



CONSTGLASS



Table of results
Klausen



1-Pilot object

Pilot object:

Klausen, Parish Church

I, choir, axial window, "Crucifixion and Flight to Egypt" (1878)

Picture



internal face

Identification of the panel:

Panel: 1b
internal face

Treatment

The last conservation campaign took place in 1991, carried out by a commercial workshop. In the course of this campaign the investigated panel was chosen as a test object for paint-layer consolidation (fired and unfired paint). The stained glass studio of Cologne Cathedral made tests with three different materials for the sake of comparison:

Applied products:

- ORMOCER®
- SZA
- Paraloid® B 72 (not included in the Constglass investigation)

Application

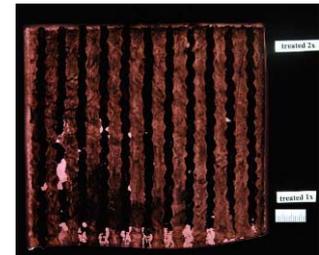
- with a soft brush, no preceding cleaning of the surface.
- the application was carried out in the marked areas. Mainly the contours were treated. Some areas were completely covered.



internal face



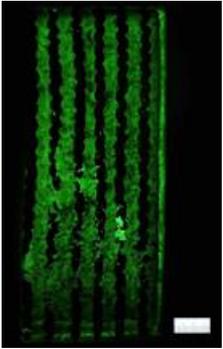
Kla_ORMOCER_1 (internal face)



Kla_SZA_1 (internal face)



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Remarks:	<p>In some segments the contour lines resp. the paint-layer were coated either with ORMOCER[®] or SZA in comparison to Paraloid[®] B72. For the scientific investigations one ORMOCER[®], one SZA and one untreated sample were selected. Visibly, the conservation materials are stable. From the conservator's point of view there is no need for elimination at the moment.</p>		



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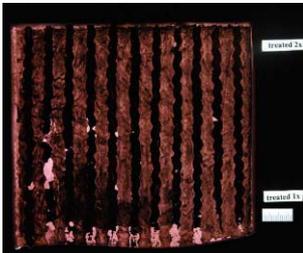


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2-Results

sample reference: **Kla_ORMOCER_1**

Questions	Techniques	Answers
<p>Morphology <i>What is the morphology of the coating? How is the bonding between coating, cold paint, fired paint and glass?</i></p>  <p>internal face</p>  <p>internal face</p>  <p>The borderline of consolidated and not consolidated parts is visible due to the darkening of consolidated areas. Flaky paint seems to be fixed well.</p>	<p>Optical Microscope (DBV, ISC)</p>	<p>The contour lines were coated with ORMOCER[®]. The upper half of the test segment was treated two times; the lower part got a single treatment. The treatment of the contours is visible (darker appearance). During the application, the ORMOCER[®] sunk sufficiently into the contours and the unfired paint layer. The today's condition of the ORMOCER[®]-layer seems to be stable.</p> <p>Additional pictures of a comparable segment, illustrating the condition of the paint-layer; the yellow glass segment was treated with ORMOCER[®], the green one with Paraloid[®] B72:</p>  <p>internal face</p>  <p>internal face</p>  <p>internal face (ORMOCER[®])</p>
	<p>SEM (ISC)</p>	<p>n/a The mix of fired glass paint and unfired paint, dust particles and conservation material cannot be distinguished in detail by SEM-investigation. See also results of SEM/EDX below.</p>



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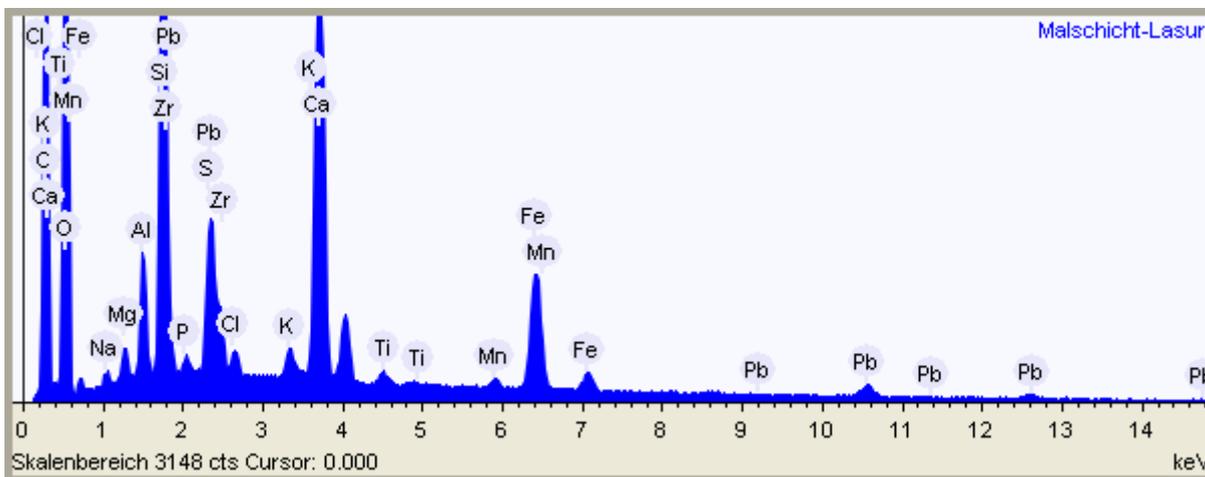


