ARTIST:	Josip Diminić
TITLE OF THE WORK and YEAR OF EXECUTION:	Objekt I / Object I (1979)
MATERIALS:	Painted steel

	Name and description of the sample	Analytical methods	Notes
1	**5/1 – coatings (cross section)**	Micro FTIR, Optical microscopy , SEM/EDS	Samples 5/4, 5/5 and 5/6 are taken from the same position as samples 5/1, 5/2 and 5/3. In order to get the insight of the coatings, optical microscopy, SEM/EDS and micro FTIR analysis were performed on prepared crossed sections of samples 5/1, 5/2 and 5/3.
2	**5/2 – coatings (cross section)**	Micro FTIR, Optical microscopy , SEM/EDS	
3	**5/3 – coatings (cross section)**	Micro FTIR, Optical microscopy , SEM/EDS	
4	**5/7 – corrosion products**	SEM/EDS	
5	**5/8 – corrosion products**	FTIR	

Description of the analytical methods, equipment and procedures:

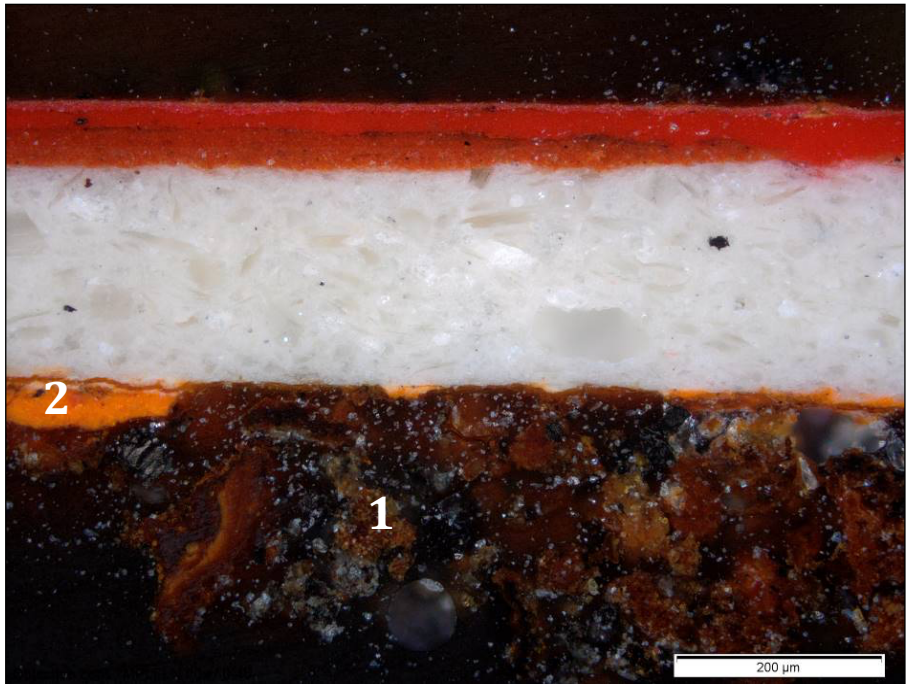
-Optical microscopy: analysis performed on sample or cross section using visible (VIS), ultraviolet (UV), polarized (POL) or infrared (IR) light depending on the characteristic of the observed sample. Observation and images taken from 50X to 1000X magnification. **Equipment used:** Optical microscopy Olympus BX51 and optical microscopy Carl Zeiss Image m2M.

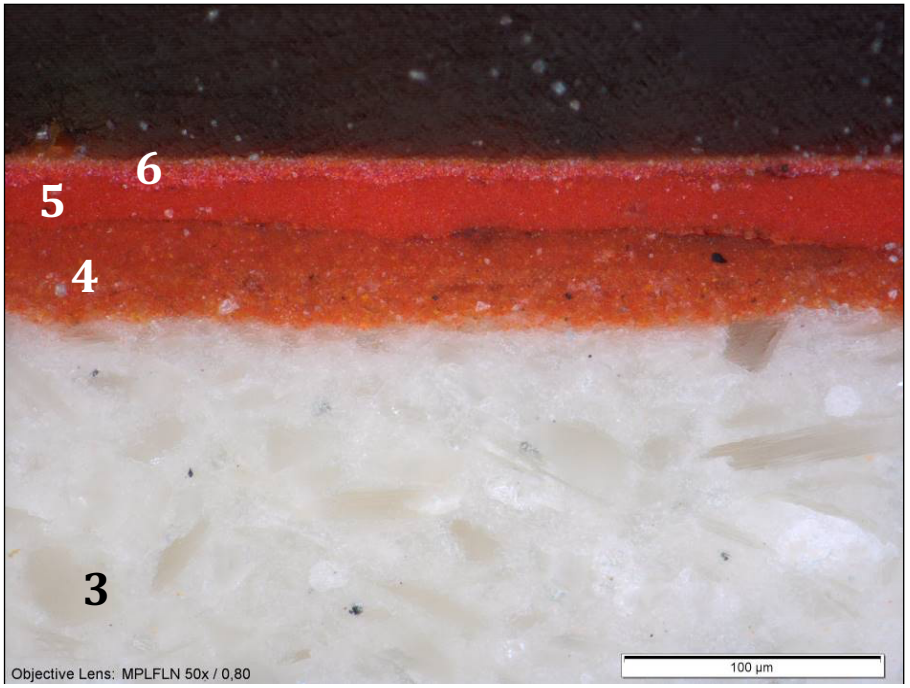
-Fourier Transform Infrared Spectroscopy (FTIR): analysis performed using KBr pellets preparation (2 mg sample + 120 mg Kbr). Each spectrum is a result of 64 scans taken at resolution of 4 cm^{-1} in the range from 4000 to 400 cm^{-1}. Collected spectra were baseline corrected and when necessary smoothed according to Savitzky/Golay algorithm. **Equipment used:** FTIR spectrometer Tensor 27 Bruker.

