Zavod za varstvo kulturne dediščine Slovenije
*Institute for the Protection of Cultural Heritage of Slovenia*

Scuola universitaria professionale della Svizzera italiana
Dipartimento ambiente costruzioni e design
SUPSI

University *of Ljubljana*
Academy *of Fine Arts and Design*

Sveučilište u Zagrebu
Akademija likovnih umjetnosti

# REPORT: INTERNATIONAL 2021 SUMMER SCHOOL GRADIŠČE PRI DIVAČI (SLOVENIA)

2nd to 27th of August 2021

## CHURCH OF ST. HELEN
## CONSERVATION-RESTORATION OF WALL PAINTINGS

## VOLUME 1
## FINAL REPORT


**Organizers of the Summer School:** Alberto Felici, Ajda Mladenović, Anita Kavčič Klančar, Jelka Kuret, Marta Bensa, Minka Osojnik, Andrej Jazbec, Katja Kavkler, Anka Batič.

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**Information on the object:**

| | |
|---|---|
| LOCATION | Gradišče pri Divači |
| OBJECT | Church of Saint Helen |
| REGISTER OF CULTURAL HERITAGE, SLOVENIA | Number 1566 |
| SUBJECT | Wall paintings in the nave: The Passion of Christ, The journey and Adoration of Magi. |
| AUTHOR/DATE | Presumably The workshop of Johannes from Kastav, around 1490 |
| TECHNIQUE/MATERIAL | *Fresco*, *Secco* painting |
| OWNER | Parish of Divača/The Municipality of Divača |
| CONSERVATOR OF THE OBJECT | Minka Osojnik, IPCHS, Regional office Nova Gorica |

**Information on the International Summer School:**

| | |
|---|---|
| INSTITUTIONS | Academy of fine arts and design University of Ljubljana, Slovenia, Department for restoration (ALUO); Academy of fine arts, University of Zagreb, Croatia, Department for Conservation and Restoration of Works of Art (ALU); The University of Applied Sciences and Arts of Southern Switzerland (SUPSI); Institute for the protection of cultural heritage of Slovenia (IPCHS Restoration Center - RC and Regional office Nova Gorica - NG). |
| ORGANIZERS | Alberto Felici (SUPSI), Ajda Mladenović (IPCHS RC), Anita Kavčič Klančar (IPCHS RC), Jelka Kuret (IPCHS RC), Marta Bensa (IPCHS NG), Minka Osojnik (IPCHS NG), Andrej Jazbec (IPCHS RC), Blaž Šeme (ALUO), Katja Kavkler (IPCHS RC), Anka Batič (IPCHS RC). |
| PROFESSORS | Alberto Felici (SUPSI), Neva Poloski (ALU), Suzana Damiani (ALU), Blaž Šeme (ALUO). |
| MENTORS | Marta Bensa, Andrej Jazbec, Anka Batič (all IPCHS). |
| STUDENTS | Katarina Bartolj (ALUO), Eva Marija Fras (ALUO), Marko Odič (ALUO), Luka Ružić Stasiow (ALU), Mischa Hiltensperger (HKB), Lea Bianca Vollenweider (HKB), Melissa Cannizzo (SUPSI), Chiara Milazzo (SUPSI), Cecile Roulin (SUPSI). |
| DURATION | 2 – 27$^{th}$ of August 2021 |

Authors of the report: Professors, mentors and students of the Summer School Gradišče 2021.
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SHORT GUIDE TO FINAL REPORT 2021

The 2021 Summer School was focused on the extensive documentation of the wall paintings.

This report is a compilation of all the work the professors, organizers students and other participants have done in the online part and on site part of the 2021 Summer School. It is divided into two parts: Volume 1 and Annexes. Volume 1 is a report on all the gathered information of the site, the church and most importantly wall paintings. The authors are professors and mentors, all of them conservators-restorers working in the field of conservation-restoration of wall paintings.

Annexes contain documentation of the wall paintings in the church in a form of visual glossary, photodocumentation and mapping, all made by students under the supervision of mentors. Also there is a report on all the investigations made by Research Department of IPCHS, selected photodocumentation, gathered lectures and activities of the 2021 Summer School.