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	Desktop tomography (Institute)	n/a
	Phase-contrast tomography on Synchrotron (Institute)	n/a
Chemical Composition	SEM/EDX (ISC)	See table below

Analyse of paint layer / glaze:



Element	weight%	weight % σ	atom %
Carbon	36.210	0.360	49.820
Oxygen	39.023	0.302	40.307
Sodium	0.199	0.028	0.143
Magnesium	0.338	0.023	0.230
Aluminium	0.997	0.027	0.611
Silicon	5.258	0.056	3.094
Phosphor	0.113	0.025	0.060
Sulphur	0.782	0.035	0.403
Chloride	0.246	0.024	0.115
Potassium	0.306	0.025	0.129
Calcium	7.648	0.074	3.154
Titan	0.215	0.030	0.074
Manganese	0.338	0.041	0.102
Iron	4.946	0.083	1.464
Zirconium	0.252	0.072	0.046
Lead	3.130	0.126	0.250

Various components are found in proportions difficult to interpret. Main elements: carbon, oxygen, silicon, calcium, iron and lead – it is not possible to distinguish clearly fired paint layer (inorganic), unfired paint (probably organic and inorganic), dust (organic and inorganic) and conservation material (pure organic). In comparison to the spectra taken at the reference sample and the sample treated with SZA more carbon is detected – this might be a hint for the presence of ORMOCER®.



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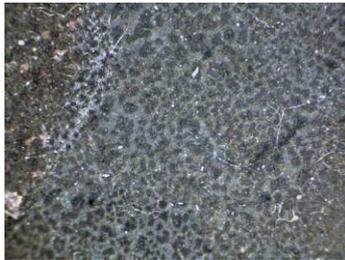


Organic component composition	FTIR (ISC)	n/a The roughness of the sample was too high, so μ -ATR or FTIR was not possible.
	RAMAN (Institute)	n/a



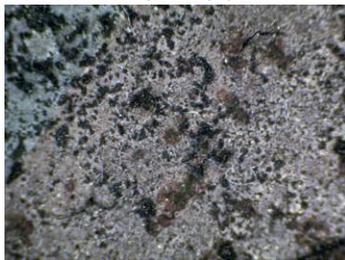
Microbiology

treated with Paraloid® B72



Microscopical analysis reveals no visible fungal infestation on glass fragment

treated with ORMOCER®



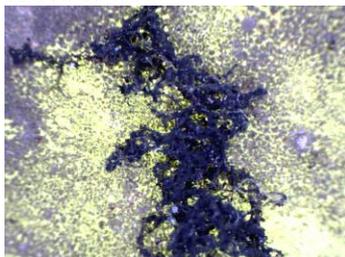
Microscopical analysis reveals no visible fungal infestation on glass fragment

treated with SZA



Microscopical analysis reveals no visible fungal infestation on glass fragment

untreated area



Microscopical analysis reveals accumulation of dirt, but only poor fungal infestation

Microscopical analysis, metabolic activity and taxonomical description of microorganisms (LBW)

The investigations took place on the whole panel not only on Kla_ORMOCER®_1

Treatment with Paraloid® B72 (in storage, 3 samples):
- low metabolic activity (ATP 168 RLU/25 cm²)
- isolated microorganisms: Scopulariopsis brevicaulis, Penicillium expansum and Cladosporium herbarum (fungi; low contamination)

Treatment with ORMOCER® (in storage, 4 samples):
- low metabolic activity (ATP 173 RLU/25 cm²)
- isolated microorganisms: Cladosporium herbarum, Aspergillus versicolor, Scopulariopsis brevicaulis, Penicillium expansum and P. aurantiogriseum (fungi; low contamination)

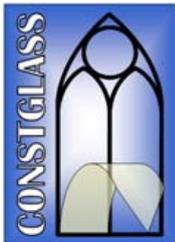
Treatment with SZA (in storage, 4 samples):
- low metabolic activity (ATP 185 RLU/25 cm²)
- isolated microorganisms: Cladosporium herbarum, Acremonium strictum, Chaetomium globosum, Penicillium expansum and Scopulariopsis brevicaulis (fungi; low contamination)

No consolidating treatments (in storage, 6 samples):
- low metabolic activity (ATP 198 RLU/25 cm²)
- isolated microorganisms: Penicillium chrysogenum, P. brevicompactum, Aspergillus ochraceus, Trichoderma viride, Cladosporium herbarum and Fusarium oxysporum (fungi; generally low contamination, but one sample area highly contaminated by Trichoderma viride!)

