Horizon 2020

Nano-Cathedral

D1.5 – Mapping of stones and their decay Part IV Monitoring and standardised photography

Project Information

Grant Agreement Number	646178
Project Full Title	Nanomaterials for conservation of European architectural heritage developed by research on characteristic lithotypes
Project Acronym	NANO-CATHEDRAL
Funding scheme	NMP-21-2014 Materials-based solutions for protection or preservation of European cultural heritage
Start date of the project	June, 1 2015
Duration	36 months
Project Coordinator	Andrea Lazzeri (INSTM)
Project Website	www.nanocathedral.eu

Deliverable Information

Deliverable n°	1.5
Deliverable title	Mapping of stones and their decay Part I Natural stone test methods Part II Mapping of stones and their decay Part III Condition assessment and technical goals to reach for the different cases **Part IV Monitoring and standardised photography**
WP no.	1
WP Leader	Consorzio Interuniversitario Nazionale Per La Scienza e Technologia dei Materiali
Contributing Partners	8 (UBAM) University of Bamberg
Nature	Report
Authors	Rainer Drewello, Max Rahrig, Anna Luib, David Höpfner
Contributors	Opera della Primaziale Pisana (2), HDK (7), Fundatión Catedral Santa Maria (11), Dombausekretariat St. Stephan (14), Arhitectenbureau Bressers (17) and Statsbygg (19)
Reviewers	Matea Ban
Contractual Deadline	Month 18
Delivery date to EC	Month 21

Dissemination Level

PU	Public	
PP	Restricted to other programme participants (incl. Commission Services)	
RE	Restricted to a group specified by the consortium (incl. Commission Services)	
CO	Confidential, only for the members of the consortium (incl. Commission Services)	✓

Document Log

Version	Date	Author	Description of Change
1	19.12.16	Matea Ban	Layout, corrections authors, table of contents
2	18.01.17	Pablo Garcia	Correction of a Table

Table of Contents

Part I

Annex I	**Petrographic examination including SEM-EDS analysis on broken pieces and thin sections (IATCS)**
Annex II	**Uniaxial compressive strength on dry and wet specimens (BI.GEO)**
Annex III	**Flexural strength under concentrated load (BI.GEO)**
Annex IV	**Static elastic modulus (BI.GEO)**
Annex V	**Splitting tensile strength (BI.GEO)**

Part II

Annex VI	**Mapping Classes (BI.GEO)**

Part III

Annex VII	**Microscopic observations (PLM, SEM/EDX) on weathered stone samples (IATCS)**

Part IV Monitoring and standardised photography

Being non-destructive this newly established monitoring method is an excellent tool for early detection of changes on the surface of stone on historic buildings. The method combines high resolution color photography with 3D pictures as well as UV and IR photographs. The position of all photographed areas is accurately mapped and can be relocated. As all data is available in digital form, the resulting pictures can be overlaid. In this way changes in color and gloss become visible as well as abrasions, crusts, gypsum, salt efflorescence, biological colonization, algae, lichen etc. This is particularly valuable, when the monitoring is repeated at regular intervals. The monitoring has to be regarded as a long term project, allowing close observation of the condition of the stone and thus helping to preserve historic buildings before damage becomes too evident. At the same time a high standardisation is established making results comparable.

So far one campaign has taken place. All trial areas on the sites involved in the Nano Cathedral Project have been photographed, the results of which are presented below. Two further campaigns are planned, one in M25, one in M34.

1. Report Ghent

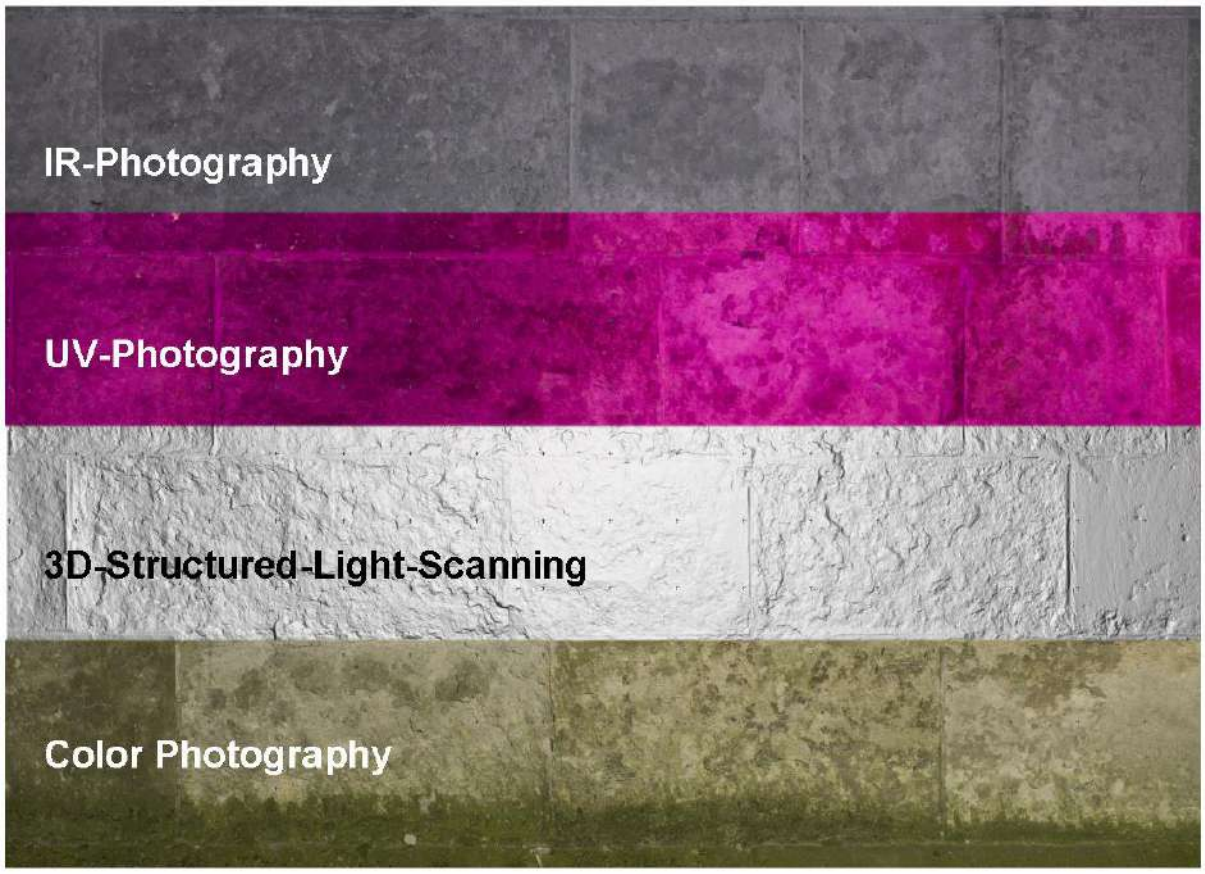
Documentation Report of

Monitoring Campaign I

Documentation of the Initial Condition of the Trail Areas

St. Bavo´s Cathedral - Gent

March-April 2016



Authors:
Max Rahrig M.A., Anna Luib M.A., David Höpfner, Prof. Dr. Rainer Drewello

Content:

1. Monitoring Campaign I, general aspects

The Monitoring Campaign I at St. Bavo´s Cathedral in Gent took place between 31st March and 2nd April. Its aim was to document the condition of the surfaces before their first treatment with nano technology or any preparatory measurements like cleaning.

Two different methods of documentation were used depending on the accessibility of the trial areas. Areas with good accessibility and enough surrounding space for bulky equipment were photographed in various techniques and in a high resolution quality. Areas at towers or with difficult accessibility were photographed in a low resolution quality requiring less equipment.

1.1 High resolution Version

If possible all areas should be documented in high resolution quality in order to get best detail and analytical information of the surface. Following techniques were used:

- Color photography (with full frame Hasselblad H2D digital camera and Broncolor flash system)
- UV-photography (with full frame Hasselblad H2D digital camera and Broncolor UV-flash system)
- IR-photography (with special Canon EOS 5 Mark II - IR camera and Broncolor flash system)
- Structured-light-scanning (high resolution 3D-Documentation with Steinbichler Comet L3D-Scanner)
- Terrestrial 3D-Scanning of surrounding areas to locate the monitoring areas (Faro Focus X120)

A standard was established to ensure same light conditions (light temperature, brightness) for all trial areas in each different location and for every monitoring campaign. Therefore, all pictures were taken at night with a broncolor grafit A4 flash system, two flashbulbs and soft boxes for smoother light. For color calibration the pictures were taken with a Kodak color chart.
UV pictures require absolute darkness and a blocking out of all surrounding light. Day light would inhibit or overlay UV light. Therefore, special UV-pass filter in front of the flashbulbs were used to generate the UV light.
The flash system as well as the structured-light-scanner (SLS) are bulky and need around 6 m² space in front of the trial area. The space is also necessary to obtain the required working distance between the trial areas and the SLS. Furthermore both instruments are heavy (approximately 25 kg) and are to be transported in big cases. For that reason they can only be used for trial areas with good accessibility.
After taking all pictures, all photos where aligned and straightened out to the 3D-Surface of the SLS making it later possible to overlay all images (Color, UV and IR). In combination with the topography of the surface (3D-Modell) this allowed the best possible basis for the comparability of the trial areas.

1.2 Light Version

Areas at towers or with difficult accessibility were documented with less equipment. Following techniques were used:

- Color photography (with full frame Hasselblad H2D digital camera and Broncolor flash system)
- IR-photography (with special Canon EOS 5 Mark II - IR camera and Broncolor flash system)
- Terrestrial 3D-Scanning (with Faro Focus X120)

This documentation is done without a flash system or structured light scanner, thus bearing considerable disadvantages.
Because of the missing flash system the documentation has to be done during day time. Thus the pictures are not calibrated to the same light conditions. The colour of the stone changes depending on the weather (sunshine, rain or cloudy etc.). Also the lighting could change and shadows could affect the pictures. UV-photography is impossible without a flash system.
For alignment and straightening out the pictures the SLS can be used in the high resolution version, documenting the surface in a resolution of 0.3 mm. In the light version, however, the surfaces are documented by the terrestrial laser scanner only with a resolution of about 3 mm/ 10 m, a considerably lower quality.

2. Trial Areas

2.1 Trial Area 1

Trial area 1 is located on the west facade of the northern transept, at ground level with easy access. The area is enclosed and has a northwest orientation. Directly in front of the area are parking lots providing ideal conditions for a documentation in high resolution quality.

Condition of the surfaces: The selected areas are mostly original and were left relatively untouched during the several historical restoration campaigns. The surfaces are uncleaned.

Date, weather and temperature: 31st March; measuring time around 22:00-24:00; cloudy but dry; temperature between 6-8 °C.

Size of documented area: 180 x 120 cm

Material: Balegem and Gobertange

Fig. 01: General view of Trial Area 1.

3D-scanning: Structured-Light-Scanner Comet L3D in a resolution of 0.3 mm (800mm lens). The area was scanned with 17 single scans.

Color photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 Megapixel); lens e: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/125 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with stereo flash; setup of right flashbulb: Soft box 60x120 cm; focal ratio: 6.3; setup of left flashbulb: soft box 60x60 cm; focal ratio: 5,6; taken with single flash impulse.

UV-photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 Megapixel); lens:: Hasselblad HC 50 mm; ISO: 100; focal ratio: F/11; exposure time: 16 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 60x120 cm; focal ratio: 9.3; setup of left flashbulb: soft box 60x60 cm; focal ratio: 8,6; taken with multi flash impulse (4 impulses).

IR- photography: single shot taken with Canon EOS 5 Mark II (21 Megapixel); lens : Canon 35mm; ISO: 100; focal ratio: F/11; exposure time: 1/200 Sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 60x60 cm; focal ratio: 6.3; setup of left flashbulb: soft box 60x120 cm; focal ratio: 5,6; taken with single flash impulse.

2.2 Trial Area 2

The area is located on the west facade of the southern transept, at ground level with easy access. The area is situated behind a fence and bushes with enough space for a documentation in high resolution quality.

Condition of the surfaces: The selected areas are mostly original and were left relatively untouched during the several historical restoration campaigns. The surfaces are uncleaned.

Date, weather and temperature: 1st April; measuring time around 21:00-23:00; cloudy but dry; temperature between 8-10 °C.

Size of documented area: 200 x 120 cm

Material: Balegem and Gobertange

Fig. 02: General view of Trial Area 2.

3D-scanning: Structured-Light-Scanner Comet L3D in a resolution of 0.3 mm (800mm lens). The area was scanned with 15 single scans.

Color photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 Megapixel); lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/125 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with stereo flash; setup of right flashbulb: soft box 60x120 cm; focal ratio: 7,3; setup of left flashbulb: soft box 60x60 cm; focal ratio: 6,6; taken with single flash impulse.

UV-photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 Megapixel); lens: Hasselblad HC 50 mm; ISO: 100; focal ratio: F/3,5; exposure time: 1/45 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 60x120 cm; focal ratio: 9.3; setup of left flashbulb: soft box 60x60 cm; focal ratio: 8,6; taken with single flash impulse.

IR- photography: single shot taken with Canon EOS 5 Mark II (21 megapixel); lens: Canon 30mm; ISO: 100; focal ratio: F/11; exposure time: 1/160 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 60x120 cm; focal ratio: 7,3; setup of left flashbulb: soft box 60x60 cm; focal ratio: 6,6; captured with single flash impulse.

2.3 Trial Area 3

The area is located on the south façade of the tower, at ground level with easy access. The area is situated behind a fence with enough space for a documentation in high resolution quality.

Condition of the surfaces: The selected areas are mostly original and were left relatively untouches during the several historical restoration campaigns. The surfaces are uncleaned.

Date, weather and temperature: 1st April; measuring time around 00:00-02:00; cloudy but dry; temperature between 4-6 °C.

Size of documented area: 195 x 80 cm

Material: Balegem and Gobertange

Fig. 03: General view of Trial Area 3.

3D-scanning: Structured-Light-Scanner Comet L3D in a resolution of 0.3 mm (800mm lens). The Area was scanned with 14 single scans.

Color photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 Megapixel) lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/125 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with stereo flash; setup of right flashbulb: soft box 60x120 cm; focal ratio: 6,3; setup of left flashbulb: soft box 60x60 cm; focal ratio: 5,6; taken with single flash impulse.

UV-photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 Megapixel); lens: Hasselblad HC 50 mm; ISO: 100; focal ratio: F/4; exposure time: 1/15 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 60x120 cm; focal ratio: 9.3; setup of left flashbulb: soft box 60x60 cm; focal ratio: 8,6; taken with single flash impulse.

IR- photography: single shot taken with Canon EOS 5 Mark II (21 Megapixel); lens: Canon 35 mm; ISO: 100; focal ratio: F/11; exposure time: 1/160 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 60x120 cm; focal ratio: 6,3; setup of left flashbulb: soft box 60x60 cm; focal ratio: 5,6; taken with single flash impulse.

2.4 Trial Area 4

The area is located on the north façade of the tower, at ground level with easy access enough space for documentation in high resolution quality.

Condition of the surfaces: The selected areas are mostly original and were left relatively untouches during the several historical restoration campaigns. The surfaces are uncleaned.

Date, weather and temperature: 31st March; measuring time around 20:00-22:00; rainy; temperature between 8-10 °C. The documentation was done under a tarp because of rain.

Size of documented area: 140 x 100 cm

Material: Balegem and Gobertange

Fig. 04: General view of Trial Area 4.

3D-scanning: Structured-Light-Scanner Comet L3D in a resolution of 0.3 mm (800mm lens). The Area was scanned with 16 single scans.

Color photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 Megapixel); lens : Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/125 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with stereo flash; setup of right flashbulb: soft box 60x60 cm; focal ratio: 5,5; setup of left flashbulb: soft box 60x120 cm; focal ratio: 6,2; taken with single flash impulse.

UV-photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 Megapixel); lens: Hasselblad HC 50 mm; ISO: 100; focal ratio: F/4,8; exposure time: 1/45 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 60x60 cm; focal ratio: 8,6; setup of left flashbulb: soft box 60x120 cm; focal ratio: 9,3; taken with single flash impulse.