-Micro Fourier Transform Infrared Spectroscopy (μFTIR): analysis performed on prepared cross section using Attenuated Total reflection objective (ATR) suitable of analysis on area of approximately 50 x 50 μm. The spectra are the results of 32 scans taken at resolution of 4 cm^{-1} in the range from 4000 to 600 cm^{-1}. **Equipment used:** FTIR microscope Hyperion 1000 Bruker and as source FTIR spectrometer Tensor 27 Bruker.

-**Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscopy (EDS)- SEM/EDS:** analysis performed operating under low vacuum conditions for non-conductive samples (80 Pa) and under high vacuum for conductive samples. Images were recorded with Backscattered electrons detector (BSED) with spot from 3 to 5, working distance 10 mm, acceleration voltage from 20 to 30 kV. **Equipment used:** FEG Quanta 250 FEI. EDS microanalysis were performed on observed samples at acceleration voltage of 30 kV and working distance10 mm. **Equipment used:** Penta FET X-act detector Oxford Instruments. NOTE: The EDS microanalysis of the chemical composition by SEM is performed by analysing the chemical composition in a small sample segment and under a certain magnification, whereby the results are not quantitatively comparable, i.e. the measurements vary considerably from one point to another due to inhomogeneity of the tested samples, surface contamination, segregation of the elements and sensitivity of the method. The results of EDS analysis do not represent the chemical composition of the whole sample but the chemical composition of the examined point/field on the sample's surface.

Results:
Sample 5/1

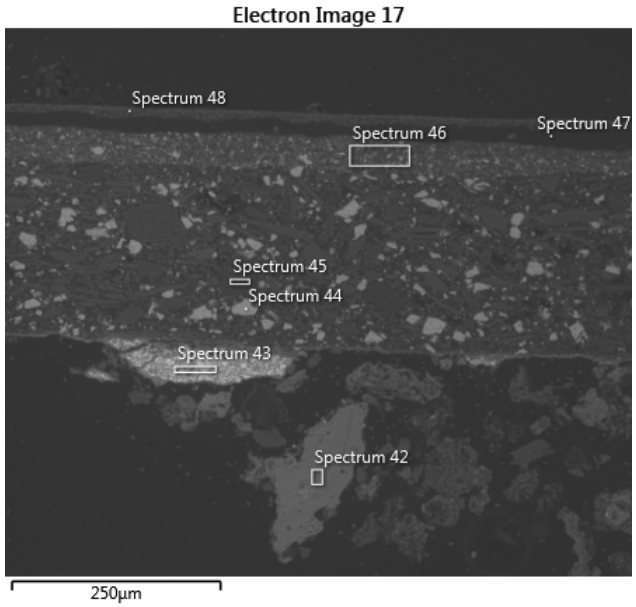




Sample 5/1 – optical microscopy (magnification 50X and 500X), SEM/EDS and micro FTIR analysis has shown the following structure and composition

1- Support (steel)
2- Orange base coat of regular thickness about 100 µm, containing minium and an organic binder.
3- White ground layer of regular thickness of about 200 µm, containing barite, chalk and alkyd binder.
4- Red paint layer, average thickness 50 µm, containing iron red, barium sulphate, silicates, alkyd binder possibly minium and chrome red.
5- Red paint layer, average thickness 30 µm, containing organic pigment and binder
6- Red paint layer, average thickness 20 µm, containing minium, chrome red, titanium white, most probably barite and alkyd binder.

Sample 5/1 - SEM/EDS analysis



Spectrum 42	Wt%	Wt% Sigma
Fe	42.89	0.97
O	34.92	1.02
C	19.12	1.37
Pb	2.46	0.61
Si	0.61	0.12
Total	100.00	

Spectrum 43	Wt%	Wt% Sigma
Pb	50.65	1.14
C	32.19	1.18
O	14.21	0.87
Fe	2.94	0.19
Total	100.00	

Spectrum 44	Wt%	Wt% Sigma
Ba	38.57	1.23
O	25.88	1.35
C	25.04	1.84
S	8.13	0.38
Mg	1.06	0.23
Fe	0.68	0.18
Si	0.62	0.18
Total	100.00	

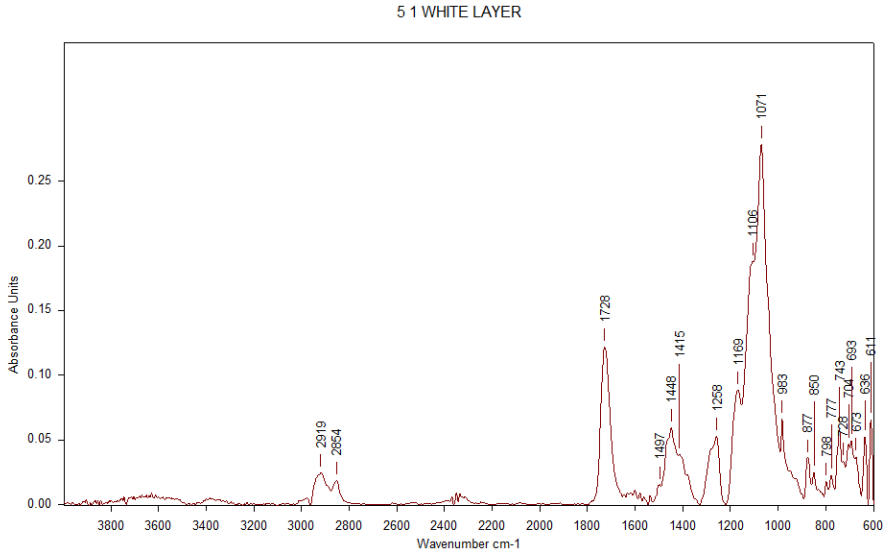
Spectrum 45	Wt%	Wt% Sigma
O	50.18	1.14
C	28.76	1.31
Mg	17.57	0.49
Ba	1.42	0.18
Si	0.78	0.09
Fe	0.64	0.10
Ca	0.37	0.06
S	0.29	0.07
Total	100.00	