No consolidating treatments (in situ, 5 samples):
- low metabolic activity (ATP 177 RLU/25 cm²)
- isolated microorganisms: Penicillium glabrum, P. expansum, P. chrysogenum, Aspergillus fumigatus, Trichoderma viride, Mucor plumbeus and Cladosporium herbarum (fungi; low contamination)

Protective glazing (in situ, 1 sample):
- medium metabolic activity (ATP 1.419 RLU/25 cm²)
- isolated microorganisms: Cladosporium herbarum (fungus; high contamination !)





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Reversibility	Test studies elimination	Tests for the removal of ORMOCER [®] were not intended on this sample, because this has been performed on the sample COL_ORMOCER [®] _separated_1 (Cologne NVI).
Re-treatability	Test studies re-treatability	not intended



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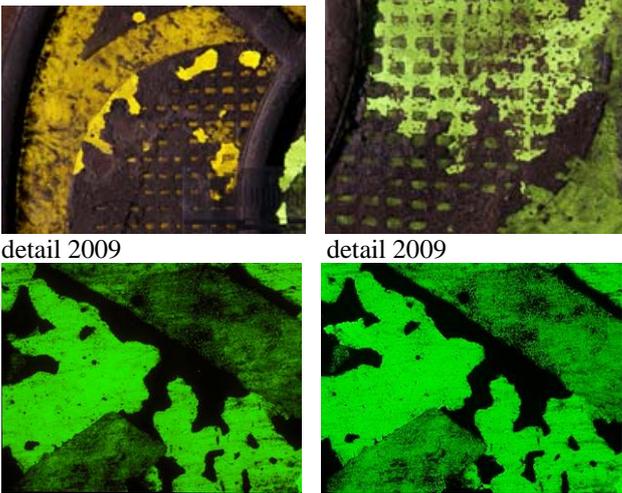


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2-Results

sample reference: **Kla_SZA_1**

Questions	Techniques	Answers
<p>Morphology <i>What is the morphology of the SZA-coating?</i> <i>How is the bonding between the SZA-coating, the fired resp. unfired paint and the glass?</i></p>  <p>internal face</p> <p>These picture shows the complete sample, that was afterwards divided in 3 single pieces</p>	<p>Optical Microscope (DBV, ISC)</p>	<p>The fired paint contours were coated with SZA. The upper half of the test segment was treated 4 x, the lower was treated 3 x.</p> <p>The SZA treatment of the contours is not visible. During the application SZA sunk well into the contours. But due to its highly fluid character, the SZA inevitably spread out onto the surrounding area, including the overlaying film of unfired pigmented oil-lacquer that was applied in restoration around 1900.</p> <p>The today's condition of the SZA seems to be stable. The SZA can hardly be identified by light microscopy. There are no alteration phenomena (e.g. whitening effect) of the consolidant detectable at the sample. Flaky paint seems to be stable and does not flake off if stressed mechanically softly.</p> <p>Additional pictures of comparable segment, illustrating the condition of the paint-layer treated with SZA</p>  <p>detail 2009 detail 2009</p> <p>detail 1991.... in comparison to 2009</p>



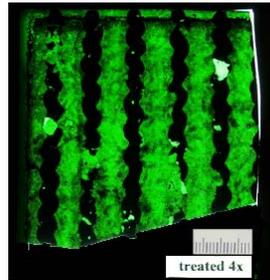
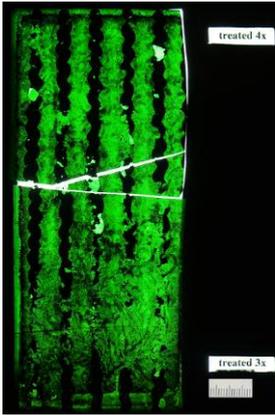
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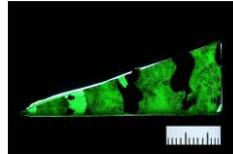
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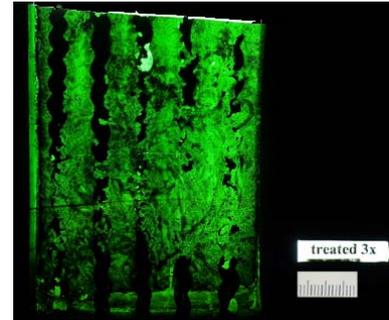
KLA_SZA_1_separated