IR- photography: Single shot taken with Canon EOS 5 Mark II (21 megapixel); lens: Canon 34 mm; ISO: 100; focal ratio: F/11; exposure time: 1/160 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 60x60 cm; focal ratio: 5,5; setup of left flashbulb: soft box 60x120 cm; focal ratio: 6,2; captured with single flash impulse.

2.5 Trial Area 5

No documentation of Trial Area 5 was possible because of a short time frame.

2.6 Trial Area 6

The area is located on the west tower, on a height of 80 meters. It is separated in to 4 sub areas (facing in all directions). Each sub area is separated in to two sites of pillars. The whole area is accessible by a spiral staircase. Because of the height and narrow staircase it was impossible to carry up the StructuredLight-Scanner and the flash system. Therefore it was necessary to use the light version of documentation.

Condition of the surfaces: the surfaces had been cleaned by low pressure with wet abrasive blasting and rotating nozzle. Stonework were repointed with lime mortar.

Date, weather and temperature: 1st April; measuring time around 14:00-18:00; sunny and dry; temperature between 14-16 °C.

2.6.1 Trial Area 6_S

Orientation of sub area: South

Size of documented area: West pillar 50 x 160 cm; East pillar: 50 x 150 cm

Material: Balegem and Gobertange

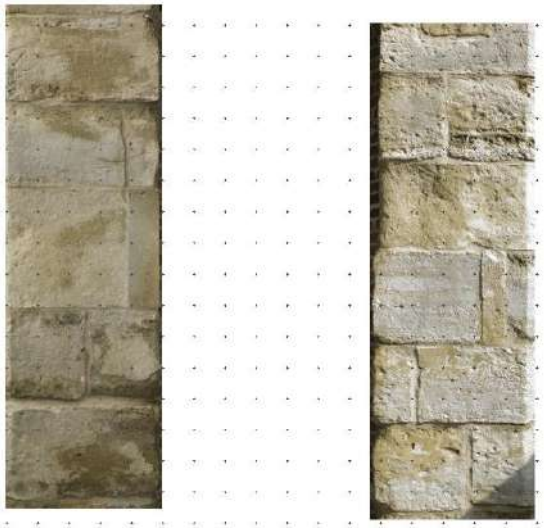


Fig. 05: General view of Trial Area 6_S.

3D-Scanning: Faro Focus X120 (terrestrial laser scanner), resolution 3 mm on 10 m distance (Resolution ½, Quality ¼). Both areas were taken with one single scan.

Color photography:
West Pillar: single shot captured with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens : Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/8 sec.; measurement mode: center-weighted. Flash System: no flash system, picture taken during day time.
East Pillar: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/6 sec.; measurement mode: center-weighted. Flash System: no flash system, picture taken during day time.

UV-photography: no UV-photography possible because of problematic accessibility.

IR- photography:
West Pillar: single shot taken with Canon EOS 5 Mark II (21 megapixel); lens: Canon 33 mm; ISO: 100; focal ratio: F/11; exposure time: 1/40 sec.; measurement mode: center-weighted. Flash System: no flash system, picture taken during day time.
East Pillar: Single shot taken with Canon EOS 5 Mark II (21 megapixel); lens: Canon 33 mm; ISO: 100; focal ratio: F/11; exposure time: 1/25 sec.; measurement mode: center-weighted. Flash System: no flash system, picture taken during day time.

2.6.2 Trial Area 6_W

Orientation of sub area: West

Size of documented area: North pillar 50 x 160 cm; South Pillar: 50 x 160 cm

Material: Balegem and Gobertange

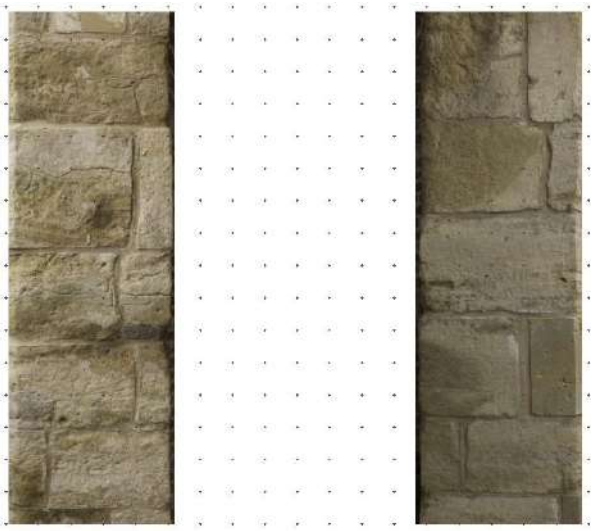


Fig. 06: General view of Trial Area 6_W.

3D-sScanning: Faro Focus X120 (terrestrial laser scanner), resolution 3 mm on 10 m distance (resolution ½, quality ¼). Both areas were taken with one single scan.

Color photography:
North Pillar: Ssngle shot taken with Hasselblad H2 with ixpress CFH digital body (39 Megapixel); lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/10 sec.; measurement mode: center-weighted. Flash System: no flash system, picture taken during day time.
South Pillar: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/10 sec.; measurement mode: center-weighted. Flash System: no flash system, picture taken during day time.

UV-photography: No UV-photography possible because of problematic accessibility.

IR- photography:

North Pillar: single shot taken with Canon EOS 5 Mark II (21 megapixel); lens: Canon 35 mm; ISO: 100; focal ratio: F/11; exposure time: 1/15 sec.; measurement mode: center-weighted. Flash System: no flash system, picture take during day time.

South Pillar: single shot captured with Canon EOS 5 Mark II (21 megapixel); lens: Canon 35 mm; ISO: 100; focal ratio: F/11; exposure time: 1/15 Sec.; measurement mode: center-weighted. Flash System: no flash system, picture taken during day time.

2.6.3 Trial Area 6_N

Orientation of sub area: North

Size of documented area: East pillar 50 x 160 cm; West pillar: 50 x 150 cm

Material: Balegem and Gobertange

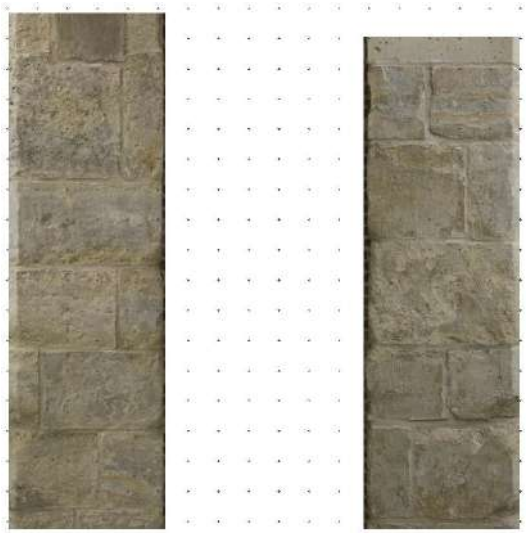


Fig. 07: General view of Trial Area 6_N.

3D-Scanning: Faro Focus X120 (terrestrial laser scanner), resolution 3 mm on 10 m distance (resolution ½, quality ¼). Both areas where captured with one single scan.

Color photography:
East pillar: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/8 sec.; measurement mode: center-weighted. Flash System: no flash system, picture taken during day time.
West pillar: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/8 Sec.; Measurement mode: center-weighted. Flash System: no flash system, picture taken during day time.

UV-photography: No UV-photography possible because of problematic accessibility.

IR- photography:

East pillar: single shot taken with Canon EOS 5 Mark II (21 megapixel); lens: Canon 33 mm; ISO: 100; focal ratio: F/10; exposure time: 1/15 sec.; measurement mode: center-weighted. Flash System: no flash system, picture taken during day time.
West pillar: single shot taken with Canon EOS 5 Mark II (21 megapixel); lens: Canon 33 mm; ISO: 100; focal ratio: F/10; exposure time: 1/15 sec.; measurement mode: center-weighted. Flash System: no flash system, picture taken during day time.

2.6.4 Trial Area 6_E

Orientation of sub area: East

Size of documented area: South pillar 50 x 160 cm; North pillar: 50 x 160 cm

Material: Balegem and Gobertange

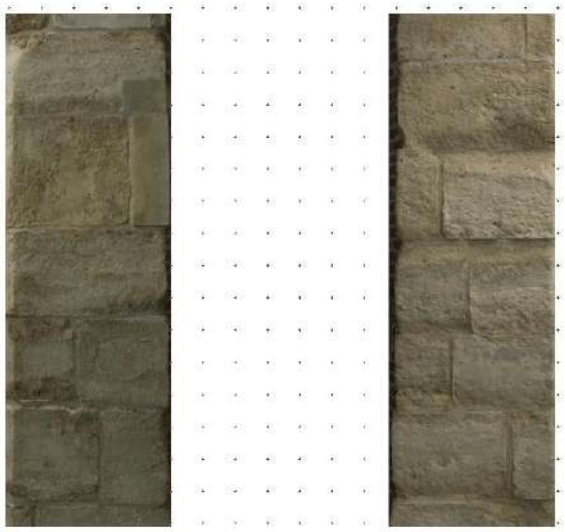


Fig. 08: General view of Trial Area 6_E.

3D-scanning: Faro Focus X120 (terrestrial laser scanner), resolution 3 mm on 10 m distance (resolution ½, quality ¼). Both areas were taken with one single scan.

Color photography:
South pillar: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/8 sec.; measurement mode: center-weighted. Flash System: no flash system, picture taken during day time.
North pillar: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/8 sec.; measurement mode: center-weighted. Flash System: no flash system, picture taken during day time.

UV-photography: No UV-Photography possible because of problematic accessibility.

IR- photography:
South pillar: single shot taken with Canon EOS 5 Mark II (21 Megapixel); lens: Canon 33 mm; ISO: 100; focal ratio: F/10; exposure time: 1/13 sec.; measurement mode: center-weighted. Flash System: no flash system, picture taken during day time.
North pillar: single shot taken with Canon EOS 5 Mark II (21 megapixel); lens: Canon 33 mm; ISO: 100; focal ratio: F/10; exposure time: 1/13 sec.; measurement mode: center-weighted. Flash System: no flash system, picture taken during day time.

2. Report Cologne

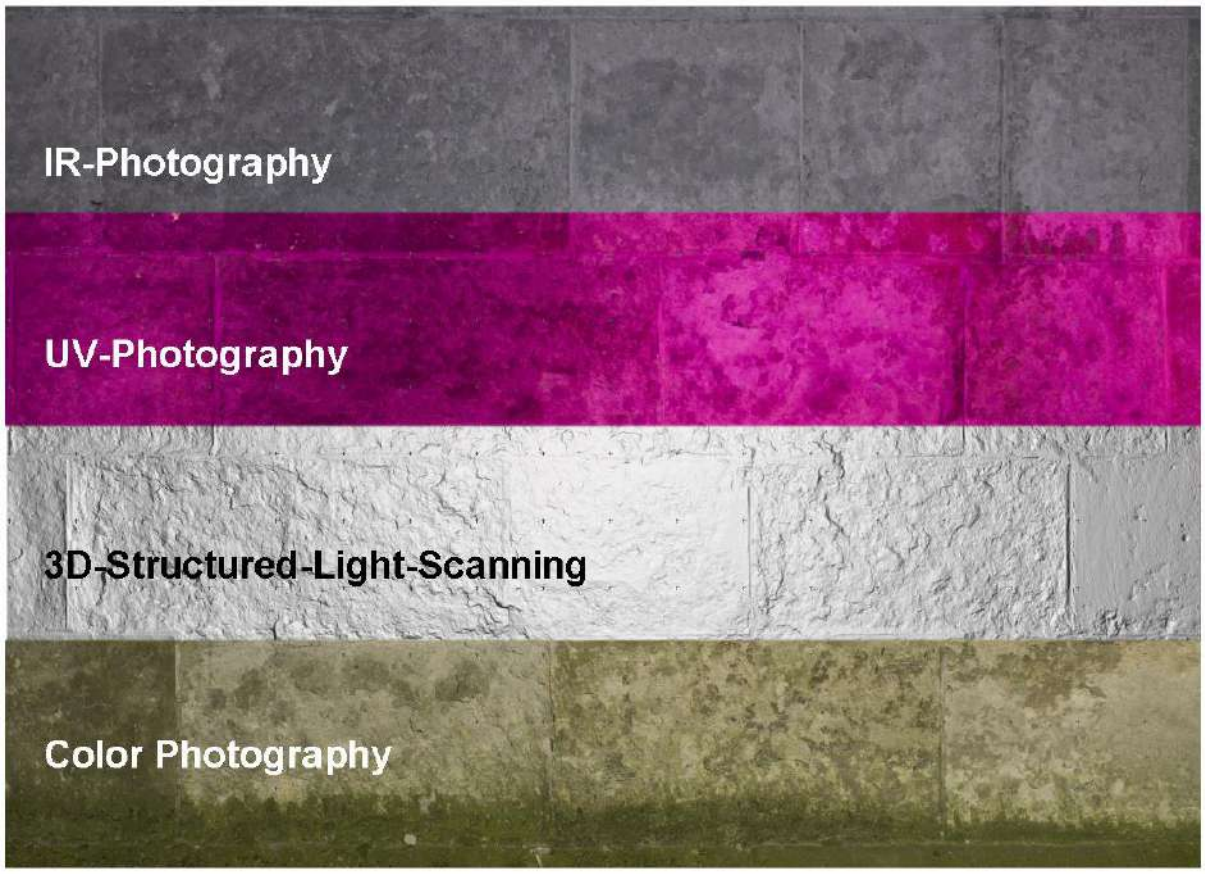
Documentation Report of

Monitoring Campaign I

Documentation of the Initial Condition of the Trail Areas

Hohe Domkirche St. Peter - Cologne

March-April 2016



Authors:
Max Rahrig M.A., Anna Luib M.A., David Höpfner, Prof. Dr. Rainer Drewello

Content:

2. Monitoring Campaign I, general aspects

The Monitoring Campaign I at the Hohe Domkirche St. Peter in Cologne took place between 29th March and 11th April. Its aim was to document the condition of the surfaces before their first treatment with nano technology or any preparatory measurements like cleaning.

Two different methods of documentation can be used depending on the accessibility of the trial areas. Areas with good accessibility and enough surrounding space for bulky equipment are photographed in various techniques and in a high resolution quality. Areas at towers or with difficult accessibility were photographed in a low resolution quality requiring less equipment.

In Cologne, all Trial Areas could be documented in the high resolution version.

2.7 High resolution Version

If possible all areas should be documented in high resolution quality in order to get best detail and analytical information of the surface. Following techniques were used:

- Color photography (with full frame Hasselblad H2D digital camera and Broncolor flash system)
- UV-photography (with full frame Hasselblad H2D digital camera and Broncolor UV-flash system)
- IR-photography (with special Canon EOS 5 Mark II - IR camera and Broncolor flash system)
- Structured-light-scanning (high resolution 3D-Documentation with Steinbichler Comet L3D-Scanner)
- Terrestrial 3D-Scanning of surrounding areas to locate the monitoring areas (Faro Focus X120)

A standard was established to ensure same light conditions (light temperature, brightness) for all trial areas in each different location and for every monitoring campaign. Therefore, all pictures were taken at night with a broncolor grafit A4 flash system, two flashbulbs and soft boxes for smoother light. For color calibration the pictures were taken with a Kodak color chart.
UV pictures require absolute darkness and a blocking out of all surrounding light. Daylight would inhibit or overlay UV light. Therefore, special UV-pass filter in front of the flashbulbs were used to generate the UV light.
The flash system as well as the structured-light-scanner (SLS) are bulky and need around 6 m² space in front of the trial area. The space is also necessary to obtain the required working distance between the trial areas and the SLS. Furthermore both instruments are heavy (approximately 25 kg) and are to be transported in big cases. For that reason they can only be used for trial areas with good accessibility.
After taking all pictures, all photos were aligned and straightened out to the 3D-Surface of the SLS making it later possible to overlay the images (Color, UV and IR). In combination with the topography of the surface (3D-model) this allowed the best possible basis for the comparability of the trial areas.