Spectrum 46	Wt%	Wt% Sigma
C	53.83	1.15
O	25.17	1.15
Ba	10.79	0.38
S	2.38	0.13
Pb	2.35	0.50
Fe	1.80	0.14
Si	1.70	0.11
Ca	0.75	0.07
Mg	0.73	0.11
Cr	0.49	0.10
Total	100.00	

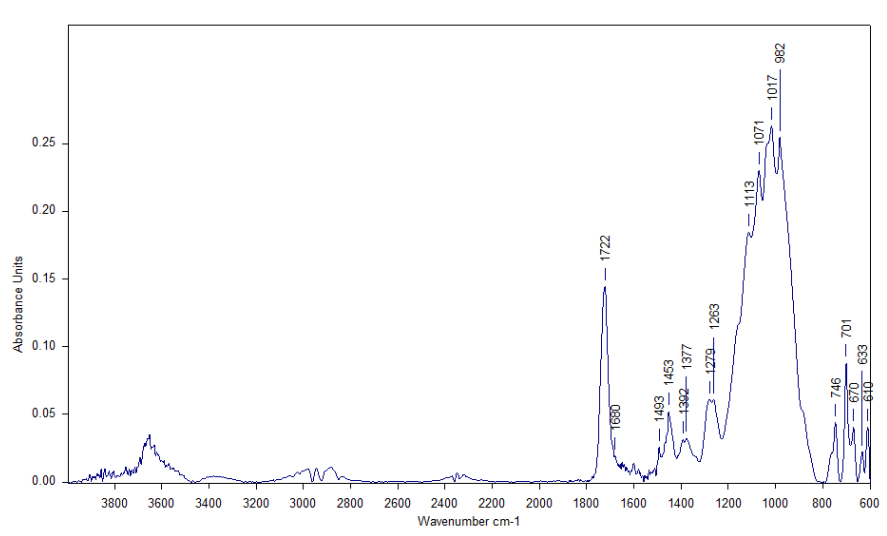
Spectrum 47	Wt%	Wt% Sigma
C	63.96	0.98
O	33.36	0.99
Ba	0.70	0.14
Ca	0.56	0.05
Fe	0.43	0.07
Si	0.33	0.05
S	0.24	0.05
Mg	0.22	0.06
Ti	0.20	0.06
Total	100.00	

Spectrum 48	Wt%	Wt% Sigma
C	76.76	1.51
Pb	9.45	1.29
Ti	6.50	0.47
Ba	3.74	0.80
Cr	1.72	0.26
Fe	1.09	0.26
Si	0.74	0.16
Total	100.00	

Sample 5/1 - Micro FTIR analysis

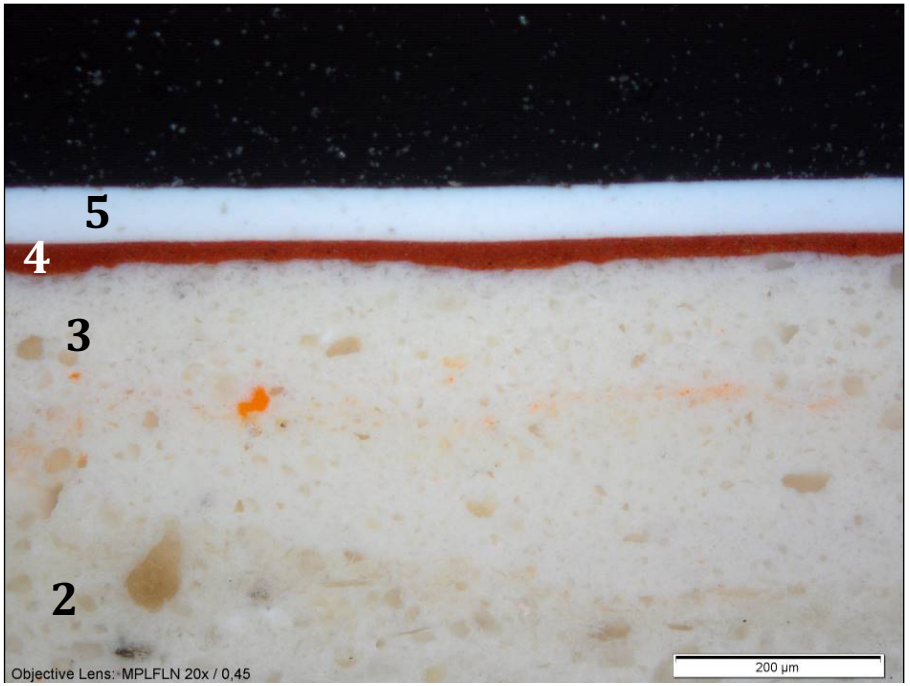


Experiment HYPERION1000_ATR.xpm
Path of File C:\CAPUS\MICRO FTIR\MEAS
Operator Name Administrator
Date of Measurement 23.7.2019.
Instrument Type TENSOR 27
Sample Form HYPERION 1000_15x objective
Resolution 4
Sample Scans 32



Experiment HYPERION1000_ATR.xpm
Path of File C:\CAPUS\MICRO FTIR\MEAS
Operator Name Administrator
Date of Measurement 23.7.2019.
Instrument Type TENSOR 27
Sample Form HYPERION 1000_15x objective
Resolution 4
Sample Scans 32