KLA_SZA_1_separated_2

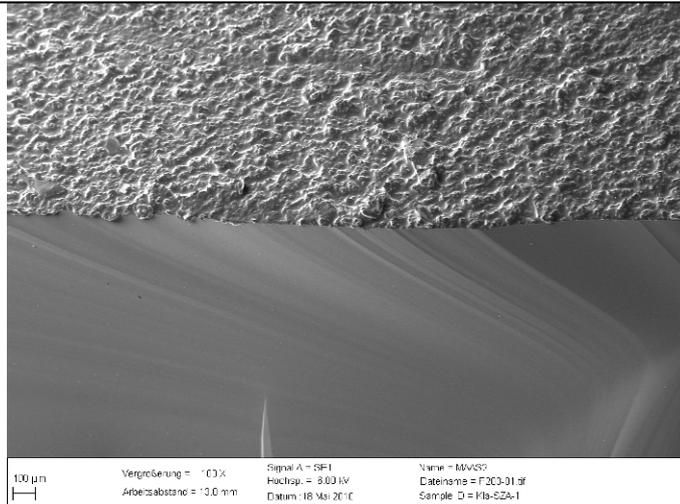


KLA_SZA_1_separated_1



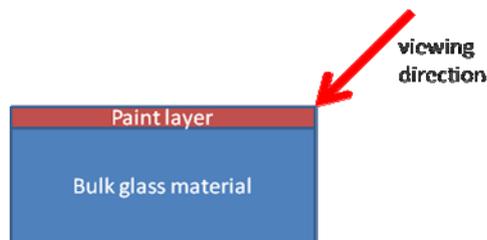
KLA_SZA_1_separated_3

**SEM
(ISC)**



KLA_SZA_1_separated_1 (after re-treatment with Paraloid® B72).

Broken glass fragment. The roughness of the thin paint layer is very good observable in the upper part of the picture. In the lower part the glass bulk material is visible. The picture was taken in a perspective view, see scheme below.

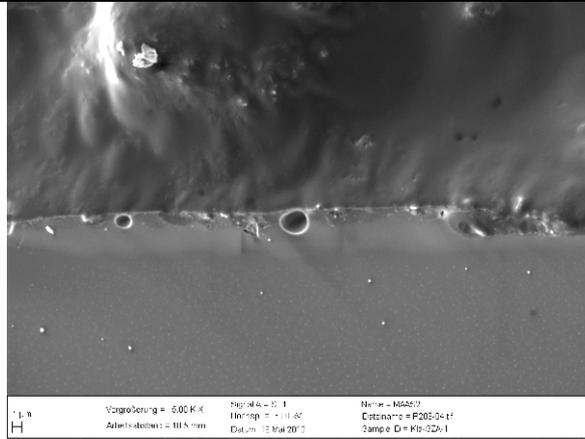




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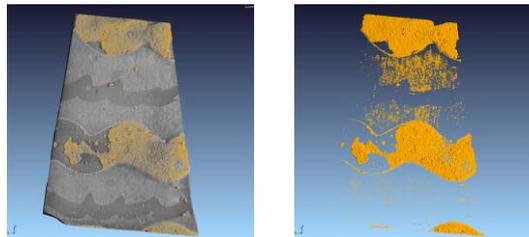
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Between coating and glass is a thin layer visible; this might be the paintlayer.

Desktop tomography (U-Gent) µ-CT

KLA_SZA_1_separated_1



3D visualization of the glass sample, with dense layer coloured in yellow.

Phase-contrast tomography on Synchrotron (Institute)

n/a

Chemical Composition

SEM/EDX (ISC)

See table below



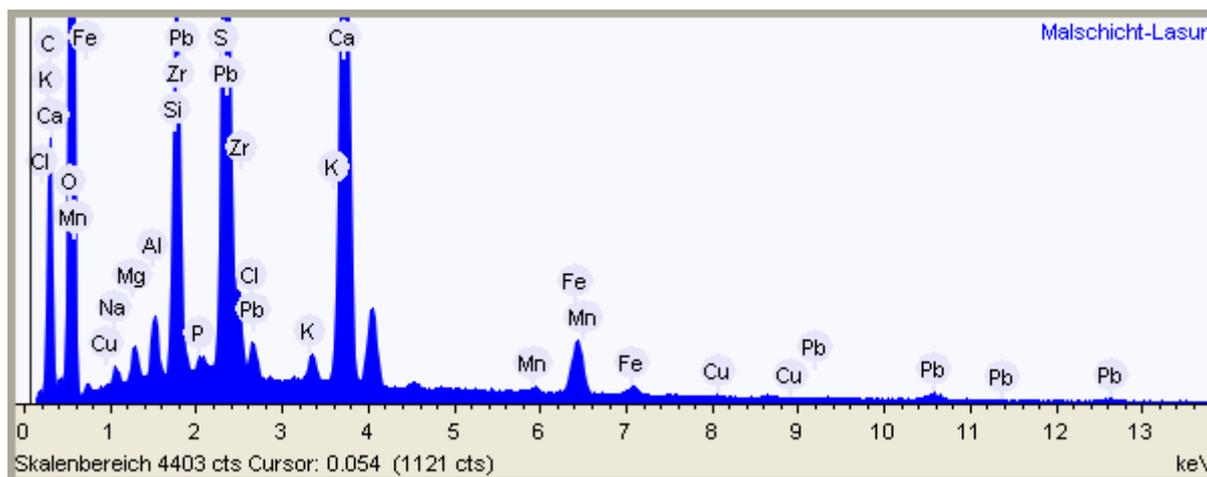
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Analysis of paint layer / lasur:



Element	weight%	weight% σ	atom%
Carbon	24.407	0.321	35.691
Oxygen	47.350	0.276	51.980
Sodium	0.285	0.029	0.217
Magnesium	0.382	0.022	0.276
Aluminium	0.534	0.021	0.347
Silicon	3.372	0.039	2.109
Phosphor	0.001	0.023	0.001
Sulphur	6.235	0.059	3.416
Chloride	0.407	0.024	0.201
Potassium	0.377	0.022	0.170
Calcium	10.098	0.077	4.425
Manganese	0.160	0.033	0.051
Iron	2.290	0.055	0.720
Copper	0.001	0.052	0.000
Zirconium	0.445	0.068	0.086
Lead	3.655	0.156	0.310

The spectrum is again very difficult to interpret due to the fact of the mix of dirt, cold paint (organic and inorganic), fired paint (inorganic) and conservation material (inorganic). Mainly organic components are detected and corrosion products containing sulfur and calcium.

Organic component composition	FTIR (Institute)	n/a The roughness of the samples was too high, so μ -ATR or FTIR was not possible. The spectra overlay and therefore can not be interpreted. A separation of different components (fired paint, cold paint, consolidation material and dirt) was not possible.
	RAMAN (Institute)	n/a



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Microbiology

**Molecular biology
ATP measurements (LBW)**

The investigations took place on the whole panel not only on Kla_SZA_1

○ = Materialproben ATP Stick Okt. 2009, LWB (Wiederholung an 1, 3, 6, 10, 11, 15 Mai 2010, DBH)



Paraloid®B72 1x

Kla 1): ATP: 136 RLU/25 cm²

Fungi: Scopulariopsis brevicaulis

Kla 7): ATP: 197 RLU/25 cm²

Fungi: Cladosporium herbarum, Penicillium expansum, Chaetonium funicola

Paraloid®B72 2x

Kla 2): ATP: 172 RLU/25 cm²

Fungi: Cladosporium herbarum

ORMOCER® 1x

Kla 3): ATP: 162 RLU/25 cm²

Fungi: Cladosporium herbarum, Aspergillus versicolor, Penicillium aurantiogriseum
Bacteria: Bacillus sp.

ORMOCER® 2x

Kla 11): ATP 151 RLU/ 25 cm²

Fungi: Cladosporium herbarum

ORMOCER® 3x

Kla 4) ATP: 189 RLU/25 cm²

Fungi: Cladosporium herbarum, Aspergillus versicolor

SZA 2x

Kla 6) ATP: 167 RLU/25 cm²

Fungi: Cladosporium herbarum, Scopulariopsis bevicaulis



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SZA: 3x

Kla 9): ATP: 209 RLU/25 cm²

Fungi: Cladosporium herbarum, Acremonium strictum

Bacteria: Micrococcus luteus (yunnanensis)

Kla 10): ATP: 176 RLU/25 cm²

Fungi: Chaetonium globosum, Cladosporium herbarum, Penicillium expansum

SZA 4x

Kla 5): ATP: 190 RLU/25 cm², no fungi

Without treatment

Kla 12): ATP: 328 RLU/25 cm²

Fungi: Trichoderma viride

Bacteria: Deinococcus aerolatus

Kla 13): ATP: 215 RLU/25 cm²

Fungi: Penicillium chrysogenum, Cladosporium herbarum,

Bacteria: Agrococcus sp., Rathayibacter sp.

Kla 14): ATP: 153 RLU/25 cm²

Fungi: Penicillium brevicompactum, Aspergillus ochraceus

Kla 15): ATP: 156 RLU/25 cm², no fungi

Kla 16): ATP: 182 RLU/25 cm²

Fungi: Cladosporium herbarum, Penicillium chrysogenum, Fusarium oxysporum,

Kla 17): ATP: 159 RLU/25 cm², no fungi,

Bacteria: Bacillus sp.

Reversibility

How can I remove the paint layer fixation without damage? Which kind of method can I use?

Test studies elimination (DBH)

Note: For the reversibility/re-treatability tests the Constglass-consortium decided, that exclusively the solvent MEK should be used.

Treatment:

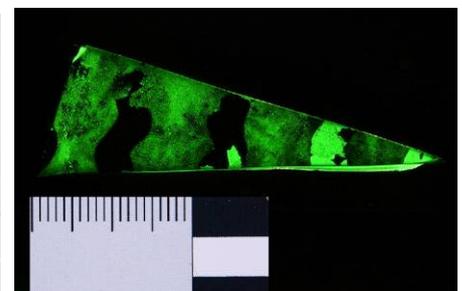
MEK-gel (5 % Klucel[®] G) / compress

Duration: 180 minutes

Result:

The exposure time of the MEK-gel was decided to be long enough (by Constglass consortium). Whether SZA has been removed or not, can visibly not be detected.

