STONE MONUMENT ENSEMBLES AND THE CLIMATE CHANGE IMPACT

Project ID: 101098422

MILESTONE 2

COMPLETION OF THE CONDITION ASSESSMENT OF THE REFERENCE SITES

Funded by
the European Union

MILESTONE 2 – COMPLETION OF THE CONDITION ASSESSMENT OF THE REFERENCE SITES

Project acronym:	STECCI
Project full title:	STone monument Ensembles and the Climate Change Impact
Programme:	European Commission, Horizon Europe
Project ID:	101094822
Date:	09/2024
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Reviewer	Stefan Simon, Saida Ibragić

HISTORY OF CHANGES

Version	Issue date
0.0	06/09/2024
0.1.	27/09/2024

Table 1. Revision and approval table

Version	Date of revision	Reviewer's name	Reviewer's comments	Approved
0.0	[16/09/24]	[UNSA, Saida Ibragic]	Exact site names to be added to the Executive Summary. Bioassessment to be elaborated, as part of M2. Numeration of all chapters required.	[UAA] [27/09/2024]

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EXECUTIVE SUMMARY

As part of Work Package 3 of the STECCI Project according to the Grant Agreement (2024), condition assessments were planned and executed on four non-stećci reference sites (Task 3.1). These sites, located outside the stećci region, were selected for their similarities to stećci sites, particularly in terms of the lithotype used and technological details, such as flat carvings and monolithic monuments. These sites represent different climatic environments across Europe, where limestone monuments will likely face challenges due to future climatic changes. The four sites are Hundskirche (Austria), Jewish cemeteries in Kleinbardorf and Unsleben (Germany), Cimetière Saint Jean in Caen (France), and Domvs Romana (Malta).

The condition assessments for these four sites have been completed, revealing initial similarities and differences between them. The preservation state of each site is directly linked to the lithotype used, the specific properties of the stone, the climatic conditions at the site, the age of the monument, and any previous conservation treatments undertaken.

In addition to these preliminary findings, the methodological approach outlined in the project proposal was tested on-site and refined where necessary. These refinements guide the upcoming condition assessments on the stećci sites, which are part of Task 3.3 of the same project. The interdisciplinary team, composed of members from various institutions, was able to collaborate effectively. Minor adjustments were made throughout the process to enhance the workflow.

Thus, the Task 3.1 of the STECCI Project was completed successfully. All four condition assessments were completed on-site, and the detailed results will be integrated with those from Task 3.3 into Deliverable D 3.1 – Condition Assessment Report, scheduled for Month 21 of the project. Additionally, the findings will contribute to Deliverable D 3.2 – Glossary of Decay and Damage Patterns on Artefacts Made of Limestone.

1 INTRODUCTION

As part of Work Package 3 of the STECCI Project, condition assessments were planned and carried out for both stećci sites (Task 3.3) and non-stećci reference sites (Task 3.1). The non-stećci, or reference sites are monuments located outside the stećci regions but feature characteristics that similar those of the stećci sites, such as the use of materials (e.g., limestone) and technological details like flat carvings and the monolithic nature of the monuments. To better understand the specifics of limestone deterioration under different environmental and climatic conditions (crucial for Deliverable 3.2), the reference sites were chosen to represent climatic and environmental situations not covered by the stećci sites. The four selected reference sites were assessed in the spring and summer of 2024, as proposed and planned in the project. This report summarizes the on-site work conducted for these four sites and certifies the achievement of Milestone 2 within the project.

2 CONDITION ASSESSMENTS

Most of the work required for the condition assessments was conducted on-site. Consequently, four trips were made during this period, as summarized in Table 1.