Anka Batič

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# Introduction of the International Summer School

by Anita Klančar Kavčič and Ajda Mladenović, IPCHS Restoration Center

The International Summer School is intended for professional development of students and young professionals in the field of conservation-restoration of wall paintings. The aim of the Summer School is to develop and implement a conservation plan for the preservation of medieval wall paintings in the church of St. Helen in Gradišče pri Divači, Slovenia. Developing a conservation-restoration project for these wall paintings represents an ideal case study for the implementation of a rigorous methodological and interdisciplinary approach in the conservation process, useful both for students and professionals working in the field of decorated architectural surfaces.

The workshop will run for 3 years, from 2021 to 2023. The on site and online program includes preliminary analyses, documentation and development of appropriate methodology, as well as practical conservation-restoration work on the wall paintings in the church of St. Helen. Parallel to the practical project work, numerous lectures will be given by experts from various fields.

The project is organized by:

- Institute for the Protection of Cultural Heritage of Slovenia (IPCHS), Restoration Center and Regional Office Nova Gorica;

- University of Applied Sciences and Arts of Southern Switzerland (SUPSI); Master's programme in Conservation and Restoration;

- University of Ljubljana, Academy of Fine Arts and Design (ALUO), Department for Restoration;

- University of Zagreb, Academy of Fine Arts (ALU), Department for Conservation and Restoration of Works of Art.

The Summer School is intended for students coming from University of Ljubljana, University of Zagreb, Conservation-restoration master's programme of SUPSI and associated school of the Swiss Conservation-Restoration Campus, as well as selected young professionals from the Institute for the Protection of Cultural Heritage of Slovenia (IPCHS). We want to offer participants a stimulating international environment in which they can develop theoretical knowledge, methodological discussions, and practical skills and participate in conservation-restoration of wall paintings.

The activities will be developed gradually over all three years. The students will change each year, but the organizers will remain the same. Some of the activities and interventions that will not be carried out within the workshop due to its short duration will be carried out by IPCHS Restoration Center in the following years.

In addition to the professional significance of the workshop, its broader socio-cultural aspect is also important. With the organization of this project, the church of St. Helen in Gradišče became a meeting point of cultural, professional, international and friendship connections. The word “connection” has an important meaning in the implementation of this multi-annual project. It stands for connection and collaboration between different institutions and the local community, different skills and expertise, cultural and natural heritage, youth and experience, and last but not least between different European languages and cultures (Slovenian, Italian, German, French, Croatian, etc.). Thus, the workshop is a great example of coexistence within our common European space and culture. The organization of the International Summer School is a great contribution to the Slovenian cultural heritage, to the church itself and to the wall paintings in it.

# Summer School Activities

by Blaž Šeme, UL ALUO Professor

The 2021 Summer school, first of the three planned Summer schools on the topic of preservation and conservation-restoration of medieval wall paintings in the church of Saint Helen in Gradišče pri Divača in the years 2021 - 2023, included four weeks of intensive activities in August 2021. Participating students from Swiss, Croatian, and Slovenian conservation-restoration schools learned about the topic and successfully performed all the main measures and procedures necessary for implementation of a comprehensive conservation-restoration plan for the preservation of the internal wall paintings.

Extensive activities on the Summer school project actually begun several months earlier. The initiative for the international Summer school was given by the conservator-restorer and SUPSI lecturer Alberto Felici already in 2019. The actual agreement on the start of the project was reached at the meeting of IPCHS RC, SUPSI and UL ALUO representatives on the workshop "The retouching of wall paintings; Methodological approaches, techniques and materials", which he led in September 2020 in Ljubljana. A broader organizational team was formed, which also included partners from the IPCHS Regional Office Nova Gorica, ALU University of Zagreb and HKB Bern. In the following months, under the leadership of conservator-restorer Ajda Mladenović, we outlined the implementation of the project, assigned tasks, took care of financial management, selected students and invited various experts to participate with online lectures and on site. Good communication with the church trustee, locals and other stakeholders also needed to be established. We collected the existing documentation on the church and the paintings. On site we checked the condition of the paintings, put data loggers to measure relative humidity and temperature (8 months earlier), took a good photo documentation and performed some preliminary tests. Some students learned the basics of AutoCad through online instructions. We made a detailed work program, provided the necessary materials, tools and instruments for documentation, testing, interventions and treatments, and took care of scaffolding and electricity in the church. An important part of the project was also the organization of travel and accommodation for students and other participants. We also organized activities outside the church, such as lectures and meetings in the conference room in nearby Matavun, a tour of the neighbouring painted churches, excursions to the cultural and natural sights of the area and informing the public about the event.