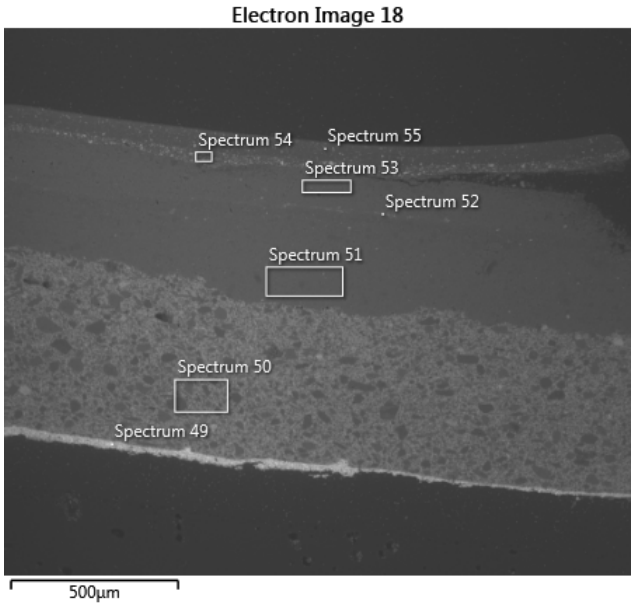
Sample 5/2



Sample 5/2 – optical microscopy (magnification 50X and 200X), SEM/EDS and micro FTIR analysis has shown the following structure and composition

1- Base coat of regular thickness about 20 µm, containing minium and an organic binder.
2- White layer of regular thickness about 250 µm (probably mastic) mainly made of barium sulphate, chalk, zinc white, silicates and alkyd binder
3- Second white ground of irregular thickness (probably mastic) consisting of chalk, titanium white and zinc white and alkyd binder. Between layer 2 and 3 it is visible a thin irregular layer consisting of minium.
4- Red paint layer of regular thickness about 20 µm containing alkyd binder, barite, chalk, titanium white and iron leading to the conclusion that red ochre is also present.
5- White paint layer consisting mainly of titanium white and alkyd binder.

Sample 5/2 - SEM/EDS analysis



Spectrum 49	Wt%	Wt% Sigma
Pb	58.01	1.28
C	22.67	1.25
O	15.10	1.03
Ba	1.38	0.28
Ca	1.12	0.13
Zn	0.92	0.20
Fe	0.79	0.14
Total	100.00	

Spectrum 50	Wt%	Wt% Sigma
O	34.08	1.06
C	25.56	1.35
Ba	10.10	0.36
Ca	9.48	0.26
Zn	7.72	0.31
S	4.48	0.17
Mg	3.29	0.20
Si	2.32	0.13
Na	1.52	0.35
Al	1.11	0.13
Fe	0.34	0.09
Total	100.00	

Spectrum 51	Wt%	Wt% Sigma
O	45.97	1.64
Ca	22.67	0.76
C	20.17	1.37
Ti	8.40	0.38
Zn	1.62	0.27
Mg	0.79	0.20
Si	0.39	0.11
Total	100.00	

Spectrum 55	Wt%	Wt% Sigma
C	42.26	1.75
O	33.22	2.00
Ti	15.71	0.65
Ba	4.93	0.59
Si	1.88	0.16
Ca	1.01	0.10
S	0.52	0.09
Al	0.48	0.11
Total	100.00	

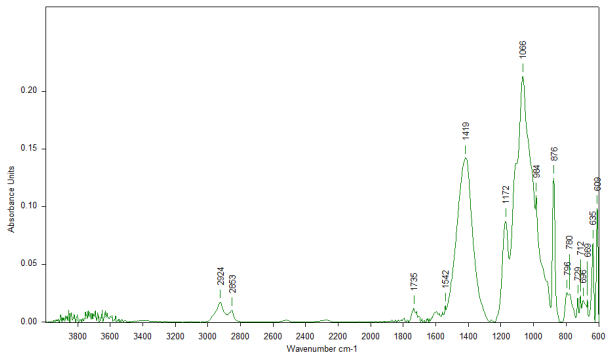
Spectrum 52	Wt%	Wt% Sigma
O	42.29	2.53
C	26.70	2.09
Ca	17.34	0.88
Ti	9.71	0.58
Zn	2.10	0.35
Mg	1.87	0.31
Total	100.00	

Spectrum 53	Wt%	Wt% Sigma
O	45.53	2.10
C	21.89	1.74
Ca	21.73	0.92
Ti	7.82	0.43
Zn	1.76	0.29
Mg	0.80	0.21
Si	0.47	0.12
Total	100.00	

Spectrum 54	Wt%	Wt% Sigma
C	45.00	1.37
O	33.22	1.38
Ba	7.80	0.45
Ca	5.31	0.21
Pb	1.97	0.56
S	1.75	0.14
Ti	1.70	0.20
Fe	1.48	0.15
Si	0.69	0.11
Zn	0.67	0.17
Mg	0.40	0.12
Total	100.00	