Pictures after MEK-treatment of SZA:



KLA_SZA_1_separated_1



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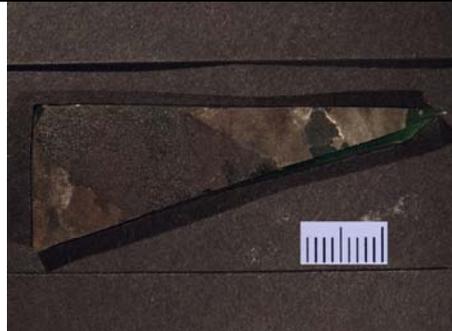


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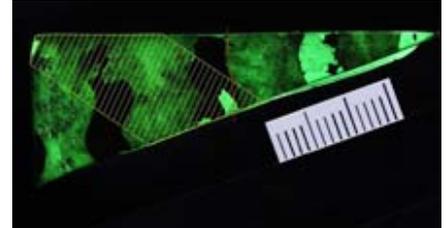


Re-treatability

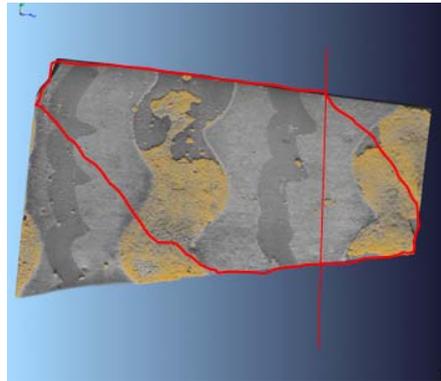
**Test studies
re-treatability**



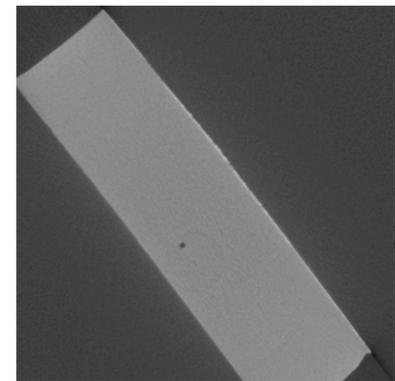
retreated with Paraloid® B 72 (doped)



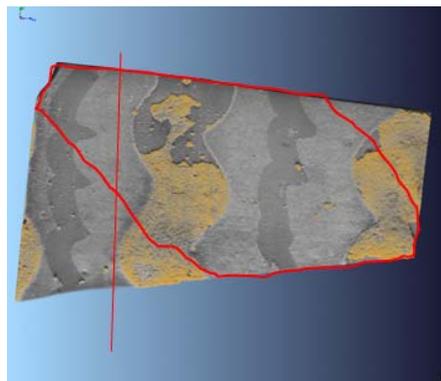
treated area is marked with yellow scratches



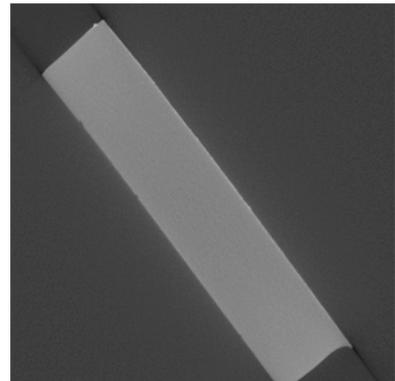
slice through the full re-treated area
(within borderline)



cross section



slice through the only cleaned (outside
borderline) and re-treated area (within
borderline)



cross section

After re-treatment, no structural changes could be seen on the pictures. We could not see the removal of SZA or the new application of Paraloid® B72 even when it is doped. This is because the layers are too thin.



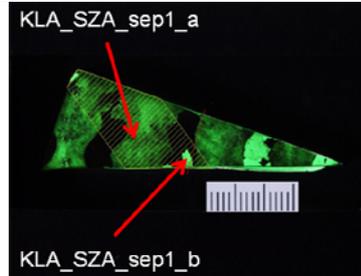
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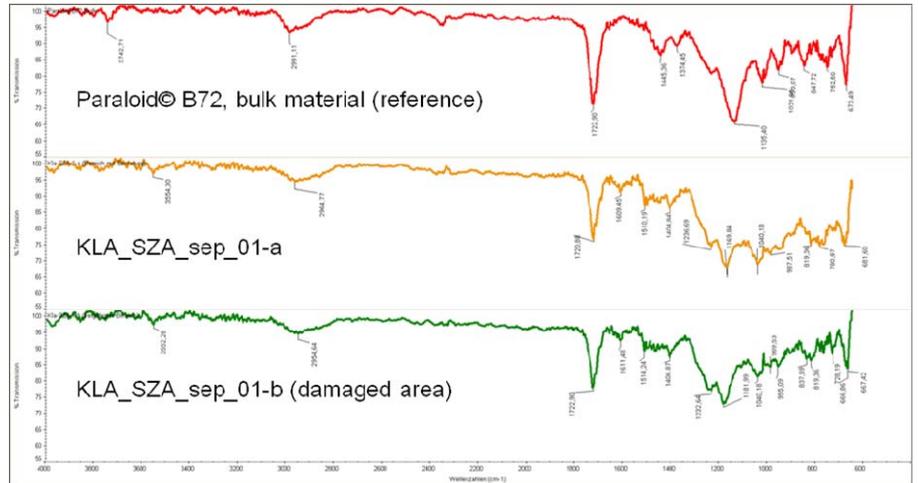


FTIR
measured with
ATR-FTIR
(ISC)



Measuring areas on the re-treated sample.