In the first, preparatory week, which took place online (2-6 August 2021), all project partners were introduced. It was followed by presentation of the site and history of the church, wall painting monuments of the Karst region and Slovenia as a whole (Marta Bensa, Minka Osojnik, IPCHS) and techniques and materials of Slovenian wall paintings (Martina Kikelj, IPCHS).

The second part of lectures addressed more technical and methodological aspects:

preparation of a basic line graphic documentation for future mapping using AutoCad (Anka Batič, IPCHS), lectures on the methodological and interdisciplinary approach for the conservation of wall paintings (Alberto Felici, SUPSI), data collection and data management (Alberto Felici, Giulia Russo, Stefania Luppichini, SUPSI), making of visual glossary (Giulia Russo, SUPSI), scientific research for the study of wall paintings (Francesca Piqué, Patrizia Moretti, SUPSI), environmental monitoring and conditions of the church (Katja Kavkler, IPCHS).

The second and third week (9-20 August 2021) the Summer school work took place on site. The head of the on site work was Alberto Felici, the main help in organizing the site were the conservators-restorers of IPCHS: Anka Batič, Marta Bensa, Andrej Jazbec and Anita Kavčič Klančar. Neva Pološki (ALU) presented a case study: Medieval Wall Paintings in the Church of Saint Mary of Pond in Gologorica; researches and treatments (Neva Pološki, ALU). The practical work on the wall paintings in the church of Gradišče included: observation, description and mapping of the painting materials and techniques, former interventions and decay phenomena (drawings and creation of a visual glossary). Knocking tests (lack of adhesion assessment), sponge tests (water absorption assessment) and swab tests (cohesion assessment) were performed. Additional optical investigation techniques were used: UV light, Dino-Lite, ranking light, which also formed part of the extensive photographic documentation. In addition, sampling and non-invasive instrumental investigations were performed (portal XRF and Raman, IR thermography). Finally, we made cleaning and consolidation trials with different materials. In parallel with wall painting investigations and documentation in the church, a second team of students compiled a visual glossary and mapping of the phenomena in AutoCad outside the church. The results of all these activities are presented in more detail in the report below. During the week, excursions to the neighboring painted churches (Famlje, Vremski Britof, Dolenja vas) and natural and cultural sights of the surroundings (Škocjan Caves, Postojna Cave, Lipica, Hrastovlje, Piran) were organized for relax and entertainment.

Last day on site (8 August 2021) we presented the results of the Summer school to the local community, representatives of the Ministry of Culture of Slovenia and interested public in the conference room in Motovun and in the church of Saint Helen in Gradišče. In the fourth week, the results of the analysis and further steps were discussed online. The focus was on the final report "Condition assessment of the wall paintings and proposal for a conservation treatment" and complete documentation on the activities carried out.

*Photo 1: Participants of the 2021 Summer School.*

# Historical information of the site and of the wall paintings

by Minka Osojnik, IPCHS Nova Gorica

Gradišče is a small settlement located in the Municipality of Divača (with 4213 inhabitants) in the Littoral region of Slovenia, near the Italian border. The seat of the municipality is the town of Divača while it's most important site is undoubtedly the Škocjan Caves - one of the cave systems in Slovenia, together with the Postojna cave also the most famous. Due to its exceptional significance the Škocjan Caves was entered on UNESCO's list of natural and cultural world heritage sites in 1986, the Regional Park was established in 1996.

With 9 houses and only 16 inhabitants Gradišče is one of the smallest settlements in the region. Although the density of inhabitants may be small, the richness of immovable cultural heritage in the village is quite the opposite, for Gradišče has as many as 4 units of immovable heritage that are listed in the Register of Slovene Cultural Heritage. Those units include the Church of Saint Hellen, the homestead Gradišče no. 8, the settlement itself and an archeological site. The name »Gradišče« actually refers to a prehistorical hillfort. Part of the archeological site is presumed to be a medieval fort located in the northeastern part of the site, which could be related to the construction of the church of St. Helen – the question whether the church is built on the site of the former chapel of a castle remains unanswered for now.