2.8 Light Version

Areas at towers or with difficult accessibility are documented with less equipment. Following techniques are used:

- Color photography (with full frame Hasselblad H2D digital camera and Broncolor flash system)
- IR-photography (with special Canon EOS 5 Mark II - IR camera and Broncolor flash system)
- Terrestrial 3D-Scanning (with Faro Focus X120)

This documentation is done without a flash system or structured light scanner, thus bearing considerable disadvantages.
Because of the missing flash system the documentation has to be done during daytime. Thus the pictures are not calibrated to the same light conditions. The colour of the stone changes depending on the weather (sunshine, rain or cloudy etc.). Also the lighting could change and shadows could affect the pictures. UV-photography is impossible without a flash system.
For alignment and straightening out the pictures the SLS can be used in the high resolution version, documenting the surface in a resolution of 0.3 mm. In the light version, however, the surfaces are documented with the terrestrial laser scanner only with a resolution of about 3 mm/10 m, a considerably lower quality.

3. Trial Areas

3.1 Trial Area M1

A proper documentation of Trial Area M1 was not possible due to bad weather conditions and a tight schedule.

3.2 Trial Area M2

Trial area M2 is located in the corner between southern nave and transept, on the pier buttress B 8, orientation west, the exposure facing south. The buttress with blind tracery was executed 1862 by stonemasons of the cathedral workshop. It is located in about 30 m height and accessible via scaffolding and a material elevator. The area is freestanding and directly reachable. Unfortunately, scaffolding tubes do not permit a frontal position for photographing. Parts of the buttress had to be photographed from an inconvenient angle. It was therefore not possible to align and completely straighten out the photographs true to scale in particular on the left part of the buttress. There might occur deviations especially in the peripheral areas.

Condition of the surfaces: The selected area is strongly sanding and shows delamination, scale formation (Fe III-oxide), crumbling, granular disintegration, black crusts, deep alveolization, subflorescence, efflorescence. The surfaces are uncleaned, there were no recent treatments of conservation.

Date, weather and temperature: 30st March; measuring time around 22:00-24:00; cloudy, drizzle; temperature between 4-8 °C.

Size of documented area: 180 x 150 cm

Material: Schlaitdorf Sandstone

Fig. 01: General view of Trial Area M2.

3D-scanning: Structured-Light-Scanner Comet L3D in a resolution of 0.3 mm (800mm lens). The area was scanned with 38 single scans.

Color photography: Single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/125 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with stereo flash; setup of right flashbulb: Soft box 60x100 cm; focal ratio: 6.4; setup of left flashbulb: soft box 120x120 cm; focal ratio: 6.9; taken with single flash impulse.

UV-photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens: Hasselblad HC 50 mm; ISO: 100; focal ratio: F/4; exposure time: 1/60 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: Soft box 60x100

cm; focal ratio: 9.2; setup of left flashbulb: soft box 120x120 cm; focal ratio: 8.7; taken with single flash impulse.

IR- photography: single shot taken with Canon EOS 5D Mark II (21 megapixel); lens: Canon 26mm; ISO: 100; focal ratio: F/11; exposure time: 1/160 Sec.; measurement mode: evaluative metering. Flash System: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: Soft box 60x100 cm; focal ratio: 6.4; setup of left flashbulb: soft box 120x120 cm; focal ratio: 6.9; focal ratio: 5.6; taken with single flash impulse.

3.3 Trial Area M3

A documentation of Trial Area M3 was not possible because of bad weather conditions and a tight schedule.

3.4 Trial Area M4

Trial area M4 is located on the eastern wall of the north tower, orientation north, the exposure also facing north. The architectural element with blind tracery, blind arcades and pinnacles was executed 1865 by stonemasons of the cathedral works department. It is located at a height of about 20 m and is accessible via scaffolding. The area is a decorative part of the eastern wall and reachable fronatally from the scaffolding.

Condition of the surfaces: The selected area shows signs of scaling, powdering, black crusts, exfoliation, flaking, soiling and powdering. The surfaces are uncleaned, there were no recent treatments of conservation.

Date, weather and temperature: 29th March; measuring time around 21:00-03:00; cloudy but dry; temperature between 8-10 °C.

Size of documented area: M4I: 60 x 120 cm and M4II:50 x 70 cm

Material: Obernkirchen Sandstone

Fig. 02: General view of Trial Area M4.

3D-scanning: Structured-Light-Scanner Comet L3D in a resolution of 0.3 mm (800mm lens). The area was scanned with 17 single scans (M4I) and 6 single scans (M4II).

Color photography: single shot taken with Canon EOS 5D Mark II (21 megapixel); lens: Canon 40mm; ISO: 100; focal ratio: F/11; exposure time: 1/160 sec.; measurement mode: evaluative metering. Flash System M4I: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 60x60 cm; focal ratio: 3.8; setup of left flashbulb: soft box 60x100 cm; focal ratio: 5.6; taken with single flash impulse. Flash System M4II: Broncolor grafit A4 with stereo flash, setup: Soft box 60x60 cm; focal ratio: 6.0. Taken with single flash impulse.

UV-photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens: Hasselblad HC 50 mm (M4I) 80 mm(M4II); ISO: 200 (M4I), 100 (M4II); focal ratio: F/4.8; exposure time: 1/60 sec. (M4I), 1/125 sec. (M4II); measurement mode: center-weighted. Flash System (M4I): Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 60x60 cm; focal ratio: 7.8; setup of left flashbulb: soft box 60x100 cm; focal ratio: 9.6; taken with single flash impulse. Flash System M4II: Broncolor grafit A4 with stereo flash, setup: Soft box 60x60 cm; focal ratio: 10.0. Taken with single flash impulse.

IR- photography: single shot taken with Canon EOS 5D Mark II (21 megapixel); lens: Canon 40mm; ISO: 100; focal ratio: F/11; exposure time: 1/160 sec.; measurement mode: Evaluative metering. Flash System (M4I): Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: Soft box 60x60 cm; focal ratio: 5.8; setup of left flashbulb: soft box 60x100 cm; focal ratio: 7.6; captured with single flash impulse. Flash System M4II: Broncolor grafit A4 with stereo flash, setup: Soft box 60x60 cm; focal ratio: 7.0. Taken with single flash impulse.

3.5 Trial Area M5

Trial area M5 is located on the eastern façade of the apse, between pier buttress 17.2 and 18.1, orientation and exposure both northeast. The area is slightly above ground level, easily accessible on the platform all round and with enough space for a documentation in high resolution quality.

Condition of the surfaces: No information available in D1.3.

Date, weather and temperature: 11th April; measuring time around 20:00-23:00; cloudy but dry; temperature between 4-6 °C.

Size of documented area: 200 x 150 cm

Material: Drachenfelstrachit

Fig. 03: General view of Trial Area M5.

3D-scanning: Structured-Light-Scanner Comet L3D in a resolution of 0.3 mm (800mm lens). The Area was scanned with 30 single scans.

Color photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel) lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/60 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with stereo flash; setup of right flashbulb: soft box 120x120 cm; focal ratio: 7.6; setup of left flashbulb: soft box 120x120 cm; focal ratio: 8.3; taken with single flash impulse.

UV-photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens: Hasselblad HC 50 mm; ISO: 800; focal ratio: F/8; exposure time: 1/45 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 120x120 cm; focal ratio: 8.6; setup of left flashbulb: soft box 120x120 cm; focal ratio: 9.3; taken with single flash impulse.

IR- photography: single shot taken with Canon EOS 5D Mark II (21 megapixel); lens: Canon 35 mm; ISO: 100; focal ratio: F/11; exposure time: 1/160 sec.; measurement mode: evaluative metering. Flash System: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 120x120 cm; focal ratio: 7.6; setup of left flashbulb: soft box 120x120 cm; focal ratio: 8.3; taken with single flash impulse.

3. Report Oslo

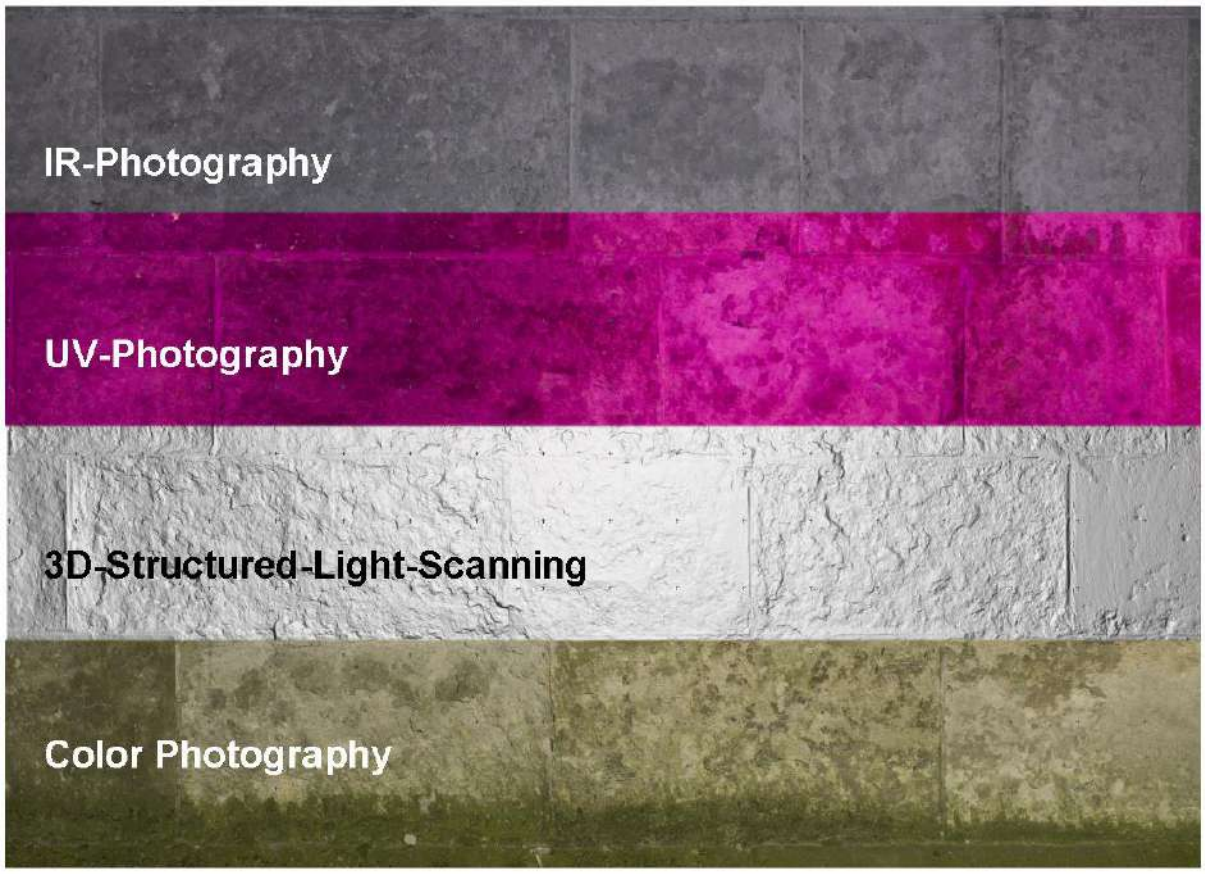
Documentation Report of

Monitoring Campaign I

Documentation of the Initial Condition of the Trail Areas

Den Norske Opera - Oslo

April 2016



Authors:
Max Rahrig M.A., Anna Luib M.A., David Höpfner, Prof. Dr. Rainer Drewello

Content:

3. Monitoring Campaign I, general aspects

The Monitoring Campaign I at Den Norske Opera in Oslo took place between 13th and 15th April. Its aim was to document the condition of the surfaces before their first treatment with nano technology or any preparatory measurements like cleaning.

Two different methods of documentation can be used depending on the accessibility of the trial areas. Areas with good accessibility and enough surrounding space for bulky equipment are photographed in various techniques and in a high resolution quality. Areas at towers or with difficult accessibility were photographed in a low resolution quality requiring less equipment.

In Oslo, all Trial Areas could be documented in the high resolution version.

3.6 High resolution Version

If possible all areas should be documented in high resolution quality in order to get best detail and analytical information of the surface. Following techniques were used:

- Color photography (with full frame Hasselblad H2D digital camera and Broncolor flash system)
- UV-photography (with full frame Hasselblad H2D digital camera and Broncolor UV-flash system)
- IR-photography (with special Canon EOS 5 Mark II - IR camera and Broncolor flash system)
- Structured-light-scanning (high resolution 3D-Documentation with Steinbichler Comet L3D-Scanner)
- Terrestrial 3D-Scanning of surrounding areas to locate the monitoring areas (Faro Focus X120)

A standard was established to ensure same light conditions (light temperature, brightness) for all trial areas in each different location and for every monitoring campaign. Therefore, all pictures were taken at night with a broncolor grafit A4 flash system, two flashbulbs and soft boxes for smoother light. For color calibration the pictures were taken with a Kodak color chart.
UV pictures require absolute darkness and a blocking out of all surrounding light. Daylight would inhibit or overlay UV light. Therefore, special UV-pass filter in front of the flashbulbs were used to generate the UV light.
The flash system as well as the structured-light-scanner (SLS) are bulky and need around 6 m² space in front of the trial area. The space is also necessary to obtain the required working distance between the trial areas and the SLS. Furthermore both instruments are heavy (approximately 25 kg) and are to be transported in big cases. For that reason they can only be used for trial areas with good accessibility.
After taking all pictures, all photos where aligned and straightened out to the 3D-Surface of the SLS making it later possible to overlay all images (Color, UV and IR). In combination with the topography of the surface (3D-model) this allowed the best possible basis for the comparability of the trial areas.

3.7 Light Version

Areas at towers or with difficult accessibility were documented with less equipment. Following techniques were used:

- Color photography (with full frame Hasselblad H2D digital camera and Broncolor flash system)
- IR-photography (with special Canon EOS 5 Mark II - IR camera and Broncolor flash system)
- Terrestrial 3D-Scanning (with Faro Focus X120)

This documentation is done without a flash system or structured light scanner, thus bearing considerable disadvantages.
Because of the missing flash system the documentation has to be done during daytime. Thus the pictures are not calibrated to the same light conditions. The colour of the stone changes depending on the weather (sunshine, rain or cloudy etc.). Also the lighting could change and shadows could affect the pictures. UV-photography is impossible without a flash system.
For alignment and straightening out the pictures the SLS can be used in the high resolution version, documenting the surface in a resolution of 0.3 mm. In the light version, however, the surfaces are documented with the terrestrial laser scanner only with a resolution of about 3 mm/10 m, a considerably lower quality.

4. Trial Areas

Kirsten Flagstads Plass 1, 0464 Oslo
Latitude : 59.907683324839255 / Longitude10.7527031733522

ACCESS TYPE:
No scaffolding required. Testing on site is NOT recommended on winter season due to safety and extreme snow weather conditions.

DIMENSION OF THE TEST AREA:
Mable thickness is 100 mm and sizes vary from 300x300 to 1000 x 2500 mm^2.
As adviced: Trial areas for consolidation products should be about 0,25 - 1 m^2. Trial areas for protection products should be about 2 - 4 m^2.

ASSESSMENT OF RELEVANT DECAY:
Problem: Change in colour

RECENT TREATMENTS OF CONSERVATION:
In 2008 the exterior marble surface was treated with fluoride-acrylic copolymer to protect the stone and facilitate maintenance. In 2013 it emerged that large parts of the exterior marble surface had turned yellowish brown to brown. There appears to be no uniformity to the colour changes.

AVAILABLE LITHOTYPES: Carrara Marble – La Facciata

4.1 Trial Area P1

A proper documentation of Trial Area P1 was not possible due to bad weather conditions and a tight schedule.

4.2 Trial Area P2

Trial area P2 is located in the middle of the slope in front of the northern façade of the Opera Interior. The slope is running down from northeast towards southwest. It serves as one of the main accesses to the Opera's rooftop. As the trial area is on the ground, there is no explicit orientation, nor any specific weather condition, but pedestrian traffic to be taken into consideration.

Date, weather and temperature: 14th March; measuring time around 01:00-03:00; cloudy but dry; temperature between 2-4°C.

Size of documented area: 140 x 150 cm

Material: Carrara Marble – La Facciata

Fig. 01: General view of Trial Area P2.

3D-scanning: Structured-Light-Scanner Comet L3D in a resolution of 0.3 mm (800mm lens). The area was scanned with 17 single scans.