Table 1. The condition assessment trips conducted as part of WP3, Task 3.1

No.	Destination	Date	Partner on-site	Partner Report
1.	"Hundskirche", Paternion, Austria	18th – 19th April 2024	UAA, SPK	UAA, SPK, IMT
2.	"Domvs Romana", Rabat, Malta	15th – 19th May 2024	UAA, SPK, UMAS, UNSA, HM	UAA, UMAS, SPK, UNSA
3.	Jewish Cementry Kleinbardorf and Unsleben, Germany	20th – 21st June 2024	UAA, SPK	UAA, SPK
4.	"Cimetière Saint Jean", Caen, France	29th July – 2nd August 2024	UAA, SPK, IMT	UAA, SPK, IMT

Reference monuments (e.g., individual gravestones in the case of cemeteries) or reference areas (i.e., larger monuments like "Hundskirche" and "Domvs Romana") were selected at the outset of the condition assessments, with the work, tests, and analyses focused on these specific assets. The reference assets or areas were chosen based on their patterns of damage, decay and preservation conditions, rather than their historical or artistic significance.

For the *in-situ* condition assessments, non-destructive methods were employed where possible. These included:

- visual inspection of the monument
- digital mapping of observed damage patterns
- reflectance Transformation Imaging (RTI)
- color and gloss measurements
- superficial water uptake using the "Contact Sponge Method"
- water uptake using the "Karsten Tube"
- material loss through abrasion via the "Brush Method"
- ultrasonic velocity measurements and/or tomography
- bioassessment

Where necessary and permitted by the authorities responsible for the monument, small samples were taken for material analysis and to investigate specific decay and damage patterns. These samples included small stone chips, surface efflorescence from salts, or biofilm where applicable.

The decision regarding the implementation and frequency of each method was made collaboratively by the team and was dependent on the monument's state of preservation and the visible damage and decay. These assessments were documented through graphical mapping (Fig. 1).

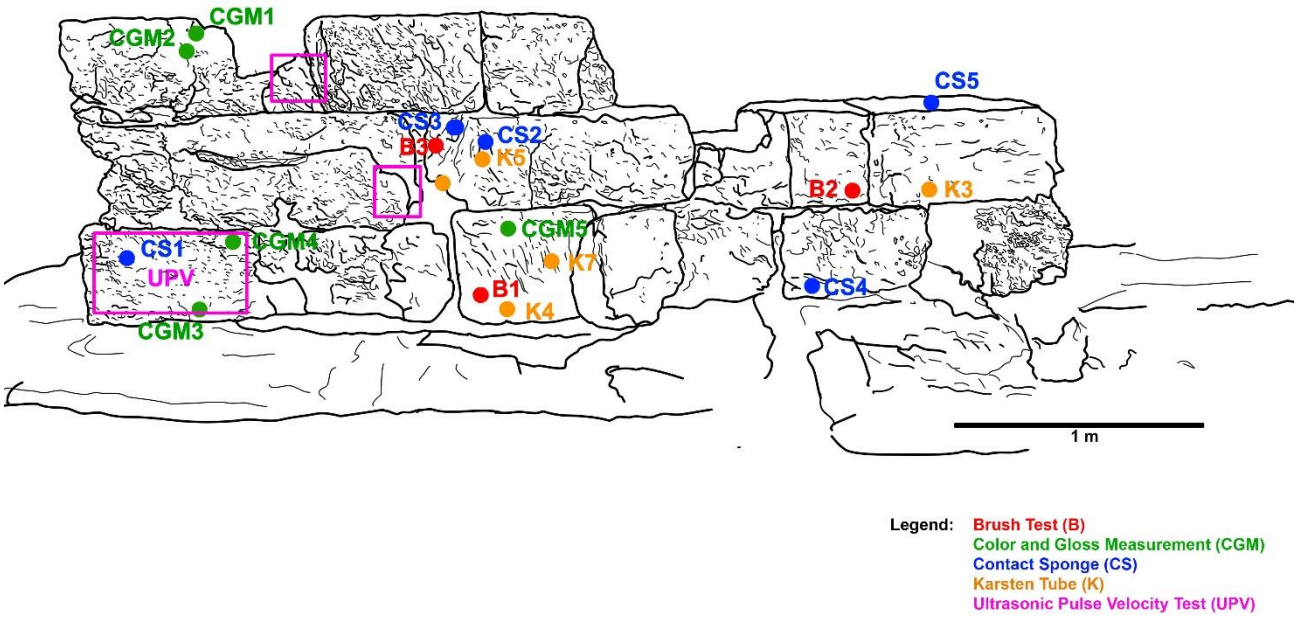

Fig. 1: Mapping of the different *in-situ* tests and Analyses conducted on one of the Reference areas in "*Domvs Romana*", Rabat, Malta

The results of the single condition assessments (reference sites and stećci sites) will be part of the D 3.1 and will contribute to D 3.2. In the following only a short report on the *in-situ* work on the reference sites should be given.