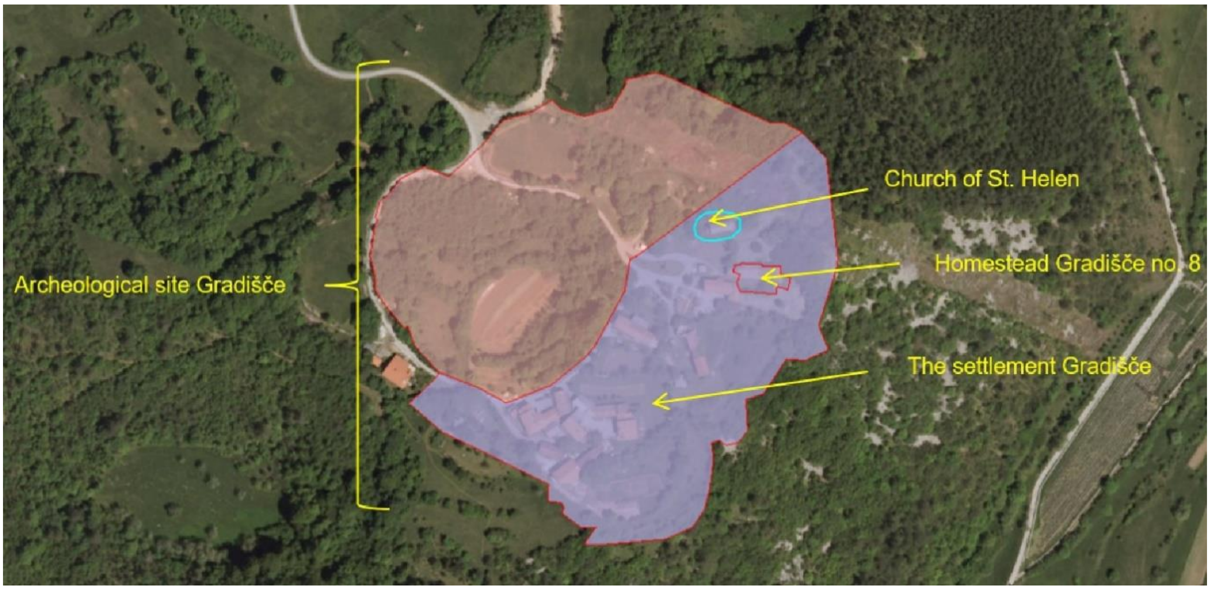


*Photo 1: Gradišče pri Divači – Map of the units of immovable heritage that are listed in the Register of Slovene Cultural Heritage (source: https://www.gov.si/teme/register-kulturne-dediscine/).*

The church of St. Helen is a filial church in the parish of Divača. The absence of regular religious ceremonies in the past few years and the increasing interest of tourist to visit the place brought to light the idea of passing the management of the building from the Parish to the Municipality of Divača. The treaty was signed in December 2021 as the first example of that kind in Slovenia.

The church is a composite historical architecture with a rectangular nave and a presbytery with a termination forming three sides of a regular octagon, both covered with an uniform slated roof, with a bell-cote in the façade and a vestibule before it. The building is 14,63 m long and 5,54 m wide and is oriented towards east. At the junction with the nave the presbytery starts with the same width as the nave, towards east it slightly narrows down.

*Photo 2: The exterior of the Church of Saint Helen in Gradišče (by: Minka Osojnik).*

At its core, the church of St. Helen is an example of early gothic architecture. Based on its preserved architectural tissue and various methods of building, different authors date the nave of the church in the early or the late 14th century, or maybe even in the beginning of the 15th century. By method of building we mean the so called ashlar masonry, where all the stones are cut and worked, so they have the same shape, size and surface texture. When building a wall, the ashlar blocks are laid in horizontal courses, or layers. The stones usually have smooth, parallel faces, and they fit together tightly with very little mortar. This kind of masonry we see on the nave of the church of St. Helen on the south and the north wall and it is the typical for early gothic period. In that period the church of St. Helen was smaller and so was its presbytery which was probably also narrower than the nave. Nevertheless the georadar investigations carried out in the year 2003 didn‘t show any further information about foundations of any older structures. The interior of the early gothic church, which had a rather long but not very tall nave with 3 small windows in the south wall, was probably decorated with frescoes as well for fragments can be seen in two cases on the south wall of the nave.

*Photo 3: The ashlar masonry on the north wall of the Church of Saint Helen (by: Minka Osojnik).*

The wall paintings that we see today were executed around 1490 while the church still had its early gothic dimensions.