All photographs except for UV-documentation were done with modeling light.

Color photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/125 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with stereo flash; setup of right flashbulb: Soft box 120x120 cm; focal ratio: 9.3; setup of left flashbulb: soft box 120x120 cm; focal ratio: 8.6; taken with single flash impulse.

UV-photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens: Hasselblad HC 50 mm; ISO: 400; focal ratio: F/6.8; exposure time: 1/90 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 120x120 cm; focal ratio: 8.6; setup of left flashbulb: soft box 120x120 cm; focal ratio: 9.3; taken with multi flash impulse.

IR- photography: single shot taken with Canon EOS 5D Mark II (21 megapixel); lens: Canon 40mm; ISO: 100; focal ratio: F/11; exposure time: 1/160 Sec.; measurement mode: evaluative metering. Flash System: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 120x120 cm; focal ratio: 5.0; setup of left flashbulb: soft box 120x120 cm; focal ratio: 5.4; taken with single flash impulse.

4.3 Trial Area P3A

Trial area P3A is located on the northeastern part of the Opera's rooftop, next to the smaller of the two rooftop boxes. The area is relatively flat. As the trial area is on the ground, there is no explicit orientation, but a shielding effect from the rooftop box in the West might be taken into consideration.

Date, weather and temperature: 13th March; measuring time around 21:00-23:00; cloudy but dry; temperature between 4-6 °C.

Size of documented area: 210 x 150 cm

Material: Carrara Marble – La Facciata

Fig. 02: General view of Trial Area P3A.

3D-scanning: Structured-Light-Scanner Comet L3D in a resolution of 0.3 mm (800mm lens). The area was scanned with 18 single scans.

All photographs except for UV-documentation were done with modeling light.

Color photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens e: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/125 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with stereo flash; setup of right flashbulb: Soft box 120x120 cm; focal ratio: 6.6; setup of left flashbulb: soft box 120x120 cm; focal ratio: 7.3; taken with single flash impulse.

UV-photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens: Hasselblad HC 50 mm; ISO: 400; focal ratio: F/6.8; exposure time: 1/90 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 120x120 cm; focal ratio: 8.6; setup of left flashbulb: soft box 120x120 cm; focal ratio: 9.3; taken with multi flash impulse.

IR- photography: single shot taken with Canon EOS 5D Mark II (21 megapixel); lens: Canon 36mm; ISO: 100; focal ratio: F/11; exposure time: 1/160 Sec.; measurement mode: evaluative metering. Flash System: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 120x120 cm; focal ratio: 6.6; setup of left flashbulb: soft box 120x120 cm; focal ratio: 7.3; taken with single flash impulse.

4.4 Trial Area P3B

Trial area P3B is located in the South of the Opera, on the smaller slope from the rooftop downwards. As the trial area is on the ground, there is no explicit orientation, nor any specific weather condition, but pedestrian traffic to be taken into consideration.

Date, weather and temperature: 14th March; measuring time around 21:00-23:00; cloudy but dry; temperature between 4-6 °C.

Size of documented area: 190 x 170 cm

Material: Carrara Marble – La Facciata

Fig. 02: General view of Trial Area P3B.

3D-scanning: Structured-Light-Scanner Comet L3D in a resolution of 0.3 mm (800mm lens). The area was scanned with 27 single scans.

All photographs except for UV-documentation were done with modeling light.

Color photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens e: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/125 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with stereo flash; setup of right flashbulb: Soft box 120x120 cm; focal ratio: 5:3; setup of left flashbulb: soft box 120x120 cm; focal ratio: 6:0; taken with single flash impulse.

UV-photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens: Hasselblad HC 50 mm; ISO: 400; focal ratio: F/8; exposure time: 1/90 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 120x120 cm; focal ratio; setup of left flashbulb: soft box 120x120 cm; focal ratio; taken with multi flash impulse.

IR- photography: single shot taken with Canon EOS 5D Mark II (21 megapixel); lens: Canon 31mm; ISO: 100; focal ratio: F/11; exposure time: 1/160 Sec.; measurement mode: evaluative metering. Flash System: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 120x120 cm; focal ratio: 5:7; setup of left flashbulb: soft box 120x120 cm; focal ratio: 6:4; taken with single flash impulse.

4.5 Trial Area P6

Trial area P6 is located on the southeastern part of the Opera's rooftop, next to the bigger of the two rooftop boxes. The area is relatively flat. As the trial area is on the ground, there is no explicit orientation, but a shielding effect from the rooftop box in the West might be taken into consideration.

Date, weather and temperature: 13th March; measuring time around 23:00-01:00; cloudy but dry; temperature between 2-5 °C.

Size of documented area: 200 x 170 cm

Material: Carrara Marble – La Facciata

Fig. 02: General view of Trial Area P6.

3D-scanning: Structured-Light-Scanner Comet L3D in a resolution of 0.3 mm (800mm lens). The area was scanned with 30 single scans.

All photographs except for UV-documentation were done with modeling light.

Color photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens e: Hasselblad HC 50 mm; ISO: 400; focal ratio: F/11; exposure time: 1/125 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with stereo flash; setup of right flashbulb: Soft box 120x120 cm; focal ratio: 3:3; setup of left flashbulb: soft box 120x120 cm; focal ratio: 4:0; taken with single flash impulse.

UV-photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens: Hasselblad HC 50 mm; ISO: 400; focal ratio: F/8; exposure time: 1/120 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 120x120 cm; focal ratio: 8.6; setup of left flashbulb: soft box 120x120 cm; focal ratio: 9.3; taken with multi flash impulse.

IR- photography: single shot taken with Canon EOS 5D Mark II (21 megapixel); lens: Canon 33mm; ISO: 100; focal ratio: F/11; exposure time: 1/160 Sec.; measurement mode: evaluative metering. Flash System: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 120x120 cm; focal ratio: 5:8; setup of left flashbulb: soft box 120x120 cm; focal ratio: 6:5; taken with single flash impulse.

4. Report Pisa

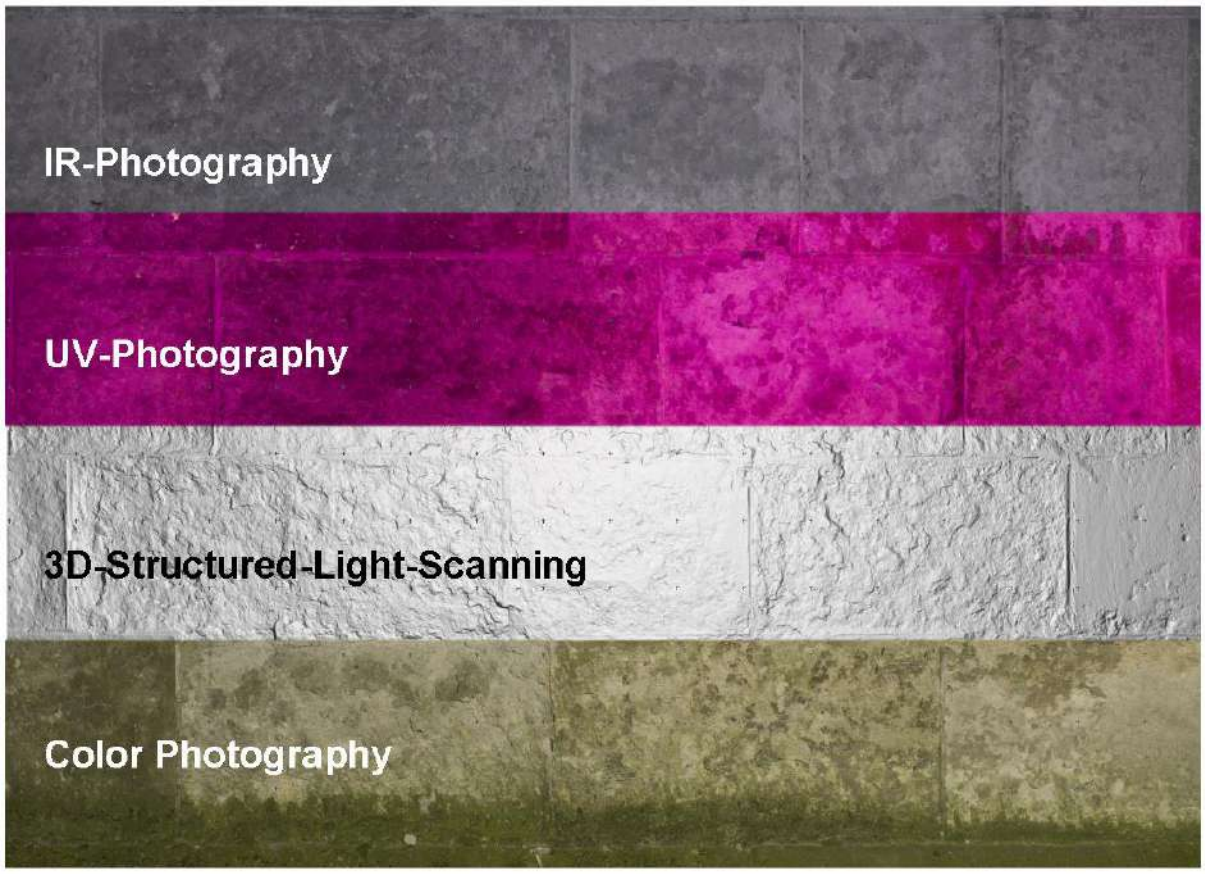
Documentation Report of

Monitoring Campaign I

Documentation of the Initial Condition of the Trail Areas

Cattedrale di Santa Maria - Pisa

April 2016



Authors:
Max Rahrig M.A., Anna Luib M.A., David Höpfner, Prof. Dr. Rainer Drewello

Content:

4. Monitoring Campaign I, general aspects

The Monitoring Campaign I at the Cattedrale di Santa Maria in Pisa took place between 18th April and 20th April. Its aim was to document the condition of the surfaces before their first treatment with nano technology or any preparatory measurements like cleaning.

Two different methods of documentation were used depending on the accessibility of the trial areas. Areas with good accessibility and enough surrounding space for bulky equipment were photographed in various techniques and in a high resolution quality. Areas at towers or with difficult accessibility were photographed in a low resolution quality requiring less equipment.

4.6 High resolution Version

If possible all areas should be documented in high resolution quality in order to get best detail and analytical information of the surface. Following techniques were used:

- Color photography (with full frame Hasselblad H2D digital camera and Broncolor flash system)
- UV-photography (with full frame Hasselblad H2D digital camera and Broncolor UV-flash system)
- IR-photography (with special Canon EOS 5 Mark II - IR camera and Broncolor flash system)
- Structured-light-scanning (high resolution 3D-Documentation with Steinbichler Comet L3D-Scanner)
- Terrestrial 3D-scanning of surrounding areas to locate the monitoring areas (Faro Focus X120)

A standard was established to ensure same light conditions (light temperature, brightness) for all trial areas in each different location and for every monitoring campaign. Therefore, all pictures were taken at night with a broncolor grafit A4 flash system, two flashbulbs and soft boxes for smoother light. For color calibration, the pictures were taken with a Kodak color chart.
UV pictures require absolute darkness and a blocking out of all surrounding light. Daylight would inhibit or overlay UV light. Therefore, special UV-pass filter in front of the flashbulbs were used to generate the UV light.
The flash system as well as the structured-light-scanner (SLS) are bulky and need around 6 m² space in front of the trial area. The space is also necessary to obtain the required working distance between the trial areas and the SLS. Furthermore both instruments are heavy (approximately 25 kg) and are to be transported in big cases. For that reason, they can only be used for trial areas with good accessibility.
After taking all pictures, all photos where aligned and straightened out to the 3D-Surface of the SLS making it later possible to overlay all images (Color, UV and IR). In combination with the topography of the surface (3D-model) this allowed the best possible basis for the comparability of the trial areas.

4.7 Light Version

Areas at towers or with difficult accessibility were documented with less equipment. Following techniques were used:

- Color photography (with full frame Hasselblad H2D digital camera and Broncolor flash system)
- IR-photography (with special Canon EOS 5 Mark II - IR camera and Broncolor flash system)
- Terrestrial 3D-scanning (with Faro Focus X120)

This documentation is done without a flash system or structured light scanner, thus bearing considerable disadvantages.
Because of the missing flash system, the documentation has to be done during daytime. Thus, the pictures are not calibrated to the same light conditions. The colour of the stone changes depending on the weather (sunshine, rain or cloudy etc.). Also, the lighting could change and shadows could affect the pictures. UV-photography is impossible without a flash system.
For alignment and straightening out the pictures the SLS can be used in the high resolution version, documenting the surface in a resolution of 0.3 mm. In the light version, however, the surfaces are documented with the terrestrial laser scanner only with a resolution of about 3 mm/10 m, a considerably lower quality.

5. Trial Areas

5.1 Trial Area B1

Trial area B1 is located on the south side, exposure also south, in the first order of the choir.
This area of the choir is supposed to be the first stage of the Cathedral's construction, dating back to the eleventh century. It is the first work site where reused stones and marble spolia where employed as building materials. In the masonry were inserted also ancient marble, containing high relief (flowers and spiral), and classical epigraphs; fragments of tendrils, dating back to the early medieval time, are located in the pillar of this area.
The trial area is located in about 5m height and accessible via scaffolding. Due to its width, several parts of the trial area lay behind scaffolding tubes and are therefore difficult to capture properly with scanner and camera. There might occur interpolations in the scanning data and shadows in the photographs.

Condition of the surfaces:

Apuan marble: Black crusts cover a few protected parts in the area of the high reliefs. The marble has also a strong sanding in the area of the high reliefs and a weak sanding or powdering in the other areas. The joints and gaps are filled with Portland cement.

Monte Pisano marble: Presence of weak erosion with differential decay and weak powdering. The joints and gaps are filled with Portland cement.

Breccia corallina: Presence of weak powdering. The joints and gaps are filled with Portland cement.

Recent treatments of conservation: There are no documents regarding recent treatments. In the years 1939-40 there was a restoration where Portland cement and mechanical cleaning of the surfaces were executed.

Date, weather and temperature: 18th April; measuring time around 22:00-24:00; a bit cloudy but dry; temperature between 12-14 °C.

Size of documented area: 392 x 200 cm

Material: Apuan marble, Monte Pisano marble, Bloch Limestone

Fig. 01: General view of Trial Area B1 (left part).

Fig. 02: General view of Trial Area B1(right part).

3D-scanning: Structured-Light-Scanner Comet L3D in a resolution of 0.3 mm (800mm lens). The area was scanned with 57 single scans.

Due to the Trial Area's width, all photographic documentation had to be subdivided into four single shots to properly capture the whole area. All photographs except for UV-documentation were done with modeling light. There might occur changes in color at the junction of the single shots.

Color photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/125 sec.; measurement mode: center-weighted. Flash system: Broncolor grafit A4 with stereo flash; setup of right flashbulb: soft box 60x100 cm; focal ratio: 5.0; setup of left flashbulb: soft box 60x100 cm; focal ratio: 5.0; taken with single flash impulse.

UV-photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/125 sec.; measurement mode: center-weighted. Flash system: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 60x100 cm; focal ratio: 9.0; setup of left flashbulb: soft box 60x100 cm; focal ratio: 9.0; taken with multi flash impulse.

IR- photography: single shot taken with Canon EOS 5D Mark II (21 megapixel); lens: Canon 35mm; ISO: 100; focal ratio: F/11; exposure time: 1/160 Sec.; measurement mode: evaluative metering. Flash system: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 60x100 cm; focal ratio: 5.0; setup of left flashbulb: soft box 60x100 cm; focal ratio: 5.0; taken with single flash impulse.

5.2 Trial Area B2

Trial area B2 is located on the first order of the choir in south side, exposure south, directly beneath trial area B1 on ground level. Accessible through/behind scaffolding. Due to its width, several parts of the trial area lay behind scaffolding tubes and are therefore difficult to capture properly with scanner and camera. There might occur interpolations in the scanning data and shadows in the photographs.
The area of the choir in that position is considered the first stage of construction from the eleventh century with use of reused stones and spolia from the ancient to the early medieval and medieval time

Condition of the surfaces:
Apuan marble: the marble presents little cracks, fissures and losses. The joints and gaps are filled with Portland cement.
Monte Pisano marble: presence of weak erosion with differential decay and weak powdering. Presence of little cracks and fissures. The joints and gaps are filled with Portland cement.
Bloch Limestone: presence of little cracks and fissures. The joints and gaps are filled with Portland cement.