2.1 HUNDSKIRCHE (AT)

A four-member team from WP3 visited the "Hundskirche" in Carinthia on 18th to 19th April 2024, for the first condition assessment of the STECCI Project. The team included Abdelrhman Fahmy (SPK), Katharina Fuchs (UAA), Marija Milchin (UAA), and Farkas Pintér (UAA).

The “Hundskirche” (Fig. 2) is a rock formation near Paternion, Carinthia, Austria, featuring historically significant carvings (Fig. 3) that reflect the spread of early Protestantism in Austria during the 16th century. The monument is connected to the bedrock and composed of compact dolomitic limestone.

The condition assessment involved a visual inspection and various *in-situ* tests, including gloss and color measurements, ultrasonic velocity tests, contact sponge, and Karsten tube tests. RTI photography was also used to capture detailed images of selected carvings, along with brush-off tests. Decay and damage mapping were conducted, along with comprehensive mapping of all tests and analytical methods used. Two samples were collected for further microscopic analysis.

Despite Carinthia's alpine character greeting the team with a 15 cm snow cover, the condition assessment was successfully completed. It quickly became clear that the primary damage risks at this site stem from freeze-thaw cycles, combined with inherent microcracking in the material and significant biological colonization (Fig. 4).

Fig. 2: Overview, “Hundskirche”

Fig. 3: The carvings on the right-hand site of the rock formation

Fig. 4: Some of the lichens present on the surface of “Hundskirche”

2.2 DOMVS ROMANA (MA)

A seven-member team from WP3 visited the so-called "Domvs Romana" in Malta in May 2024 for the second condition assessment within the STECCI Project. The team consisted of Katharina Fuchs, Marija Milchin and Farkas Pintér from the University of Applied Arts Vienna, Siniša Bizjak and Krešimir Bosnić from the Arts Academy in Split, Samir Đug from the University of Sarajevo, and Abdelrhman Fahmy from the Stiftung Preußisches Kulturerbe.

This was the second of four condition assessments planned as part of Task 3.1 of the STECCI project. The site, "Domvs Romana" in Rabat, Malta (Fig. 5), consists of archaeological remains of a rich residential building from the Roman period (built in the 1st century BC) and a later layer from the 11th century AD consisting of Muslim graves; the site was reused as a cemetery during the time of the Fatimid Caliphate. The monuments are made of a highly porous local limestone, most of which are identified as different qualities of Globigerina limestone.

The condition assessment included visual inspection and a range of *in-situ* tests, such as contact sponge and Karsten tube tests, the so-called brush test, gloss and color measurements, ultrasonic velocity, etc. Digital mapping of decay and damage patterns as well as RTI photography (Fig. 8) were used to visually capture the situation. For the bioassessment, which was conducted as part of the condition assessment microbial biofilm samples were collected for lab analyses. Sampling was performed according to the standard guidelines (UNI EN Standard, 2012). The samples were protected from contamination, mechanical damage, and alternation during transportation to storage. Each sample was identified with the sample identification code and stored until analysis.

Contrary to the cold and snowy experience in Carinthia, the assessment in Malta was conducted in fairly warm, sometimes quite hot weather. Despite some minor problems resulting from the heat (with equipment as well as operators), all the necessary work could be completed on site in the planned time frame.

Some initial conclusions were drawn shortly after the on-site work. The proximity to the sea, combined with wind and heat, appear to be the most significant causes of decay, particularly when interacting with the properties of the stone material used.