*Photo 4 and 5: The interior of the Church of Saint Helen (by: Marta Bensa).*

In the middle of the 16th century, a new wider and taller late Gothic presbytery was added, and thus, accordingly, the walls of the nave had to be elevated as well. The new triumphal arch was wider as the previous one – its extension ruined most of the frescoes on the east wall, where quite certainly the Annunciation was depicted. From the 16th and the 17th centuries there are a several interesting graffiti in the frescoes as well.

As the inscription “1653” on the front portal documents and witnesses, a last major renewal and upgrade occurred in the middle of the 17th century. This was the period when the

Catholic Church renovation in the region was in full swing – the attacks of the Turkish Empire were over, so was the black plague, and after a short period of reformation, the restoration of Catholicism brought a series of bigger and smaller interventions and renovations in the churches of the region.

It was in that time that the church of St. Helen acquired the appearance it has preserved more or less unaltered to the present day. New rectangular windows were built in, so was the new portal with the year 1653 and the inicial A.C. inscribed on it. The presbytery was given a new ribbed vault, the one-story bell-cote was built on the main facade and the porch supported by two pillars in front of it. The porch probably had a slated roof like the one we still see in front of the church in near-by Dolnje Ležeče.

On the basis of stylistic comparisons and archival documentation these works were attributed by Božidar Premrl – a quite famous researcher of cultural heritage of the region – to the master mason Gašper Perhavec from Dolnje Ležeče and the Cerkvenik brothers, Andrej and Ivan, who were the masons and stone cutters from Gradišče. (An interesting fact that there are no stonemason‘s marks on the building maybe suggests that the church was built by local Stonemasons from the very beginning.)

The church‘s land registers offer some data about the furnishing and the renovations in the 18th century and later. The new altar was raised in 1744 (commissioned by Frančišek Ksaver of the noble Garzarolli family, the vicar of Vreme, whose initials are on the altar), in 1753 the new stone pavement was laid, the slated roof renovated, the church got a new painted wooden ceiling.

**The wall paintings**

The nave is richly decorated with wall paintings which were discovered in the 1950s and uncovered and restored in 1966-67. Although the author of the wall paintings is unknown, similarities in style and iconography of other wall paintings found in the Holly Trinity Church in Hrastovlje, dated to 1490, allow us to make an undoubtable connection with the painter Johannes from Kastav (Janez iz Kastva). In fact at least one textile pattern connects the two workshops while the depiction of the Virgin Mary in the Adoration of the Magi is almost a copy of the painting in Hrastovlje. Most probably the church in Gradišče was painted by one of Janez’s assistants or associates with whom he might have already worked in Hrastovlje.

The iconographic composition is conventional for a smaller medieval church. On the triumphal arch one could once admire the *Annunciation*, which is not preserved (only in two small fragments).

On the nave’s south wall there are scenes from the *Passion of Christ* arranged chronologically in two horizontal strips. The story starts on the right side of the upper part with the Arrest of Christ (mostly ruined), Christ before Pilate (mostly ruined), Flagellation (mostly ruined), Crowning with Thorns, Carrying of the Cross (fragment), Jesus is nailed to the cross (partly destroyed), Crucifixion,  then on the far left shifts to the lower strip and continues to the right with Descent from the Cross, The Entombment (fragment), Christ in

Limbo (damaged), Resurrection, Three Marys at the empty Tomb, *Noli Me Tangere*, The Ascension. In the Passion of Gradišče there are three more scenes than in the Passion of Hrastovlje (Jesus nailed to the Cross, Descent from the Cross, Three Marys at the empty Tomb).

*Orthophoto 6: Frescoes on the south wall of the nave depictig The Passion of Christ (by: Gašper Rutar).*

On the west wall most of the frescoes are ruined, as a consequence of the later built-in portal. On the far right we see Jesus rides into the city of Jerusalem on a donkey, while on the far left only fragments of the Last supper are preserved.