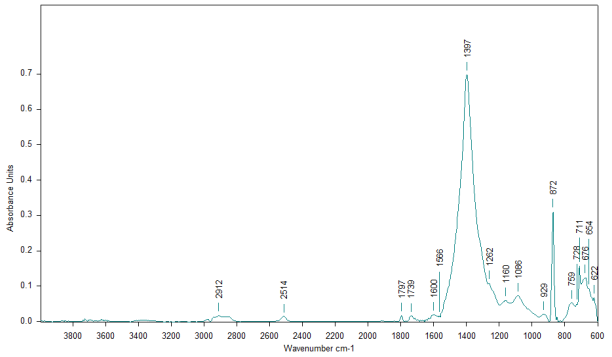
Sample 5/2 - Micro FTIR analysis

5 2 1-WHITE LAYER



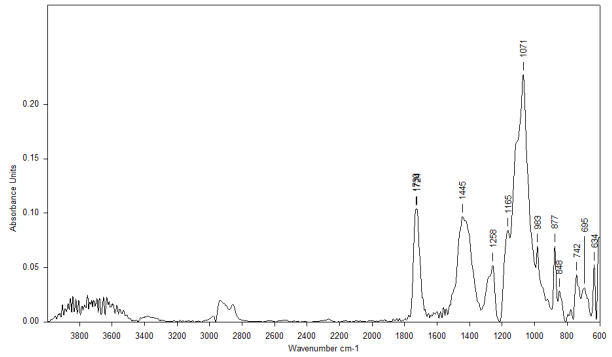
Experiment HYPERION1000_ATR.xpm
Path of File C:\CAPUS\MICRO FTIR\MEAS
Operator Name Administrator
Date of Measurement 23.7.2019.
Instrument Type TENSOR 27
Sample Form HYPERION 1000_15x objective
Resolution 4
Sample Scans 32

5 2 2-WHITE LAYER



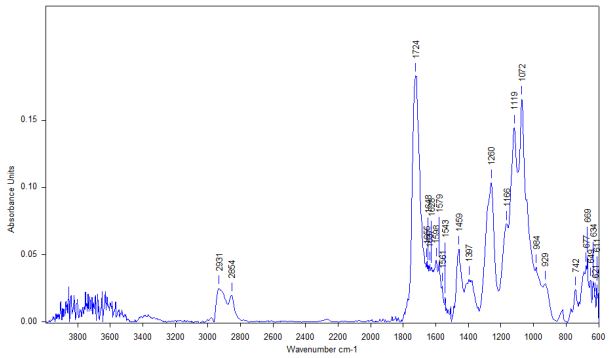
Experiment HYPERION1000_ATR.xpm
Path of File C:\CAPUS\MICRO FTIR\MEAS
Operator Name Administrator
Date of Measurement 23.7.2019.
Instrument Type TENSOR 27
Sample Form HYPERION 1000_15x objective
Resolution 4
Sample Scans 32

5 2 RED LAYER



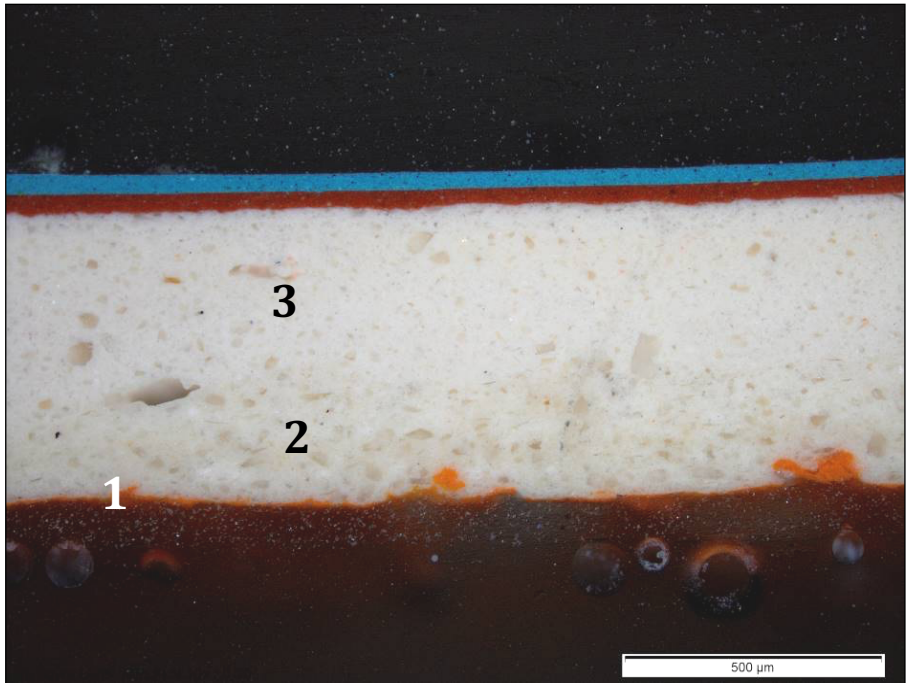
Experiment HYPERION1000_ATR.xpm
Path of File C:\CAPUS\MICRO FTIR\MEAS
Operator Name Administrator
Date of Measurement 23.7.2019.
Instrument Type TENSOR 27
Sample Form HYPERION 1000_15x objective
Resolution 4
Sample Scans 32