Recent treatments of conservation: there are no documents regarding recent treatments. In the years 1939-40 there was a restoration where Portland cement and mechanical cleaning of the surfaces were executed.

Date, weather and temperature: 18th April; measuring time around 24:00-02:00; clear and dry; temperature between 10-13 °C.

Size of documented area: 392 x 200 cm

Material: Apuan marble, Monte Pisano marble, Bloch Limestone

Fig. 03: General view of Trial Area B2 (left part).

Fig. 04: General view of Trial Area B2 (right part).

3D-scanning: Structured-Light-Scanner Comet L3D in a resolution of 0.3 mm (800mm lens). The area was scanned with 49 single scans. Due to the Trial Area's width, all photographic documentation had to be subdivided into four single shots. All photographs except UV were done with modeling light. There might occur changes in color at the junction of the single shots.

Color photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/125 sec.; measurement mode: center-weighted. Flash system: Broncolor grafit A4 with stereo flash; setup of right flashbulb: soft box 60x100 cm; focal ratio: 5.0; setup of left flashbulb: soft box 60x100 cm; focal ratio: 5.0; taken with single flash impulse.

UV-photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens: Hasselblad HC 50 mm; ISO: 200; focal ratio: F/5.6; exposure time: 1/90 sec.; measurement mode: center-weighted. Flash system: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 60x100 cm; focal ratio: 9.0; setup of left flashbulb: soft box 60x100 cm; focal ratio: 9.0; taken with multi flash impulse.

IR- photography: single shot taken with Canon EOS 5D Mark II (21 megapixel); lens: Canon 35mm; ISO: 100; focal ratio: F/11; exposure time: 1/160 sec.; measurement mode: evaluative metering. Flash system: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 60x100 cm; focal ratio: 5.0; setup of left flashbulb: soft box 60x100 cm; focal ratio: 5.0; taken with single flash impulse.

5.3 Trial Area L1

Trial area L1 is located in the north side, in the first bay of the choir, on the corner of the cornices at a height of about 12 m. It is accessible via scaffolding. The orientation is north, exposure also north. This area of the choir is supposed to be the first stage of the Cathedral's construction, dating back to the eleventh century: it is located above the first work site, where reused stones and spolia marble were employed as building materials.

Condition of the surfaces: Apuan marble: black crusts cover the surface in protected parts. Presence of a strong attack of biological film (algae). The marble also shows strong sanding. The joints and gaps are filled with Portland cement.

Monte Pisano marble: presence of a strong attack of biological film (algae) and advanced erosion with differential decay, powdering and scaling. The joints and gaps are filled with Portland cement.

Recent treatments of conservation: there are no documents regarding recent treatments. A restoration work had been carried out in 1939-40, treatments: mechanical cleaning of the surfaces and Portland cement to fill joints and gaps.

Date, weather and temperature: 19th April; measuring time around 22:00-24:00; clear and dry; temperature between 12-14 °C.

Size of documented area: Monte Pisano marble: 850 x 220 mm / Apuan marble: 570 x 260 mm

Material: Monte Pisano marble / Apuan marble

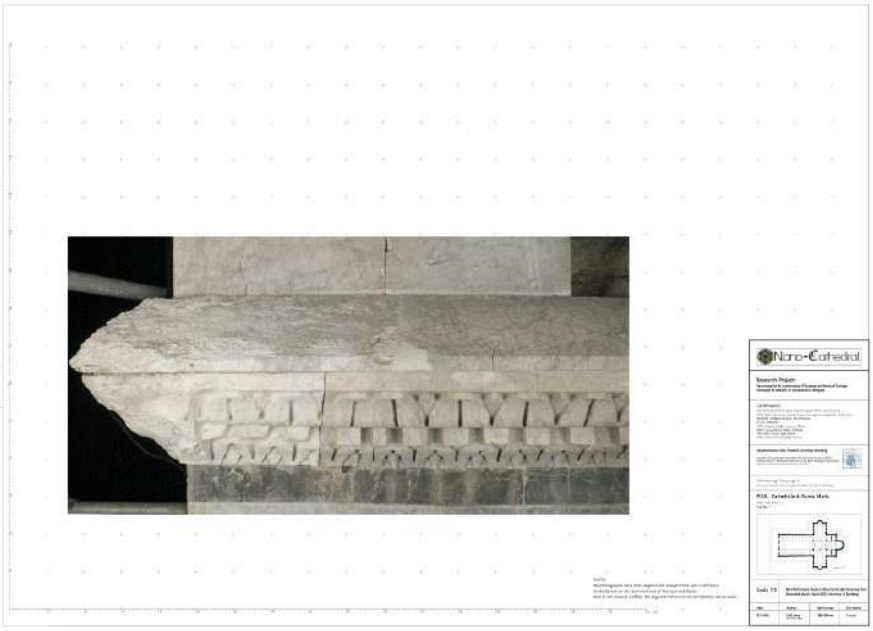


Fig. 05: General view of Trial Area L1.

3D-scanning: Structured-Light-Scanner Comet L3D in a resolution of 0.3 mm (800mm lens). The area was scanned with 14 single scans.

Color photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/125 sec.; measurement mode: center-weighted. Flash system: Broncolor grafit A4 with stereo flash; setup of right flashbulb: soft box 60x100 cm; focal ratio: 5.0; setup of left flashbulb: soft box 60x100 cm; focal ratio: 5.0; taken with single flash impulse.

UV-photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens: Hasselblad HC 50 mm; ISO: 200; focal ratio: F/5.6; exposure time: 1/60 sec.; measurement mode: center-weighted. Flash system: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 60x100 cm; focal ratio: 9.0; setup of left flashbulb: soft box 60x100 cm; focal ratio: 9.0; taken with multi flash impulse.

IR- photography: single shot taken with Canon EOS 5D Mark II (21 megapixel); lens: Canon 35mm; ISO: 100; focal ratio: F/13; exposure time: 1/160 sec.; measurement mode: evaluative metering. Flash System: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 60x100 cm; focal ratio: 5.0; setup of left flashbulb: soft box 60x100 cm; focal ratio: 5.0; taken with single flash impulse.

5.4 Trial Area Q – Dome

The area is located on the cathedral's dome, at a height of about 37 m and is accessible via scaffolding. It is separated in to 4 sub areas (Q1 facing north, Q3 east, Q5 south, Q7 west). Because of the height and narrow scaffolding, it was impossible to carry up the Structured Light-Scanner and the flash system. Therefore, it was necessary to use the light version of documentation.

5.4.1 Trial Area Q1

Trial area Q1 is located at the dome of the cathedral on the north side, orientation north, exposure also north. The area in this position dates back to the fourteenth century.
Due to its width and the constricted working space, several parts of the trial area lay behind scaffolding tubes and are therefore difficult to capture properly with scanner and camera. There are interpolations in the scanning data and shadows in the photographs. Consequently, it was not possible to align and straighten out the photographs. Please note that the photographic information is not true to scale!

Condition of the surfaces: Apuan marble: black crusts cover the surface in protected parts. Presence of a strong attack of biological film (algae). The marble also has moderate powdering and erosion. The marble shows little cracks and fissures and losses.

Recent treatments of conservation: There are no documents regarding recent treatments.

Date, weather and temperature: 19th April; measuring time around 13:00-16:00; sunny and clear; temperature between 16-18 °C.

Size of documented area: 400 x 430 cm^2

Material: Monte Pisano marble / Apuan marble

Fig. 06: Overview Trial Area Q1.

Low resolution version for Q1

3D-Scanning: Faro Focus X120 (terrestrial laser scanner), resolution 3 mm on 10 m distance (Resolution ½, Quality ¼). Q1 was taken with four single scans.

Color photography: single shots taken with Canon EOS 5D Mark II (21 megapixel); lens: Canon 30mm; ISO: 200; focal ratio: F/11; exposure time: 1/60 – 1/80 sec.; measurement mode: evaluative metering. No flash system, picture taken at daytime.

IR- photography: single shots taken with Canon EOS 5D Mark II (21 megapixel); lens: Canon 30mm; ISO: 100; focal ratio: F/11; exposure time: 1/20 – 1/50 sec.; measurement mode: evaluative metering. No flash system, picture taken at daytime.

5.4.2 Trial Area Q3

Trial area Q3 is located at the dome of the cathedral on the east side, orientation east, exposure also east. The area in this position dates back to the fourteenth century.
Due to its width and the constricted working space, several parts of the trial area lay behind scaffolding tubes and are therefore difficult to capture properly with scanner and camera. There are interpolations in the scanning data and shadows in the photographs. Consequently, it was not possible to align and straighten out the photographs. Please note that the photographic information is not true to scale!

Condition of the surfaces: Apuan marble: Black crusts cover the surface in protected parts. Presence of a strong attack of biological film (algae). The marble also has moderate powdering and erosion. The marble shows little cracks and fissures and losses.

Recent treatments of conservation: There are no documents regarding recent treatments.

Date, weather and temperature: 19th April; measuring time around 13:00-16:00; sunny and clear; temperature between 16-18 °C.

Size of documented area: 400 x 430 cm^2

Material: Apuan marble

Fig. 07: Overview Trial Area Q3.

3D-Scanning: Faro Focus X120 (terrestrial laser scanner), resolution 3 mm on 10 m distance (Resolution ½, Quality ¼). Q3 was taken with four single scans.

Color photography: single shots taken with Canon EOS 5D Mark II (21 megapixel); lens: Canon 30mm; ISO: 100; focal ratio: F/11; exposure time: 1/30 – 1/80 sec.; measurement mode: evaluative metering. No flash system, picture taken at daytime.

IR- photography: single shots taken with Canon EOS 5D Mark II (21 megapixel); lens: Canon 30mm; ISO: 100; focal ratio: F/11; exposure time: 1/25 – 1/40 sec.; measurement mode: evaluative metering. No flash system, picture taken at daytime.

5.4.3 Trial Area Q5

Trial area Q5 is located at the dome of the cathedral on the south side, orientation south, exposure also south. The area in this position dates back to the fourteenth century.
Due to its width and the constricted working space, several parts of the trial area lay behind scaffolding tubes and are therefore difficult to capture properly with scanner and camera. There are interpolations in the scanning data and shadows in the photographs. Consequently, it was not possible to align and straighten out the photographs. Please note that the photographic information is not true to scale!

Condition of the surfaces: Apuan marble: Black crusts cover the surface in protected parts. Presence of a biological film (algae). The marble also has moderate powdering and erosion. The marble shows little cracks, fissures and losses.

Recent treatments of conservation: There are no documents regarding recent treatments.

Date, weather and temperature: 19th April; measuring time around 13:00-16:00; sunny and clear; temperature between 16-18 °C.

Size of documented area: 400 x 430 cm^2

Material: Apuan marble

Fig. 08: Overview Trial Area Q5.

3D-Scanning: Faro Focus X120 (terrestrial laser scanner), resolution 3 mm on 10 m distance (Resolution ½, Quality ¼). Q5 was taken with four single scans.

Color photography: single shots taken with Canon EOS 5D Mark II (21 megapixel); lens: Canon 30mm; ISO: 100; focal ratio: F/11; exposure time: 1/50 – 1/60 sec.; measurement mode: evaluative metering. No flash system, picture taken at daytime.

IR- photography: single shots taken with Canon EOS 5D Mark II (21 megapixel); lens: Canon 30mm; ISO: 100; focal ratio: F/11; exposure time: 1/25 – 1/50 sec.; measurement mode: evaluative metering. No flash system, picture taken at daytime.

5.4.4 Trial Area Q7

Trial area Q5 is located at the dome of the cathedral on the west side, orientation west, exposure also west. The area in this position dates back to the fourteenth century.
Due to its width and the constricted working space, several parts of the trial area lay behind scaffolding tubes and are therefore difficult to capture properly with scanner and camera. There are interpolations in the scanning data and shadows in the photographs. Consequently, it was not possible to align and straighten out the photographs. Please note that the photographic information is not true to scale!

Condition of the surfaces: Apuan marble: black crusts cover the surface in protected parts. Presence of a biological film (algae). The marble also has moderate powdering and erosion. The marble shows little cracks, fissures and losses.

Recent treatments of conservation: There are no documents regarding recent treatments.

Date, weather and temperature: 19th April; measuring time around 13:00-16:00; sunny and clear; temperature between 16-18 °C.

Size of documented area: 400 x 430 cm^2

Material: Apuan marble

Fig. 09: Overview Trial Area Q7.

3D-Scanning: Faro Focus X120 (terrestrial laser scanner), resolution 3 mm on 10 m distance (Resolution ½, Quality ¼). Q1 was taken with four single scans.

Color photography: single shots taken with Canon EOS 5D Mark II (21 megapixel); lens: Canon 30mm; ISO: 100; focal ratio: F/11; exposure time: 1/80 – 1/125 sec.; measurement mode: evaluative metering. No flash system, picture taken at daytime.

IR- photography: single shots taken with Canon EOS 5D Mark II (21 megapixel); lens: Canon 30mm; ISO: 100; focal ratio: F/11; exposure time: 1/40 – 1/50 sec.; measurement mode: evaluative metering. No flash system, picture taken at daytime.

5. Report Vienna

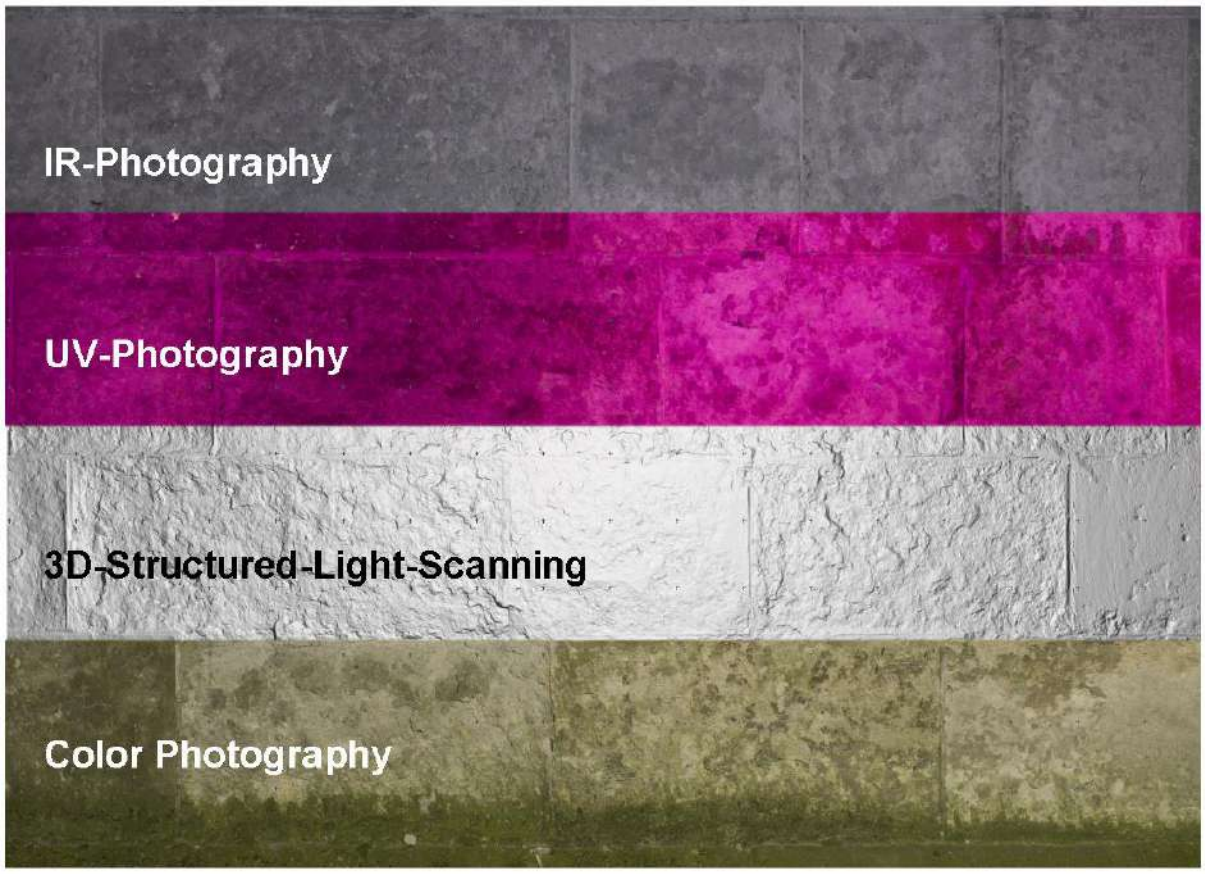
Documentation Report of

Monitoring Campaign I

Documentation of the Initial Condition of the Trail Areas

Domkirche St. Stephan - Vienna

April 2016



Authors:
Max Rahrig M.A., Anna Luib M.A., David Höpfner, Prof. Dr. Rainer Drewello

Content:

5. Monitoring Campaign I, general aspects

The Monitoring Campaign I at St. Stephan in Vienna took place between 20st April and 22nd April. Its aim was to document the condition of the surfaces before their first treatment with nano technology or any preparatory measurements like cleaning.