Fig. 5: Overview, “Domvs Romana”

Fig. 6: Condition assessment at “Domus Romana”, work in progress

Fig. 7: Typical, “honeycomb” decay pattern is the result of the action of wind and salts on (mostly) porous limestones

Fig. 8: The setup for RTI photography

2.3 KLEINBARDORF AND UNSLEBEN (DE)

The third condition assessment in the frame of Task 3.1 was carried out by a five-member team from WP3 at the Jewish cemeteries in Kleinbardorf and Unsleben (Fig.10) in Franconia, Germany, in June 2024. The team consisted of Katharina Fuchs, Marija Milchin, Farkas Pintér from the University of Applied Arts Vienna (UAA), and Stefan Simon and Abdelrhman Fahmy from the Stiftung Preußisches Kulturerbe (SPK).

The cemetery in Kleinbardorf contains of around 3,500 graves and gravestones, some dating back to the 16th century; the last funeral dated to 1938. The cemetery in Unsleben is much smaller and also presents a more compact history of use, with most of the graves originating from the 19th century. The predominant stone used was a local siliceous sandstone, however, a few limestone and marble objects were also identified and used for the detailed condition assessment for the STECCI Project.

The condition assessment included visual inspection and a range of *in-situ* tests, such as contact sponge and Karsten tube tests for water absorption, brush test for surface material loss (Fig. 11), gloss and color measurements, ultrasonic velocity (see Fig. 9), etc. Digital mapping of decay and damage patterns, as well as RTI photography, were used to visually capture the situation on-site.

Fig. 9: The SPK team conducting Ultrasonic measurements at the Jewish cemetery in Kleinbardorf

Fig. 10: The Jewish cemetery in Unsleben, overview

Fig. 11: Implementation of the “Brush test” for the evaluation of the superficial material loss and decohesion

2.4 CAEN (FR)

A five-member team from WP3, including Katharina Fuchs, Marija Milchin, and Farkas Pintér from the University of Applied Arts Vienna (UAA), Abdelrhman Fahmy from the Stiftung Preußisches Kulturerbe (SPK), and Vincent Thiery from the Institut Mines-Telecom (IMT), conducted the final condition assessment for Task 3.1 at the Cimetière Saint Jean in Caen, Normandy, France, at the end of July and the beginning of August 2024.

The Cimetière Saint Jean is a small historical cemetery featuring a few dozen 19th-century graves and crypts, primarily made of porous Caen stone (Fig.12). Now converted into a park in the city center, it has suffered a century of neglect, leading to the poor preservation of most graves. The combination of proximity to the sea, neglect, the high porosity of the stone, and the surrounding natural environment has resulted in decay mechanisms largely driven by salt, wind, and biological colonization.

Fig. 12. The Cimetière Saint Jean, an overview

The assessment focused on two objects - a small crypt and a gravestone - both made of Caen stone. The team carried out visual inspections and various *in-situ* tests, including contact sponge, Karsten tube, brush test, gloss and color measurements, and ultrasonic velocity testing (Fig. 13). Digital mapping and RTI photography were used to document the on-site conditions.

The team also explored the Normandy region (Caen, Arromanches-les-Bains, and Rouen) to gain further insights into the historical use and weathering of Caen stone.

Fig. 13: Farkas Pintér (UAA) and Vincent Thiéry (IMT) conducting ultrasonic measurements on one of the reference monuments

3 CONCLUSION

Milestone 2 has been reached, as the practical work associated with Task 3.1 has been completed. The detailed results and outputs of the condition assessments from both the reference and stećci sites (Tasks 3.1 and 3.3) will be included in Deliverable D 3.1 – Condition Assessment Report, which is scheduled for Month 21 of the project. The findings from these assessments will also contribute to Deliverable D 3.2 – Glossary of Decay and Damage Patterns on Artefacts Made of Limestone, which is planned for Month 23 of the project.

4 REFERENCES

1. STECCI Grant Agreement 101094822 - HORIZON-CL2-2022-HERITAGE-01