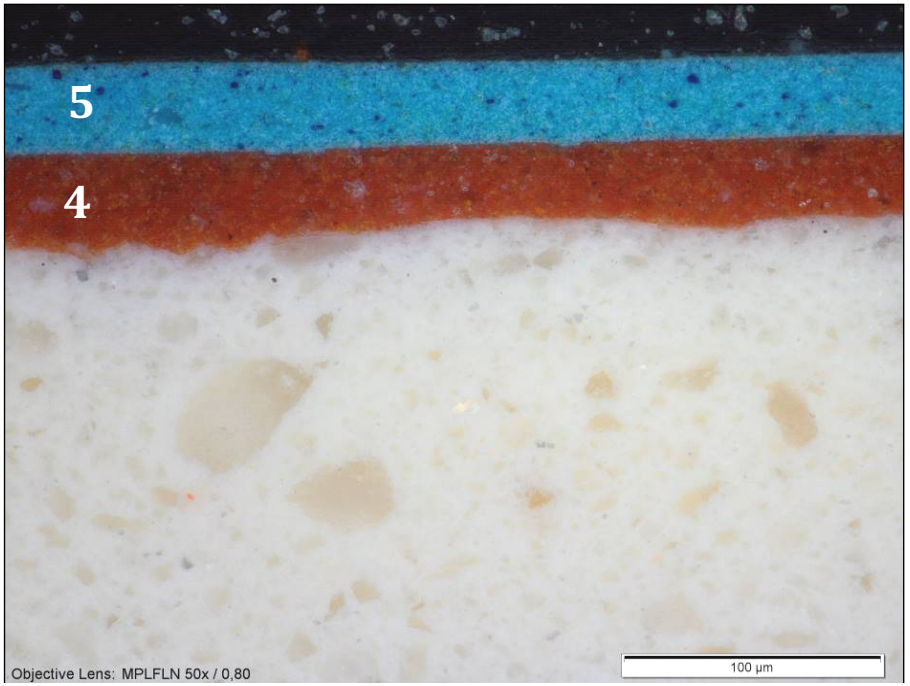
5 2 WHITE PAINT LAYER



Experiment HYPERION1000_ATR.xpm
Path of File C:\CAPUS\MICRO FTIR\MEAS
Operator Name Administrator
Date of Measurement 23.7.2019.
Instrument Type TENSOR 27
Sample Form HYPERION 1000_15x objective
Resolution 4
Sample Scans 32

Sample 5/3





Sample 5/3 – optical microscopy (magnification 50X and 500X), SEM/EDS and micro FTIR analysis has shown the following structure and composition

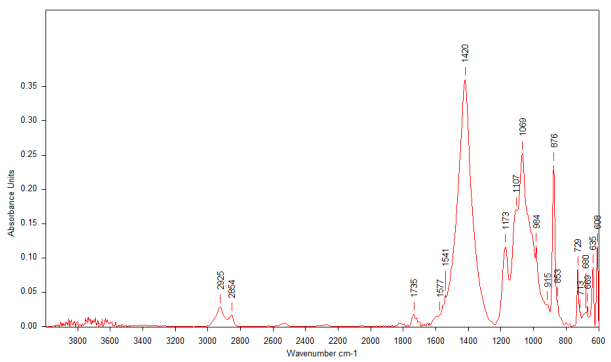
1- Base coat of regular thickness about 20 µm, containing minium and an organic binder.
2- White layer of regular thickness (probably mastic) about 250 µm mainly made of barite, chalk, zinc white, silicates, and alkyd binder.
3- Second white ground of irregular thickness (probably mastic) consisting of chalk, titanium white and zinc white. No peaks assignable to organic binders has been detected most probably because one particle of chalk has been analysed. According to the all the previous analysis, it is assumable that the layer contains some organic binder.
4- Red base coat of regular thickness about 50 µm containing alkyd binder, barium sulphate, most probably chalk, titanium white and iron leading to the conclusion that red ochre is present and that unidentified organic red pigment could also be present.

5-

6- Blue paint layer consisting mainly of titanium white, alkyd binder and Prussian blue.

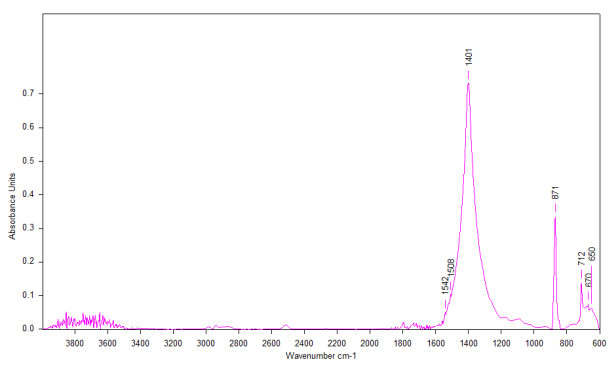
Sample 5/3 - Micro FTIR analysis

5 3 1 GROUND WHITE LAYER



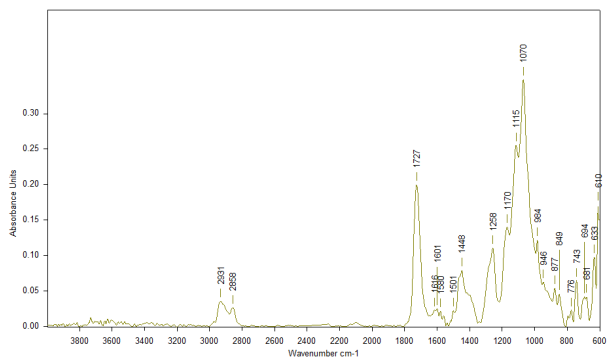
Experiment HYPERION1000_ATR.xpm
Path of File C:\CAPUS\MICRO FTIR\MEAS
Operator Name Administrator
Date of Measurement 23.7.2019.
Instrument Type TENSOR 27
Sample Form HYPERION 1000_15x objective
Resolution 4
Sample Scans 32

5 3 2 GROUND WHITE LAYER



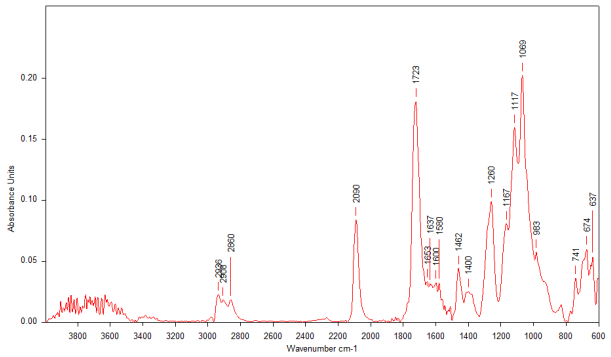
Experiment HYPERION1000_ATR.xpm
Path of File C:\CAPUS\MICRO FTIR\MEAS
Operator Name Administrator
Date of Measurement 23.7.2019.
Instrument Type TENSOR 27
Sample Form HYPERION 1000_15x objective
Resolution 4
Sample Scans 32