Two different methods of documentation were used depending on the accessibility of the trial areas. Areas with good accessibility and enough surrounding space for bulky equipment were photographed in various techniques and in a high resolution quality. Areas at towers or with difficult accessibility were photographed in a low resolution quality requiring less equipment.

5.5 High resolution Version

If possible, all areas should be documented in high resolution quality in order to get best detail and analytical information of the surface. Following techniques were used:

- Color photography (with full frame Hasselblad H2D digital camera + Broncolor flash system)
- UV-photography (with full frame Hasselblad H2D digital camera + Broncolor UV-flash system)
- IR-photography (with special Canon EOS 5 Mark II - IR camera and Broncolor flash system)
- Structured-light-scanning (high resolution 3D-Documentation with Steinbichler Comet L3D-Scanner)
- Terrestrial 3D-Scanning of surrounding areas to locate the monitoring areas (Faro Focus X120)

A standard was established to ensure same light conditions (light temperature, brightness) for all trial areas in each different location and for every monitoring campaign. Therefore, all pictures were taken at night with a broncolor grafit A4 flash system, two flashbulbs and soft boxes for smoother light. For color calibration the pictures were taken with a Kodak color chart.
UV pictures require absolute darkness and a blocking out of all surrounding light. Daylight would inhibit or overlay UV light. Therefore, special UV-pass filter in front of the flashbulbs were used to generate the UV light.
The flash system as well as the structured-light-scanner (SLS) are bulky and need around 6 m² space in front of the trial area. The space is also necessary to obtain the required working distance between the trial areas and the SLS. Furthermore both instruments are heavy (approximately 25 kg) and are to be transported in big cases. For that reason they can only be used for trial areas with good accessibility.
After taking all pictures, all photos where aligned and straightened out to the 3D-Surface of the SLS making it later possible to overlay all images (Color, UV and IR). In combination with the topography of the surface (3D-model) this allowed the best possible basis for the comparability of the trial areas.

5.6 Light Version

Areas at towers or with difficult accessibility were documented with less equipment. Following techniques were used:

- Color photography (with full frame Hasselblad H2D digital camera + Broncolor flash system)
- IR-photography (with special Canon EOS 5 Mark II - IR camera + Broncolor flash system)
- Terrestrial 3D-Scanning (with Faro Focus X120)

This documentation is done without a flash system or structured light scanner, thus bearing considerable disadvantages.
Because of the missing flash system the documentation has to be done during daytime. Thus the pictures are not calibrated to the same light conditions. The colour of the stone changes depending on the weather (sunshine, rain or cloudy etc.). Also the lighting could change and shadows could affect the pictures. UV-photography is impossible without a flash system.
For alignment and straightening out the pictures the SLS can be used in the high resolution version, documenting the surface in a resolution of 0.3 mm. In the light version, however, the surfaces are documented by the terrestrial laser scanner only, with a considerably lower resolution of about 3 mm/10m.

6. Trial Areas

6.1 Trial Area 1

Trial area 1 is located on the east side of the cathedral at a wimperg of a buttress at a height of 20 m facing south-west. During the period of the project the area is accessible with an elevator and over a scaffolding. For long term monitoring it will be accessible via a gallery from the attic but for special reasons and tests, temporary mini-scaffolds or monitoring devices will be mountable.

Condition of the surfaces: Parts were restored in 19th and 20th century. No cleaning was done before the monitoring campaign 1. Black crusts, erosion and loss of grain cohesion are visible.

Date, weather and temperature: 22nd April; measuring time around 21:00-23:00; cloudy but dry; temperature between 9-11 °C.

Size of documented area: The whole area spans over 15 m. Smaller parts could be chosen for application of treatment. The main areas were: TA1 Part 1: 90 x 170 cm, TA1 Part 2: 90 x 170 cm. These two areas were documented in the high resolution version. Additionally, four tracery parts were documented in the low resolution version: TA1 S1, TA1 S2, TA1 S3, TA1 S4, each ~ 90 x 130 cm.

Material: A. Limestone from St. Margarethen, B. Limestone from Au, C. Limestone from Bihac.

1.5.1 High resolution version for TA 1 Part 1 and Part 2

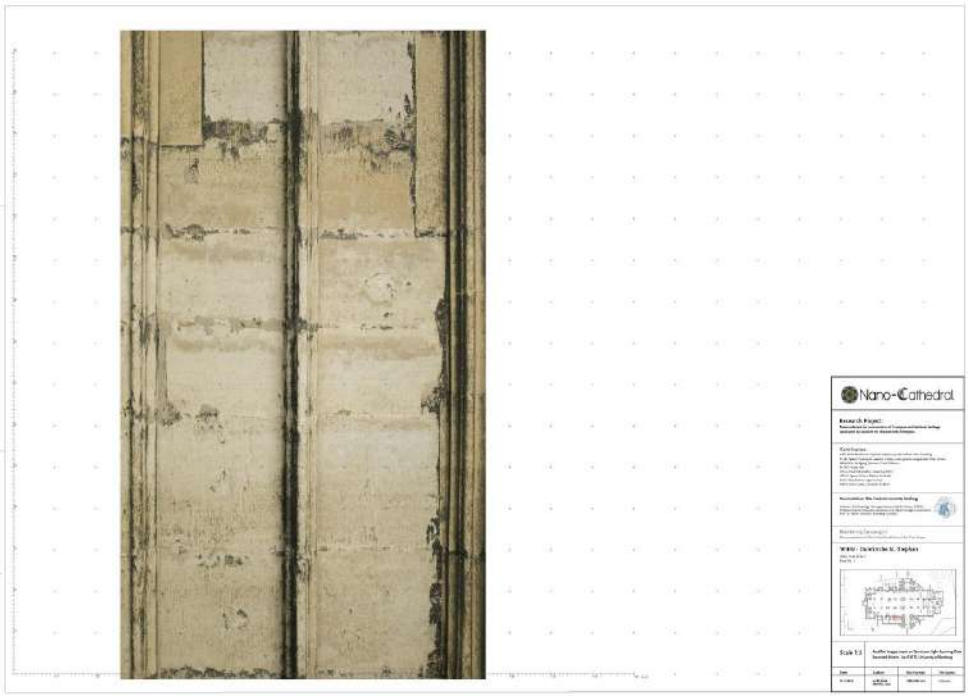


Fig. 01: General view of Trial Area 1 Part 1.

Fig. 02: General view of Trial Area 1 Part 2.

3D scanning: Structured-Light-Scanner Comet L3D in a resolution of 0.3 mm (800mm lens). The area was scanned with 29 single scans (TA1 Part 1) and 33 single scans (TA1 Part 2).

Color photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/180 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with stereo flash; setup of right flashbulb: Soft box 60x100 cm; focal ratio: 5.4; setup of left flashbulb: soft box 60x100 cm; focal ratio: 6.4; taken with single flash impulse.

UV-photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 23 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 60x100 cm; focal ratio: 8.4; setup of left flashbulb: soft box 60x100 cm; focal ratio: 9.4; taken with multi flash impulse (4 impulses).

IR- photography: single shot taken with Canon EOS 5D Mark II (21 megapixel); lens: Canon 35mm; ISO: 100; focal ratio: F/11; exposure time: 1/125 Sec.; measurement mode: evaluative metering. Flash System: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 60x100 cm; focal ratio: 5.4; setup of left flashbulb: soft box 60x100 cm; focal ratio: 6.4; taken with single flash impulse.

1.5.2 Low resolution version for TA 1 S1, S2, S3, S4

Fig. 03: General view of Trial Area 1 S1, S2, S3, S4.

3D-Scanning: Faro Focus X120 (terrestrial laser scanner), resolution 3 mm on 10 m distance (Resolution ½, Quality ¼). TA1 was taken with four single scans (one single scan each side).

Color photography: single shots taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens: Hasselblad HC 50 mm; ISO: -50; focal ratio: F/11; exposure time: varying; measurement mode: center-weighted. No flash system.

IR- photography: single shots taken with Canon EOS 5D Mark II (21 megapixel); lens: Canon 35mm; ISO: -100; focal ratio: F/11; exposure time: varying; measurement mode: evaluative metering. No flash system.

6.2 Trial Area 2

The area is located on the east façade between choir and Catherine´s Chapel at a height of 10 m facing southwest. The testing area can be reached from the flat roof of an annex building, accessible with a ladder. The terrace above the chapel is accessible through staircases of the steeple. No scaffolding is needed.

Condition of the surfaces: Some parts were restored in 19th and 20th century. No cleaning was done before the monitoring campaign 1. Black crusts and erosion are visible.

Date, weather and temperature: 22nd April; measuring time around 14:00-16:00; cloudy but dry; temperature between 14-17 °C.

Size of documented area: 120 x 200 cm.

Material: A. Limestone from St. Margarethen, B. Limestone from Au.

Fig. 04: General view of Trial Area 2.

Low resolution version for TA 2

3D-Scanning: Faro Focus X120 (terrestrial laser scanner), resolution 3 mm on 10 m distance (Resolution ½, Quality ¼). TA2 was taken with one single scan.

Color photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/15 sec.; measurement mode: center-weighted. No flash system.

IR- photography: single shot taken with Canon EOS 5D Mark II (21 megapixel); lens: Canon 35mm; ISO: 100; focal ratio: F/11; exposure time: 1/30 Sec.; measurement mode: evaluative metering. No flash system.

6.3 Trial Area 3 - South Tower

The area is located on the south tower, on a height of 80 meters. It is separated in to 7 sub areas (facing in all directions). The whole area is accessible by a spiral staircase. Because of the height and narrow staircase it was impossible to carry up the Structured Light-Scanner and the flash system. Therefore, it was necessary to use the light version of documentation.

Condition of the surfaces: The areas were restored in 2007. The surfaces had been cleaned by low pressure with wet abrasive blasting and rotating nozzle. Stonework were repointed with lime mortar.

Date, weather and temperature: 21st April; measuring time around 13:00-15:00; sunny and dry; temperature between 14-16 °C.

Size of documented area: Each side of the octagon is about 5 m long, best testing areas are only 3 m^2, above the gallery for unveiled exposure to wind and weather. There are seven Trial Areas on the whole: TA3_8 N, TA3_9 NE, TA3_10 E, TA3_11 SE, TA3_12 S, TA3_13 SW, TA3_14 W.

Material: A. Limestone from St. Margarethen, B. Limestone from Mannersdorf.

All seven Trial Areas were documented in the low resolution version.

6.3.1 Trial Area 3_8 N

Orientation of sub area: north

Size of documented area: 80 x 140 cm

Material: Limestone from St. Margarethen / Mannersdorf

Fig. 05: General view of Trial Area 3_8 N.

3D-Scanning: Faro Focus X120 (terrestrial laser scanner), resolution 3 mm on 10 m distance (Resolution ½, Quality ¼). The area was taken with one single scan.

Color photography:
Single shot with Canon EOS 5D Mark II (21 megapixel); lens: Canon 17 mm; ISO: 400; focal ratio: F/9; exposure time: 1/100 sec.; measurement mode: evaluative metering. No flash system, picture taken at daytime.

IR- photography:
Single shot with Canon EOS 5D Mark II (21 megapixel); lens: Canon 17 mm; ISO: 400; focal ratio: F/9; exposure time: 1/100 sec.; measurement mode: evaluative metering. No flash system, picture taken at daytime.

6.3.2 Trial Area 3_9 NE

Orientation of sub area: northeast

Size of documented area: 90 x 170 cm

Material: Limestone from St. Margarethen / Mannersdorf

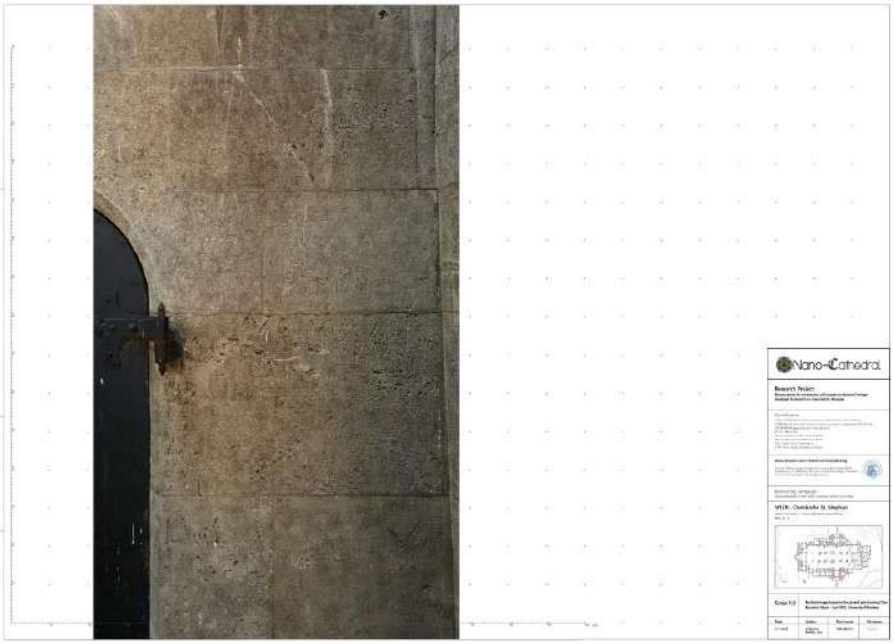


Fig. 06: General view of Trial Area 3_9 NE.

3D-Scanning: Faro Focus X120 (terrestrial laser scanner), resolution 3 mm on 10 m distance (Resolution ½, Quality ¼). The area was taken with one single scan.

Color photography:
Single shot with Canon EOS 5D Mark II (21 megapixel); lens: Canon 20 mm; ISO: 400; focal ratio: F/9; exposure time: 1/13 sec.; measurement mode: evaluative metering. No flash system, picture taken at daytime.

IR- photography:
Single shot with Canon EOS 5D Mark II (21 megapixel); lens: Canon 20 mm; ISO: 400; focal ratio: F/9; exposure time: 1/13 sec.; measurement mode: evaluative metering. No flash system, picture taken at daytime.

6.3.3 Trial Area 3_10 E

Orientation of sub area: east

Size of documented area: 80 x 90 cm

Material: Limestone from St. Margarethen / Mannersdorf

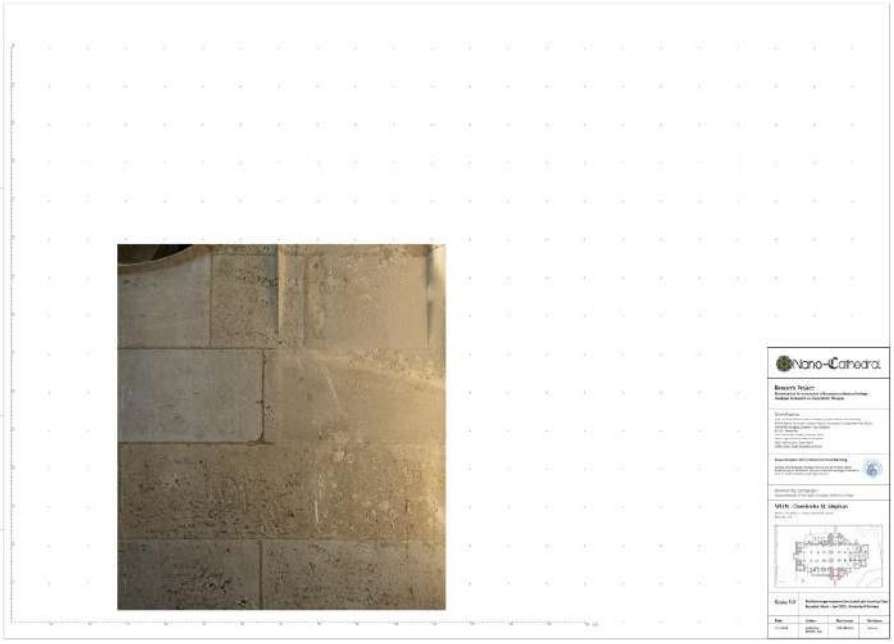


Fig. 07: General view of Trial Area 3_10 E.