Kla_SZA_separated_1_a was performed on the paint layer, Kla_SZA_separated_1_b on an area where the paint layer was damaged.



The two measured spectra are similar to Paraloid® B72, measured as a reference on bulk material. Also the damage area was coated with Paraloid® B72. The underneath paint layer has no influence on measuring (organic) spectra with ATR-FTIR, compare Kla_SZA_separated_1-a and Kla_SZA_separated_1-b.



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2-Results

sample reference: **Kla_untreated_1**

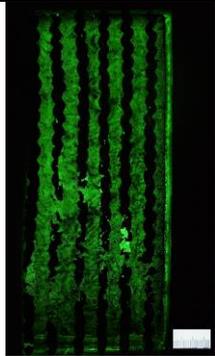
Questions	Techniques	Answers
<p>Morphology <i>What is the morphology of the paint? Is there a difference in the condition of the untreated paint in comparison to the paint on the treated samples?</i></p>	<p>Optical Microscope (DBV)</p>	<p>The original paint was insufficiently fired. It appears matt and open porous. The overlaying film of unfired pigmented oil-lacquer, applied during the restoration around 1900 is stable.</p> <p>Additional pictures of comparable segment, illustrating the condition of the untreated paint-layer</p> <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p>detail 1991....</p> </div> <div style="text-align: center;">  <p>in comparison to 2009</p> </div> </div>



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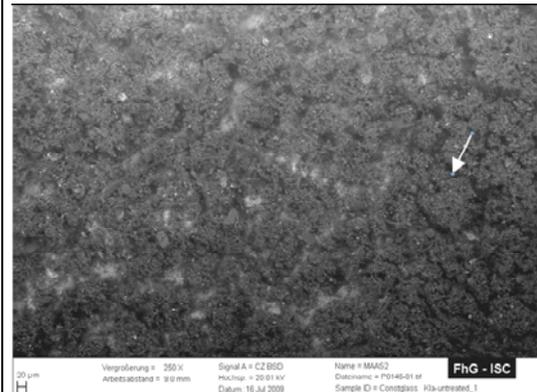


internal face



SEM
(ISC)

The surface of the sample is very inhomogeneous regarding element composition and morphology.



Loose painting with irregular structure and partially islanding.



Painting looks partial very thin. Crack structure of the original glass is visible (1). Long and fibrous structures could be interpreted as hint for microbiology (2), but this was not verified by subsequent microbial investigation.

Desktop tomography
(Institute)

n/a (reference for the treated sample was not needed)

Phase-contrast tomography on Synchrotron
(Institute)

n/a

Chemical Composition

SEM/EDX
(ISC)

See tables below



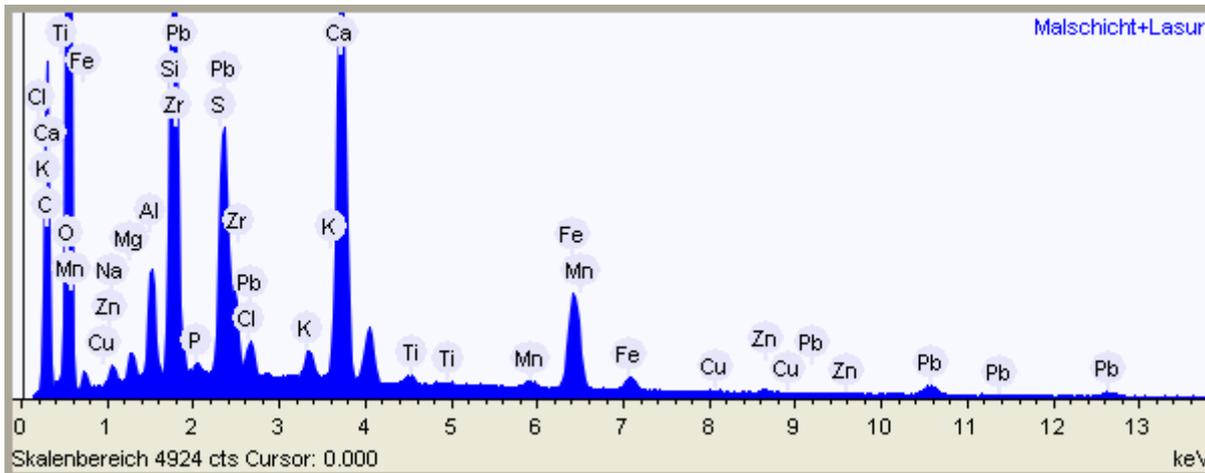
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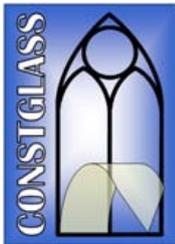
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SEM/EDX analyse of painting-glazing:



Element	weight%	weight% σ	atom%
Carbon	27.406	0.354	40.096
Oxygen	43.498	0.285	47.776
Sodium	0.291	0.033	0.222
Magnesium	0.348	0.022	0.251
Aluminium	1.116	0.026	0.727
Silicon	5.936	0.055	3.714
Phosphor	0.085	0.023	0.048
Sulphur	2.036	0.041	1.116
Chloride	0.422	0.025	0.209
Potassium	0.426	0.023	0.192
Calcium	7.755	0.068	3.400
Titan	0.190	0.027	0.070
Manganese	0.245	0.036	0.078
Iron	4.849	0.074	1.526
Copper	0.146	0.057	0.040
Zink	0.386	0.071	0.104
Zirconium	0.162	0.067	0.031
Lead	4.704	0.139	0.399



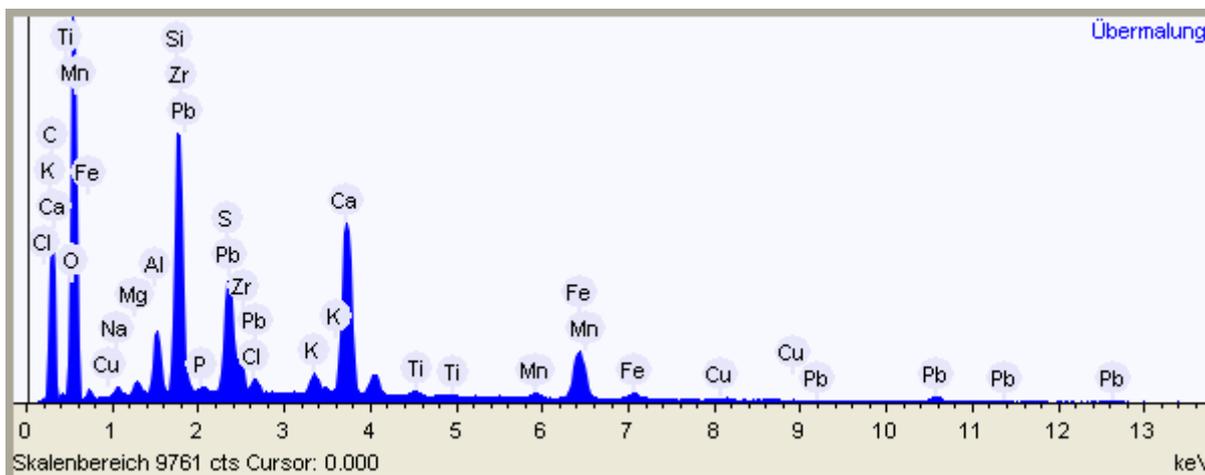
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SEM/EDX analyse of not fired paint :



Element	weight%	weight% σ	atom%
Carbon	28.670	0.362	41.218
Oxygen	43.766	0.291	47.237
Sodium	0.343	0.031	0.258
Magnesium	0.345	0.023	0.245
Aluminium	1.315	0.028	0.841
Silicon	5.800	0.056	3.566
Phosphor	0.108	0.023	0.060
Sulphur	2.039	0.041	1.098
Chloride	0.360	0.024	0.175
Potassium	0.529	0.026	0.234
Calcium	6.603	0.063	2.845
Titan	0.265	0.028	0.096
Manganese	0.395	0.038	0.124
Iron	4.984	0.076	1.541
Copper	0.382	0.061	0.104
Zirconium	0.157	0.067	0.030
Lead	3.939	0.136	0.328

Both spectra show similar results despite the fact that the first one was taken on a trace line in an area with less or no cold paint and the second spectra was taken in an area where mainly not fired paint was expected. The mix of various materials can hardly be distinguished and clearly be identified.

Organic component composition	FTIR (Institute)	n/a The roughness of the samples was too high, so μ -ATR or FTIR was not possible. The spectra overlay and can therefore not be interpreted. A separation of different components (fired paint, cold paint, and dirt) was not possible.
	RAMAN (Institute)	n/a



CONSTGLASS



Table of results
Klausen



Microbiology	Molecular biology ATP measurements (LBW)	see above
Reversibility	<p>Test studies Elimination (DBV)</p> <p>Note: This refers to a <u>preliminary test</u> on a glass segment of Klausen, it does <u>not</u> refer to the sample under scientific investigation!</p>	<p><u>Note:</u> For the reversibility/re-treatability tests the Constglass-consortium decided, that exclusively the solvent MEK should be used. Nevertheless, before starting any MEK test, preliminary tests with various solvents were carried out on this segment, in order to find out which solvent would cause the least harm to the overlaying film of pigmented oil-lacquer that was applied in a former restoration.</p> <p>Result: MEK turned out to be too aggressive, the oil lacquer became quickly soft and weak. An ethanol-water mixture would have been the best solvent in this case, because it would not have attacked the oil-lacquer.</p> <p>Pictures after preliminary removal test:</p> <div style="display: flex; justify-content: space-around;"> <div data-bbox="858 1025 1145 1240"> </div> <div data-bbox="1177 1032 1458 1240"> </div> </div> <p>internal face internal face</p>
Re-treatability	Test studies re-treatability	not intended