Avignon & the Vaucluse
Cà Foscari University of Venice
Rey Juan Carlos University at Madrid
aStyle Linguistic Competence, Vienna
S. Mohammed ben Abdellah University of Fez

[http://econsc.chem.auth.gr/VirtualCampus](http://econsc.chem.auth.gr/VirtualCampus)
The project addresses virtual mobility in the field of material cultural heritage preservation by organizing specialized course units on conservation science, as well as seminars on concrete diagnostic or safeguarding problems.

It is conceived as a virtual campus offering joint curricula in both lecturing and practicing laboratory work, and enhancing the birth of a common language in problem solving.
Contact Persons:
Evangelia A. Varella (Greece) varella@chem.auth.gr
Cathy Vielliescazes (France) cathy.vieillescazes@univ-avignon.fr
Gino Paolucci (Italy) paolucci@unive.it
Mariano Fajardo (Spain) mariano.fajardo@urjc.es
Rachid Benslimane (Morocco) rachidbenslimane@yahoo.fr
Water Zeller (administrator for linguistic issues) w.zeller@aon.at
Ioannis Kozaris (ICT administrator) ikozaris@chem.auth.gr
3rd Summer School on Conservation Science

July 19-31, 2008

Thessaloniki, Greece

http://culture.chem.auth.gr/SummerSchool2009
(available from 15th of December 2008)