3D-Scanning: Faro Focus X120 (terrestrial laser scanner), resolution 3 mm on 10 m distance (Resolution ½, Quality ¼). The area was taken with one single scan.

Color photography:
Single shot with Canon EOS 5D Mark II (21 megapixel); lens: Canon 17 mm; ISO: 400; focal ratio: F/9; exposure time: 1/200 sec.; measurement mode: evaluative metering. Flash System: no flash system, picture taken at daytime.

IR- photography:
Single shot with Canon EOS 5D Mark II (21 megapixel); lens: Canon 17 mm; ISO: 400; focal ratio: F/9; exposure time: 1/200 sec.; measurement mode: evaluative metering. Flash System: no flash system, picture taken at daytime.

6.3.4 Trial Area 3_11 SE

Orientation of sub area: southeast

Size of documented area: 80 x 150 cm

Material: Limestone from St. Margarethen / Mannersdorf

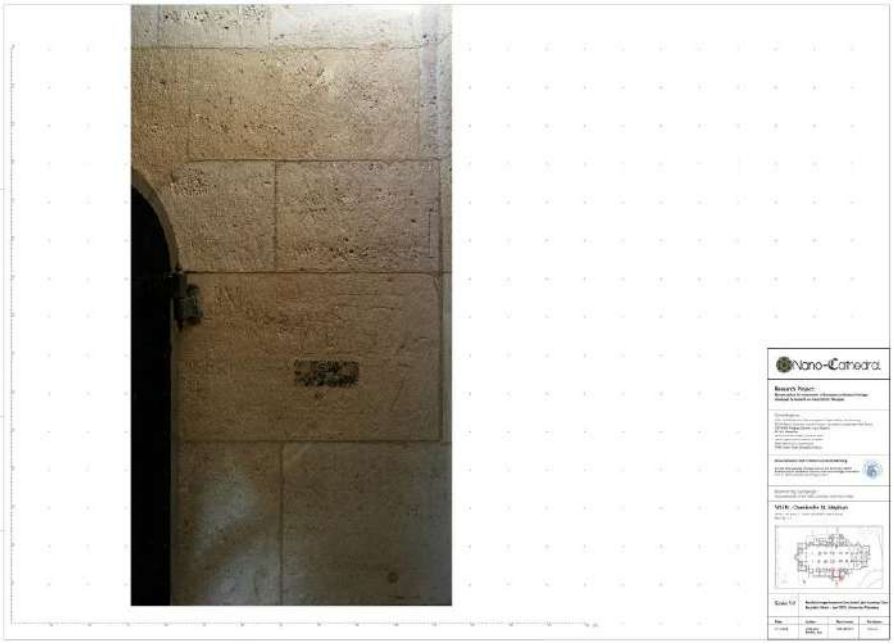


Fig. 08: General view of Trial Area 3_11 SE.

3D-Scanning: Faro Focus X120 (terrestrial laser scanner), resolution 3 mm on 10 m distance (Resolution ½, Quality ¼). The area was taken with one single scan.

Color photography:
Single shot with Canon EOS 5D Mark II (21 megapixel); lens: Canon 17 mm; ISO: 400; focal ratio: F/9; exposure time: 1/13 sec.; measurement mode: evaluative metering. Flash System: no flash system, picture taken at daytime.

IR- photography:
Single shot with Canon EOS 5D Mark II (21 megapixel); lens: Canon 17 mm; ISO: 400; focal ratio: F/9; exposure time: 1/13 sec.; measurement mode: evaluative metering. Flash System: no flash system, picture taken at daytime.

6.3.5 Trial Area 3_12 S

Orientation of sub area: south

Size of documented area: 80 x 130 cm

Material: Limestone from St. Margarethen / Mannersdorf

Fig. 09: General view of Trial Area 3_12 S.

3D-Scanning: Faro Focus X120 (terrestrial laser scanner), resolution 3 mm on 10 m distance (Resolution ½, Quality ¼). The area was taken with one single scan.

Color photography:
Single shot with Canon EOS 5D Mark II (21 megapixel); lens: Canon 19 mm; ISO: 400; focal ratio: F/9; exposure time: 1/25 sec.; measurement mode: evaluative metering. Flash System: no flash system, picture taken at daytime.

IR- photography:
Single shot with Canon EOS 5D Mark II (21 megapixel); lens: Canon 19 mm; ISO: 400; focal ratio: F/9; exposure time: 1/25 sec.; measurement mode: evaluative metering. Flash System: no flash system, picture taken at daytime.

6.3.6 Trial Area 3_13 SW

Orientation of sub area: southwest

Size of documented area: 90 x 170 cm

Material: Limestone from St. Margarethen / Mannersdorf

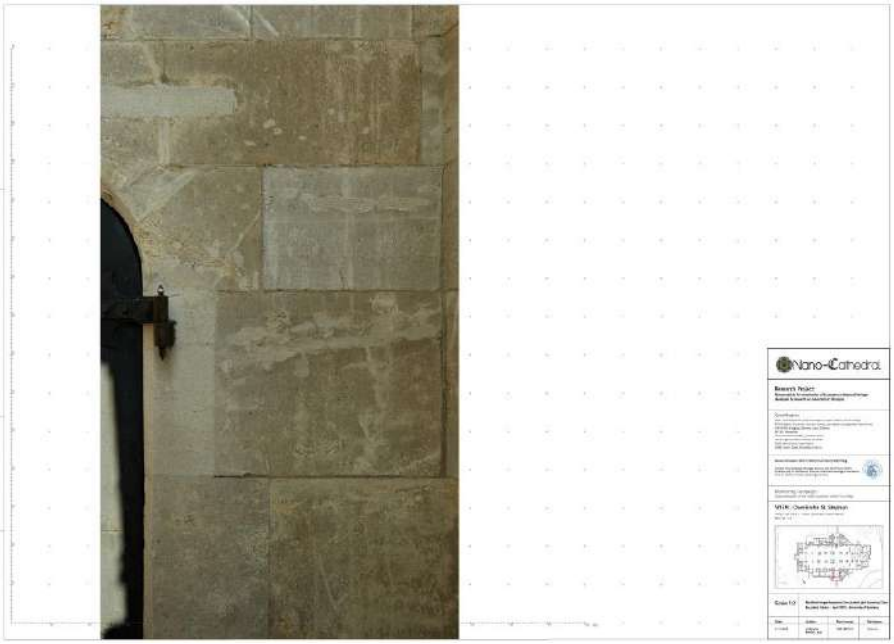


Fig. 10: General view of Trial Area 3_13 SW.

3D-Scanning: Faro Focus X120 (terrestrial laser scanner), resolution 3 mm on 10 m distance (Resolution ½, Quality ¼). The area was taken with one single scan.

Color photography:
Single shot with Canon EOS 5D Mark II (21 megapixel); lens: Canon 20 mm; ISO: 400; focal ratio: F/9; exposure time: 1/160 sec.; measurement mode: evaluative metering. Flash System: no flash system, picture taken at daytime.

IR- photography:
Single shot with Canon EOS 5D Mark II (21 megapixel); lens: Canon 20 mm; ISO: 400; focal ratio: F/9; exposure time: 1/160 sec.; measurement mode: evaluative metering. Flash System: no flash system, picture taken at daytime.

6.3.7 Trial Area 3_14 W

Orientation of sub area: west

Size of documented area: 110 x 170 cm

Material: Limestone from St. Margarethen / Mannersdorf

Fig. 11: General view of Trial Area 3_14 W.

3D-Scanning: Faro Focus X120 (terrestrial laser scanner), resolution 3 mm on 10 m distance (Resolution ½, Quality ¼). The area was taken with one single scan.

Color photography:
Single shot with Canon EOS 5D Mark II (21 megapixel); lens: Canon 17 mm; ISO: 400; focal ratio: F/9; exposure time: 1/160 sec.; measurement mode: evaluative metering. Flash System: no flash system, picture taken at daytime.

IR- photography:
Single shot with Canon EOS 5D Mark II (21 megapixel); lens: Canon 17 mm; ISO: 400; focal ratio: F/9; exposure time: 1/160 sec.; measurement mode: evaluative metering. Flash System: no flash system, picture taken at daytime.

6.4 Trial Area 4

The area is located on the north steeple between the roof of St Barbara's chapel and the cornice under the bell floor at a height ranging from 15 to 27 m and facing east to southeast. It is accessible with a scaffold from the roof of St Barbara´s Chapel. This area is rather sheltered from the wind, which is a rare occasion at Vienna´s cathedral.

Condition of the surfaces: No recent treatments were undertaken. Black crusts, erosion and loss of grain cohesion are visible.

Date, weather and temperature: 22nd April; measuring time around 20:00-24:00; rainy; temperature between 8-10 °C. The documentation was done under a tarp because of rain.

Size of documented area: About 6 m wide, 12 m high, trail area is 100 m x 120 m

Material: A. Limestone from St. Margarethen, B. Limestone from Mannersdorf

Fig. 12: General view of Trial Area 4.

3D-scanning: Structured-Light-Scanner Comet L3D in a resolution of 0.3 mm (800 mm lens). The Area was scanned with 15 single scans.

Color photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/125 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with stereo flash; setup of right flashbulb: soft box 60x100 cm; focal ratio: 5.4; setup of left flashbulb: soft box 60x100 cm; focal ratio: 6.4; taken with single flash impulse.

UV-photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 megapixel); lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/16; exposure time: 11 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 60x100 cm; focal ratio: 8.4; setup of left flashbulb: soft box 60x100 cm; focal ratio: 9.4; taken with single flash impulse.

IR- photography: Single shot taken with Canon EOS 5D Mark II (21 megapixel); lens: Canon 32 mm; ISO: 100; focal ratio: F/11; exposure time: 1/125 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with stereo flash; setup of right flashbulb: soft box 60x100 cm; focal ratio: 5.4; setup of left flashbulb: soft box 60x100 cm; focal ratio: 6.4; taken with single flash impulse.

6. Report Vitoria

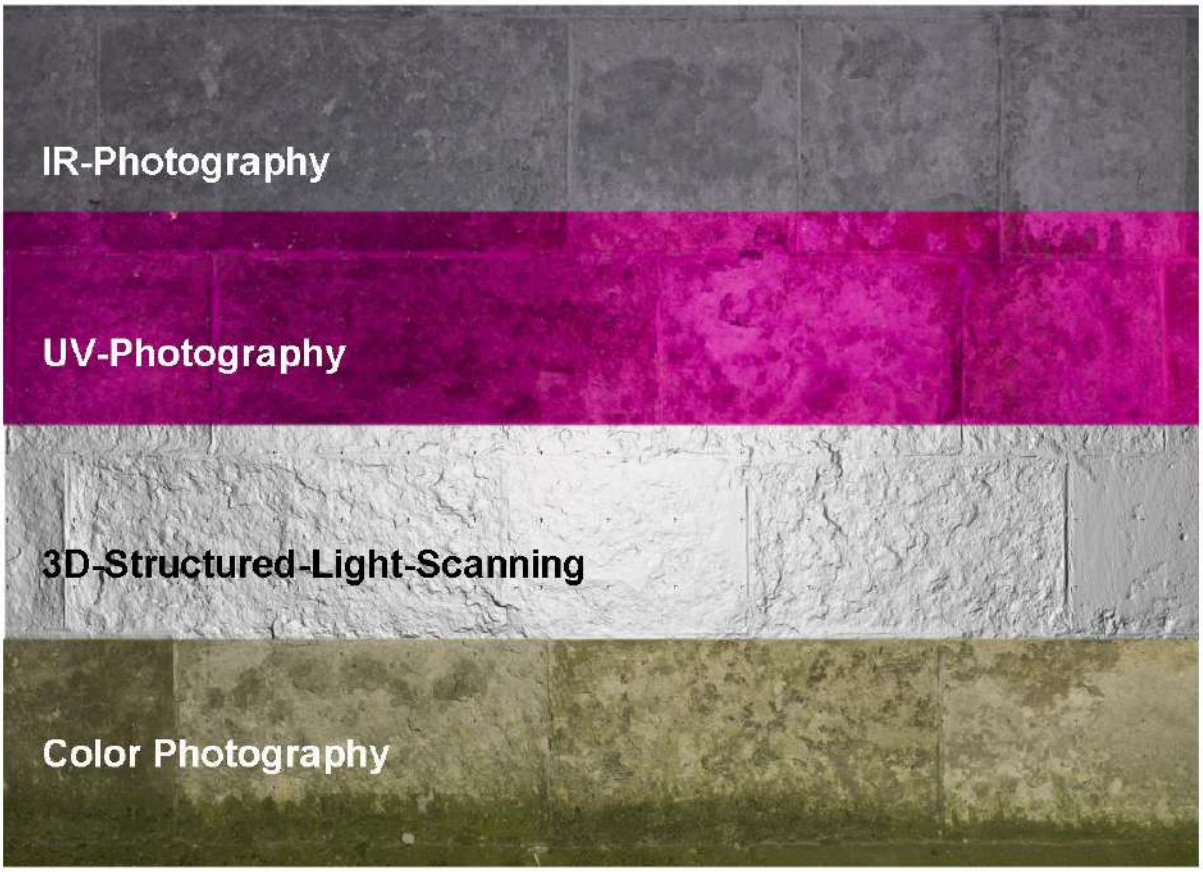
Documentation Report of

Monitoring Campaign I

Documentation of the Initial Condition of the Trail Areas

Catedral Santa María - Vitoria

August 2016



Authors:
Max Rahrig M.A., Anna Luib M.A., David Höpfner, Prof. Dr. Rainer Drewello

Content:

6. Monitoring Campaign I, general aspects

The Monitoring Campaign I at Catedral Santa María in Vitoria took place between 9th August and 10th August. Its aim was to document the condition of the surfaces before their first treatment with nano technology or any preparatory measurements like cleaning.

Two different methods of documentation can be used depending on the accessibility of the trial areas. Areas with good accessibility and enough surrounding space for bulky equipment are photographed in various techniques and in a high resolution quality. Areas at towers or with difficult accessibility were photographed in a low resolution quality requiring less equipment.

In Vitoria, all Trial Areas could be documented in the high resolution version.

6.5 High resolution Version

If possible all areas should be documented in high resolution quality in order to get best detail and analytical information of the surface. Following techniques were used:

- Color photography (with full frame Hasselblad H2D digital camera and Broncolor flash system)
- UV-photography (with full frame Hasselblad H2D digital camera and Broncolor UV-flash system)
- IR-photography (with special Canon EOS 5 Mark II - IR camera and Broncolor flash system)
- Structured-light-scanning (high resolution 3D-Documentation with Steinbichler Comet L3D-Scanner)
- Terrestrial 3D-Scanning of surrounding areas to locate the monitoring areas (Faro Focus X120)

A standard was established to ensure same light conditions (light temperature, brightness) for all trial areas in each different location and for every monitoring campaign. Therefore, all pictures were taken at night with a broncolor grafit A4 flash system, two flashbulbs and soft boxes for smoother light. For color calibration the pictures were taken with a Kodak color chart.
UV pictures require absolute darkness and a blocking out of all surrounding light. Day light would inhibit or overlay UV light. Therefore, special UV-pass filter in front of the flashbulbs were used to generate the UV light.
The flash system as well as the structured-light-scanner (SLS) are bulky and need around 6 m² space in front of the trial area. The space is also necessary to obtain the required working distance between the trial areas and the SLS. Furthermore both instruments are heavy (approximately 25 kg) and are to be transported in big cases. For that reason they can only be used for trial areas with good accessibility.
After taking all pictures, all photos where aligned and straightened out to the 3D-Surface of the SLS making it later possible to overlay all images (Color, UV and IR). In combination with the topography of the surface (3D-Model) this allowed the best possible basis for the comparability of the trial areas.