*Orthophoto 7: Frescoes on the west wall of the nave depictig Jesus rides into the city of Jerusalem (by: Gašper Rutar).*

On the nave's north wall the *Adoration of the Magi* is depicted, supplemented by scenes of people's daily lives of the period as well as some animal anecdotal motives, such as Ezop's fable about the fox and a stork and a pelican feeding his offspring with his own blood. In the upper part of the painting there are actually two complementary scenes put together: the Journey and the Adoration. The Journey of the Magi starts with the reduced image of the city of Jerusalem on the far left and one of the Magi shaking the hand of Herod. The other scene is partly destroyed because of the later built window – only the Virgin Mary with baby Jesus are preserved, while the three magi from the Adoration are not. The painter paid special attention in depicting nobility dressed in their expensive precious garments and purebred horses. Especially this wall represents a treasure chest for variety of scientists from art historians, historians, sociologist, ornithologists, etc. Such an example is the scene of the hunt of the bird called the Northern Bald Ibis (KLAVŽAR, Geronticus eremita) which was several times depicted by medieval painters (also in Hrastovlje), and lived in Istria and in Dalmatia as quite an ordinary bird, till it‘s extinction in Europe probably by the end of the 17th century. The cause for the extinction was hunting, mostly by nobility. After almost 400 years in 2006 three birds were spotted on the meadows near Postojna (20 minute drive from Gradišče) and also it was spotted in Ilirska Bistrica in the year 2021.

*Orthophoto 8: Frescoes on the north wall of the nave depictig Adoration of the Magi (By: Gašper Rutar).*

An important role in the development of medieval Istrian painting was played by the frescoes in the Parish church of St. Nicholas in Pazin where the presbytery was painted around 1470 by an anonymous painter, a trained master who was a part of the Jacob Sunter circle, also known as Austrian Master Leonardo from Brixen. The Pazin painter influenced local painters like Vincent from Kastav and Janez from Kastav.

The frescoes in Gradišče are caught in between the influences of the vernacular art of inner part of Croatian Istria and the influences of the Italian renaissance coming from the coastal towns which were under the Venetian Republic.

**The renovation of the church**

The renovation of the roof's stone tiles was concluded in 2005. Since 2017 the static load of the church has been constantly and systemically monitored. In August 2018, the roof was reconditioned through the installation of a steel reinforcing mesh and bars, while in 2019 windows with a UV protection foil were installed. The complete restoration of the church's exterior was concluded in 2021.

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# Technique of the wall paintings

By Alberto Felici, Supsi

Scientific investigations and visual inspections indicate that the entire painting cycle was carried out on large portions of plaster (pontate) using a mixed technique that could be defined as "a *mezzo fresco*", which involves an initial application of buon fresco with extensive whitewash and secco finishes, using materials and technical procedures characteristic of this period and geographical area. Through observations with raking light and direct light, with the aid of UV light and a digital portable microscope, it was possible to gather a great deal of information, useful for formulating a reasonable hypothesis on the painting procedures used by the painter.

The masonry is made of a limestone, probably of local origin. It is about 80 centimetres thick. It is made up of regular and squared blocks of small dimensions that are visible from outside, in fact all the internal walls, with the exception of a band near the roof, are entirely covered by the pictorial decorations.

There are several layers of plaster, a rinzaffo to regularise the masonry, the preparatory arriccio and the intonaco. The arriccio has a variable thickness of around 1 and a half centimetres and is greyish in colour with rather coarse aggregates. The second plaster is thinner, around half a centimetre, lighter in colour, apparently richer in binder and with finer aggregates. The surface of the latter is fairly smooth, but in some places traces of the trowel with which it was applied are visible.

The plaster was applied from relatively large pontate with square and regular shapes. The overlap indicates that the plaster was applied from right to left, from top to bottom. It was first applied on the west wall. One can see how there is a difference between the different plasters between one *pontata* and another; even the way they were laid is different and visible.

On the north wall, *intonaco* was first applied on the right, where we can see one King and the Virgin Mary with Child. Then the left-hand part of the scene was applied, bearing cavalry and other two Kings. Finally, the lower part of the wall was painted with a band of smaller figures representing hunting, a wild man fighting a bear and a scene from a fable about a fox and a stork. On the south wall there are scenes from the Passion of Christ in two bands. First the upper band with the scenes was applied, then the lower band.

The preparatory drawings were used to outline the main contours and were done with red or yellow ochre applied with a pointed brush.

The snapping cord was used to draw the shape of the frames. The imprint of the cord is visible where it was used when the plaster was still fresh. Somewhere the snapped cord was used with a pigment so that traces or small colored drops of pigment are visible.

Direct incisions are also visible. The rough, sharp edge seems to indicate that the incisions were made directly on the plaster. While the outlines of the characters were drawn with a sharp instrument, the circularity of the halos could be achieved with a compass: one can still sometimes distinguish in the plaster the axis of rotation around which the compass turned. Direct incisions are mostly used for halos and crowns.