5 3 RED LAYER



Experiment HYPERION1000_ATR.xpm
Path of File C:\CAPUS\MICRO FTIR\MEAS
Operator Name Administrator
Date of Measurement 23.7.2019.
Instrument Type TENSOR 27
Sample Form HYPERION 1000_15x objective
Resolution 4
Sample Scans 32

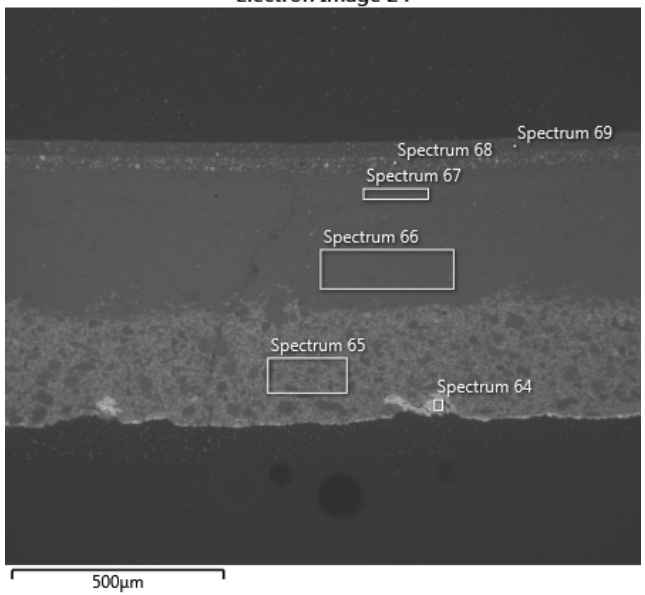
5 3 BLUE LAYER



Experiment HYPERION1000_ATR.xpm
Path of File C:\CAPUS\MICRO FTIR\MEAS
Operator Name Administrator
Date of Measurement 23.7.2019.
Instrument Type TENSOR 27
Sample Form HYPERION 1000_15x objective
Resolution 4
Sample Scans 32

Sample 5/3 - SEM/EDS analysis

Electron Image 24



Spectrum 64	Wt%	Wt% Sigma
Pb	48.57	0.79
C	30.40	0.82
O	16.12	0.70
Fe	2.07	0.11
Ca	1.09	0.08
Zn	1.05	0.12
Ba	0.70	0.17
Total	100.00	

Spectrum 65	Wt%	Wt% Sigma
C	33.48	0.94
O	32.29	0.71
Ba	9.49	0.22
Ca	7.07	0.14
Zn	5.49	0.17
S	3.90	0.10
Si	3.01	0.09
Mg	2.16	0.11
Al	0.92	0.07
Pb	0.88	0.24
Na	0.76	0.18
Fe	0.28	0.05
K	0.26	0.03
Total	100.00	

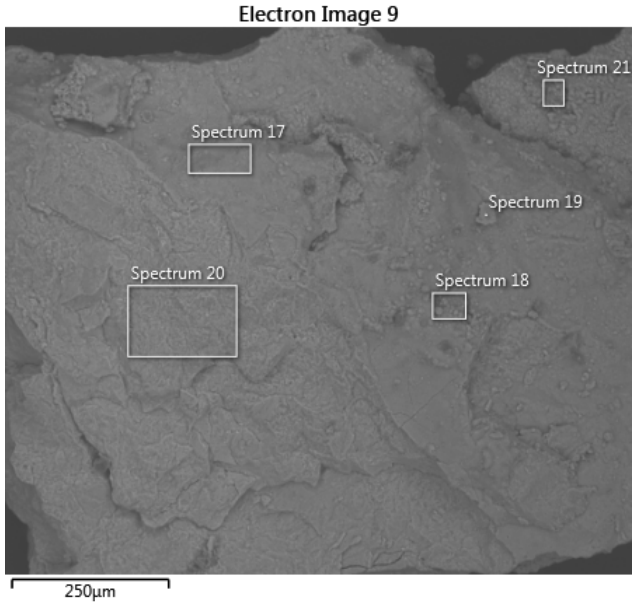
Spectrum 66	Wt%	Wt% Sigma
O	45.04	1.10
Ca	21.82	0.49
C	21.04	0.95
Ti	8.53	0.25
Zn	1.95	0.17
Mg	0.89	0.13
Si	0.50	0.07
S	0.23	0.06
Total	100.00	

Spectrum 67	Wt%	Wt% Sigma
O	45.42	1.15
C	22.10	0.97
Ca	21.36	0.50
Ti	8.62	0.26
Zn	1.57	0.17
Mg	0.66	0.12
Si	0.26	0.07
Total	100.00	

Spectrum 68	Wt%	Wt% Sigma
C	50.52	1.02
O	30.70	0.96
Ba	4.33	0.21
Fe	2.95	0.12
Mg	2.07	0.11
Ca	1.79	0.07
Si	1.70	0.08
Pb	1.51	0.28
S	1.16	0.07
Zn	0.99	0.10
Al	0.97	0.07
Ti	0.80	0.09
Cr	0.34	0.06
K	0.17	0.04
Total	100.00	

Spectrum 69	Wt%	Wt% Sigma
C	53.06	0.89
O	27.83	0.91
Ti	10.49	0.23
Ba	2.83	0.24
Pb	1.34	0.24
Si	1.16	0.06
Ca	0.93	0.05
Fe	0.81	0.06
S	0.58	0.05
Al	0.39	0.05
Zn	0.37	0.07
K	0.21	0.03
Total	100.00	