6.6 Light Version

Areas at towers or with difficult accessibility were documented with less equipment. Following techniques were used:

- Color photography (with full frame Hasselblad H2D digital camera and Broncolor flash system)
- IR-photography (with special Canon EOS 5 Mark II - IR camera and Broncolor flash system)
- Terrestrial 3D-Scanning (with Faro Focus X120)

This documentation is done without a flash system or structured light scanner, thus bearing considerable disadvantages.
Because of the missing flash system the documentation has to be done during day time. Thus the pictures are not calibrated to the same light conditions. The colour of the stone changes depending on the weather (sunshine, rain or cloudy etc.). Also the lighting could change and shadows could affect the pictures. UV-photography is impossible without a flash system.
For alignment and straightening out the pictures the SLS can be used in the high resolution version, documenting the surface in a resolution of 0.3 mm. In the light version, however, the surfaces are documented with the terrestrial laser scanner only with a resolution of about 3 mm/10 m, a considerably lower quality.

7. Trial Areas

7.1 Trial Area TA1

Trial area TA1 is located on the upper part of the bell tower, where the octagon opens on four sides with arches to house the bells. TA1 is located one of the south-facing arches. The belfry of the tower is accessible from the inside of the cathedral, through a stone spiral staircase or elevator. Once situated at the belfry, application is simple and as the selected area is not high.

Condition of the surfaces: Although there is high inter granular porosity with the subsequent sugaring effect, it is a very resistant rock and not alterable, due to the saturated inter granular contact and siliceous cementation. Known locally as asperón (sandstone), it is widely used as millstones and whetstones and in smelting furnaces, which demonstrates its strength.
No recent conservation treatments were done so far.

Date, weather and temperature: 9th August; measuring time around 22:00-24:00; clear sky, dry; temperature between 14-16 °C.

Size of documented area: 90 x 140 cm

Material: Elguea Sandstone

Fig. 01: General view of Trial Area TA1.

3D-scanning: Structured-Light-Scanner Comet L3D in a resolution of 0.3 mm (800mm lens). The area was scanned with 15 single scans.

Color photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 Megapixel); lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/125 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with stereo flash; setup of right flashbulb: Soft box 60x120 cm; focal ratio: 6.4; setup of left flashbulb: soft box 60x120 cm; focal ratio: 7.4; taken with single flash impulse.

UV-photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 Megapixel); lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 32 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 60x120 cm; focal ratio: 6.4; setup of left flashbulb: soft box 60x120 cm; focal ratio: 7.4; taken with multi flash impulse.

IR- photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 Megapixel); lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 16 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with stereo flash; setup of right flashbulb: Soft box 60x120 cm; focal ratio: 9.4; setup of left flashbulb: soft box 60x120 cm; focal ratio: 8.4; taken with single flash impulse.

7.2 Trial Area TA2

Trial area TA2 is located on the upper part of the bell tower. This second area is situated next to TA1 and with the same orientation. The base of the tower is accessed from the inside of the cathedral, through a stone spiral staircase. Once situated at the base of the Trial Area, application is simple and does not require any equipment as the selected area is not high.

Condition of the surfaces: The most important alterations are the fractures affecting the ashlar stones, due to differential forces. On the lower sections, which are in contact with the substratum, there is usually some loss of material as a result of chipping and weathering. Occasionally salts crystallise. This is all due to the high percentage of porosity, which encourages capillarity and the filtration of fluids. In areas exposed to friction, we can see anthropic wear, a result of the rock's low resistance. Nevertheless, we do not observe any intrinsic alteration, only alterations due to the action of external agents. No conservation treatments were done so far.

Date, weather and temperature: 9th August; measuring time around 24:00-01:00; clear sky, dry; temperature between 12-14 °C.

Size of documented area: 80 x 100 cm

Material: Ajarte Lumachelle Limestone

Fig. 01: General view of Trial Area P2.

3D-scanning: Structured-Light-Scanner Comet L3D in a resolution of 0.3 mm (800mm lens). The area was scanned with 22 single scans.

Color photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 Megapixel); lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/125 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with stereo flash; setup of right flashbulb: Soft box 60x120 cm; focal ratio: 6.4; setup of left flashbulb: soft box 60x120 cm; focal ratio: 7.4; taken with single flash impulse.

UV-photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 Megapixel); lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/125 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: soft box 60x120

cm; focal ratio: 6.4; setup of left flashbulb: soft box 60x120 cm; focal ratio: 7.4; taken with multi flash impulse.

IR- photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 Megapixel); lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/125 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with stereo flash; setup of right flashbulb: Soft box 60x120 cm; focal ratio: 9.4; setup of left flashbulb: soft box 60x120 cm; focal ratio: 8.4; taken with single flash impulse.

7.3 Trial Area TA3

Trial Area 3 is located next to the Cathedral Gantry, between the third and fourth south buttresses in the Santa María Square, at street level and with a south-west orientation.

Condition of the surfaces: There are alterations affecting the ashlar stones, due to differential forces. On the lower sections, which are in contact with the substratum, there is usually some loss of material as a result of chipping and weathering. This is all due to the high percentage of porosity, which encourages capillarity and the filtration of fluids. In areas exposed to friction, we can see anthropic wear, a result of the rock's low resistance. Due to the ossuary construction this wall appeared drilled in several points. Two main gaps in the upper part can be observed and a great alveolizated number of ashlars same place. In the middle point of the wall, there are quite a few mechanical damages and losses of matrix. Moreover, the low zone is very wet due to the high porosity of the stones and the capillary humidity. No conservation treatments were done so far.

Date, weather and temperature: 10th August; measuring time around 22:00-24:00; cloudy sky, dry; temperature between 14-16 °C.

Size of documented area: 170 x 110 cm

Material: Ajarte Lumachelle Limestone

-Fig. 01: General view of Trial Area P2.

3D-scanning: Structured-Light-Scanner Comet L3D in a resolution of 0.3 mm (800mm lens). The area was scanned with 27 single scans.

Color photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 Megapixel); lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/125 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with stereo flash; setup of right flashbulb: Soft box 60x120 cm; focal ratio: 5.5; setup of left flashbulb: soft box 60x60 cm; focal ratio: 5.5; taken with single flash impulse.

UV-photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 Megapixel); lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/125 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with two flashbulbs; setup of right flashbulb: Soft box 60x120 cm; focal ratio: 9.0; setup of left flashbulb: soft box 60x60 cm; focal ratio: 9.0; taken with multi flash impulse.

IR- photography: single shot taken with Hasselblad H2 with ixpress CFH digital body (39 Megapixel); lens: Hasselblad HC 50 mm; ISO: 50; focal ratio: F/11; exposure time: 1/125 sec.; measurement mode: center-weighted. Flash System: Broncolor grafit A4 with stereo flash; setup of right flashbulb: Soft box 60x120 cm; focal ratio: 9.0; setup of left flashbulb: soft box 60x60 cm; focal ratio: 9.0; taken with single flash impulse.

7. Table of all Trial Areas

Site	ID	Lithotypes	Dimension	Hight	Orientation	Method	Recent Conservation	Access-ability	Measur-ability	Analyz-ability	Repeat-ability	VALUATION
Gent	TA 1	Balegem, Gobertange	180 x 120 cm	2 m	NW	HighRes	None	3	3	3	3	**12**
	TA 2	Balegem, Gobertange	200 x 120 cm	2 m	SW	HighRes	None	3	3	3	3	**12**
	TA 3	Balegem, Gobertange	195 x 80 cm	2 m	S	HighRes	None	3	3	3	3	**12**
	TA 4	Balegem, Gobertange	140 x 100 cm	2 m	N	HighRes	None	3	3	3	3	**12**
	TA 5	Balegem, Gobertange	Unknown	60 m	N,E,S,W	Skipped	None					
	TA 6_S	Balegem, Gobertange	50 x 160 cm	80 m	S	LowRes	Cleaned	2	2	2	3	**9**
	TA 6_W	Balegem, Gobertange	50 x 150 cm	80 m	W	LowRes	Cleaned	2	2	2	3	**9**
	TA 6_N	Balegem, Gobertange	50 x 160 cm	80 m	N	LowRes	Cleaned	2	2	2	3	**9**
	TA 6_E	Balegem, Gobertange	50 x 160 cm	80 m	E	LowRes	Cleaned	2	2	2	3	**9**
Cologne	TA M1	Tercé Limestone	2,0 m²	3 m	S	Skipped	None					
	TA M2	Schlaitdorf Sandstone	180 x 150 cm	30 m	W	HighRes	None	2	1	1	1	**5**
	TA M3	Obernkirchen Sandstone	2,0 m²	0 m	SW	Skipped	None					
	TA M4 Part I	Obernkirchen Sandstone	60 x 120 cm	20 m	N	HighRes	None	1	2	2	2	**7**
	TA M4 Part II	Obernkirchen Sandstone	50 x 70 cm	20 m	N	HighRes	None	1	1	1	2	**5**
	TA M5	Drachenfelstrachit	200 x 150 cm	1 m	E	HighRes	None	3	3	3	3	**12**

Oslo	TA P1	Carrara Marble (La Facciata)	4,0 m²	0 m	N	Skipped	None					
	TA P2	Carrara Marble (La Facciata)	140 x 150 cm	0 m	N	HighRes	None	3	3	3	3	**12**
	TA P3A	Carrara Marble (La Facciata)	210 x 150 cm	0 m	NE	HighRes	None	3	3	3	3	**12**
	TA P3B	Carrara Marble (La Facciata)	190 x 170 cm	0 m	S	HighRes	None	3	3	3	3	**12**
	TA P6	Carrara Marble (La Facciata)	200 x 170 cm	0 m	SE	HighRes	None	3	3	3	3	**12**
Pisa	TA L1	Apuan/Monte Pisano Marble	850 x 220 mm 570 x 260 mm	12 m	N	HighRes	Restored 1939-40	3	3	2	2	**10**
	TA Q1	Apuan Marble	400 x 430 cm	37 m	N	LowRes	Restored 1939-40	1	2	2	2	**7**
	TA B1	Apuan/Monte Pisano Marble/Breccia Corallina	392 x 200 cm	5 m	S	HighRes	No Documents	3	2	3	3	**11**
	TA B2	Apuan and Monte Pisano Marble/Breccia Corallina	392 x 200 cm	0 m	S	HighRes	No Documents	3	2	3	3	**11**
	TA Q5	Apuan Marble	400 x 430 cm	37 m	S	LowRes	No Documents	1	2	2	2	**7**
	TA Q3	Apuan Marble	400 x 430 cm	37 m	E	LowRes	No Documents	1	2	2	2	**7**
	TA Q7	Apuan Marble	400 x 430 cm	37 m	W	LowRes	No Documents	1	2	2	2	**7**
Vitoria	TA 1	Elguea Sandstones	2,77 m²	0 m	NE	Skipped	None					
	TA 2	Ajarte Lumachelle	2,03 m²	20 m	NE	Skipped	None					
	TA 3	Ajarte Lumachelle	19,37 m²	~ 60 m	SE	Skipped	None					
	TA 4	Elguea Sandstone	2,84m²	3 m	SW	Skipped	Rest. in progress					
	TA 1	Sandstones	90 x 140 cm	~ 60 m	NE	HighRes	None	3	3	3	3	**12**
	TA 2	Limestone	80 x 100 cm	~ 60 m	NE	HighRes	None	3	3	3	3	**12**
	TA 3	Limestone	170 x 110 cm	1 m	SE	HighRes	None	3	3	3	3	**12**

Vienna	TA 1 Part 1	Limestone from St. Margarethen, Au, Bihac	90 x 170 cm	20 m	SW	HighRes	None	2	3	3	3	**11**
	TA 1 Part 2	Limestone from St. Margarethen, Au, Bihac	80 x 160 cm	20 m	SW	HighRes	None	2	3	3	3	**11**
	TA 1 S1	Limestone	90 x 130 cm	20 m	N	LowRes	None	2	1	1	2	**6**
	TA 1 S2	Limestone	90 x 130 cm	20 m	E	LowRes	None	2	1	1	2	**6**
	TA 1 S3	Limestone	90 x 130 cm	20 m	S	LowRes	None	2	1	1	2	**6**
	TA 1 S4	Limestone	90 x 130 cm	20 m	W	LowRes	None	2	1	1	2	**6**
	TA 2	Limestone from St. Margarethen / Au	120 x 200 cm	10 m	SW	LowRes	None	3	2	2	3	**10**
	TA 3 N	Limestone from St. Margarethen / Mannersdorf	80 x 140 cm	90 m	N	LowRes	Restored 2007	1	2	2	3	**8**
	TA 3 NE	Limestone from St. Margarethen / Mannersdorf	90 x 170 cm	90 m	NE	LowRes	Restored 2007	1	2	2	3	**8**
	TA 3 E	Limestone from St. Margarethen / Mannersdorf	80 x 90 cm	90 m	E	LowRes	Restored 2007	1	2	2	3	**8**
	TA 3 SE	Limestone from St. Margarethen / Mannersdorf	80 x 150 cm	90 m	SE	LowRes	Restored 2007	1	2	2	3	**8**
	TA 3 S	Limestone from St. Margarethen / Mannersdorf	80 x 130 cm	90 m	S	LowRes	Restored 2007	1	2	2	3	**8**
	TA 3 SW	Limestone from St. Margarethen / Mannersdorf	90 x 170 cm	90 m	SW	LowRes	Restored 2007	1	2	2	3	**8**
	TA 3 W	Limestone from St. Margarethen / Mannersdorf	110 x 170 cm	90 m	W	LowRes	Restored 2007	1	2	2	3	**8**
	TA 4	Limestone from St. Margarethen / Mannersdorf	100 m x 120 m	15 m	E	HighRes	None	3	2	2	3	**10**

Explanation	3 Points	2 Points	1 Point
Accessibility	On ground level or reachable via permanent scaffolding, broad staircase, etc., no obstacles, no narrow paths.	Above ground level or reachable via non-permanent scaffolding, staircase, etc., few obstacles, few narrow paths.	On high towers, not reachable via any scaffolding, narrow spiral staircase, etc., lots of obstacles, only narrow paths.
Measurability	Enough working space for scanning/photographic equipment, directly in front of object. Rather plain surfaces.	Narrow working space, angled working positions, scaffolding tubes in front of object. Rather deep surfaces.	Narrow + unstable working space, object partly hidden behind tubes, etc. Complex reliefs, ornaments on surfaces.
Analysis	Scanning and photographic information easy to process, analyse and reproduce.	Scanning and photographic information to process, analyse and reproduce with few difficulties.	Scanning and photographic information process able, analysable and reproducible only with great difficulties/not satisfyingly.
Repeatability	No change in working/site conditions for the next 3 years.	Few changes in working/site conditions in the next 3 years, substitutable with ladders, mobile scaffoldings, etc.	Many changes in working/site conditions, not substitutable, trial areas are not reachable any more.

SCORE

0-6	Monitoring difficult, scientific documentation only comparable to a restricted extent.	**FURTHER TESTING RECOMMENDED PARTIALLY**
7; 8; 9	Monitoring complex, documentation difficult but quality sufficient for objectifying assessment.	**FURTHER TESTING RECOMMENDED**
10; 11; 12	Monitoring good, documentation good.	**FURTHER TESTING RECOMMENDED**

8. Conclusion

Most of the trial areas - as shown in the reports – are suitable for monitoring and are significant in the whole scientific process. The disadvantages of several trial areas resulting from difficult accessibility or a too complex mode of analysis have to be kept in mind and be considered for further monitoring campaigns. An objective evaluation and an assessment of the applied materials and implemented methods is possible in case of a comparative analysis of the respectively treated trial areas and their context. On this account there are two more monitoring campaigns envisaged during the project's duration.