Sample 5/7 - SEM/EDS analysis



Spectrum 17	Wt%	Wt% Sigma
O	46.89	1.01
Fe	37.11	0.80
C	13.98	1.39
Si	0.80	0.12
Al	0.45	0.13
Zn	0.44	0.14
Ca	0.32	0.07
Total	100.00	

Spectrum 18	Wt%	Wt% Sigma
O	45.49	1.16
Fe	35.17	0.88
C	16.87	1.56
Si	1.40	0.15
Al	0.78	0.16
Ca	0.29	0.08
Total	100.00	

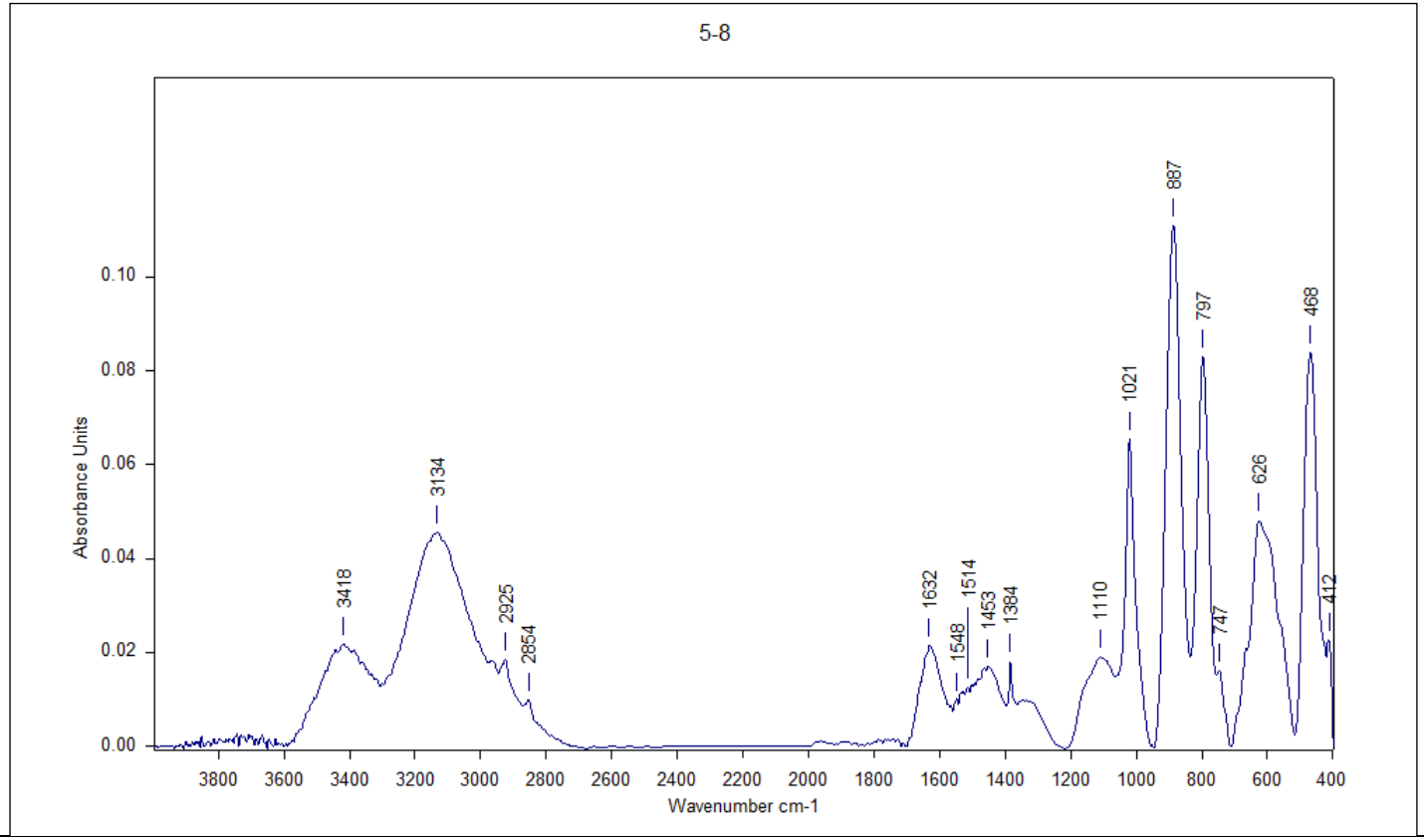
Spectrum 19	Wt%	Wt% Sigma
Fe	52.79	0.81
O	47.21	0.81
Total	100.00	

Spectrum 20	Wt%	Wt% Sigma
Fe	70.85	0.93
O	29.15	0.93
Total	100.00	

Spectrum 21	Wt%	Wt% Sigma
Fe	45.89	0.98
O	42.51	1.01
C	11.08	1.43
Si	0.52	0.13
Total	100.00	

The corrosion products are consisted mainly in iron oxides. Silicates are also present. The relatively high concentration of carbon in several points of the sample surface suggests that coatings might be also represented.

Sample 5/8 – FTIR analysis



The spectrum shows that the main component of the corrosion is iron oxide. Weak peaks attributable to organic compound are also visible

This document was produced within the project ***Conservation of Art in Public Spaces (CAPuS)***.

Author:

Tea Zubin Ferri – Institute Materials Research Centre of Region of Istria METRIS (CROATIA)

Education, Audiovisual and Culture Executive Agency
Erasmus+: Higher Education-Knowledge Alliances, Bologna Support, Jean Monnet

CAPuS project has received funding from the European Commission, Programme Erasmus+ Knowledge Alliances 2017, Project N° 588082-EPP-A-2017-1-IT-EPPKA2-KA