The *punzonatura* technique - pressing the tools into fresh mortar - also indicates work when the plaster was still fresh. The details of crowns, halos and horse straps were executed by punching. This technique is mainly used to imprint different shapes on jewellery, decorations and clothing. The most representative example is found on the crown of the Virgin Mary on the north wall.

The painting procedure involves an initial draft of colour that is not very well finished, with quick, essential, light, watery layers. These represent a first base on which the painter then applies thicker, denser, more complete and more detailed layers of paint. In the flesh tones and some of the drapery, this layer has a more complex composition. It is in fact composed of a ground with a consistent thickness, almost a preparation, made of lime white enriched with an organic additive. On this preparation, the anatomical and decorative details are executed with small, precise brushstrokes. This painting technique, known as "a *mezzo fresco*" or " lime white", was used to fix the colours by exploiting the carbonation of the lime in this preparation. The large size of the *pontata*, in fact, made it impossible to paint on plaster that was still fresh. This may be to extend the drying time of the paint, as it is about details. It is certainly also to determine the overall tone of the hue. Finally, the painting was completed with the final dry finish, a hypothesis that the fluorescence induced by UV light could confirm. Observation with UV light showed the presence of particular fluorescence in the details of the frames and in some elements of the painted architecture, the interpretation of which is still doubtful. This is probably due to a combination of an organic binder and a pigment that has not yet been precisely characterised. According to the investigations carried out so far, all pigments are compatible with the "*buon fresco*" technique, with the exception of some traces of lead white, which are thought to be the residues of dry finishes that have been lost.

Some ornamental motifs are made with the use of a template, according to the technique defined as stencil. The same motif can be seen repeated in the dress of one of the magi on the north wall.

In some places, *pentimenti* indicate that the artist has corrected the painting himself. For example, on the south wall, one can see a purple drape superimposed on the background colour.

No traces of metal foil were found.

## State of conservation

By Marta Bensa, IPCHS Nova Gorica

The Institute of Cultural heritage of Slovenia made a report after the inspection of the wall and wall paintings in the church st. Helen in Gradišče pri Divača in 2001. The results in the report were as follows: "The church is in very bad condition. The roof is worn, so there are water leaks. The constant presence of humidity in the walls and on the interior surfaces is evidenced by the extensive habitats of algae, which developed mainly in the northwestern upper corner of the nave. In addition to algae, mold also appears on the surface. Due to condensation of humidity, the binder of mortars and wall paintings has already deteriorated in some places. In other places, the plaster detaches from the support, most likely due to the transport of water-soluble salts. These phenomena cause great damage, especially to valuable wall paintings, so further deterioration must be prevented by rehabilitating the roof and the stormwater drainage system, including drainage, which must be installed immediately". In October 2001, the contractor started the repair works on the roof covered with slate, namely: the completely slate roof was dismantled. Waterproofing was carried out, a reinforcing mesh was laid on it, and everything was protected with a layer of cement mortar. All gutters and drain pipes were restored. All meteor sewers, including sandpits and the inspection shaft, have been arranged. An air kinet was made along the north wall of the building. The following year, however, the stone roofing was re-installed on the church roof. Inside, above the mural paintings, a damp and weathered plaster was removed.

Nowadays the wall paintings, on first visual inspection, show a lot of signs of decay or deterioration phenomena due to a lot of humidity present in the past. The main causes of deterioration are: condensation, rising damp, especially in the lower part of buildings resulting from the capillary rise of groundwater, soluble salts, infiltration, freeze–thaw cycles. The binder of mortars and of wall paintings has already deteriorated in some places. On the wall paintings in different places, the plaster detaches from the support, most likely due to the transport of water-soluble salts.

The other deterioration phenomena are: a previous biological growth, little amount of flaking, some longitudinal cracks/fissures especially on the north wall, chalking as well as loss of cohesion and the generation of very fine particles, lacunae with some missing part of the surface cavity or hollow space. In some little places there is a white veil, a whitish haze forming over an architectural surface. We can see also a darkening especially in the upper area of the North wall, that can be the result of a transformation of an organic binder used maybe in a past restoration. Minor hairline cracks are visible on the surface. Some areas of detached parts between painted plaster and support are visible especially in the lower part of the north wall, near the entrance. There is also a lot of abrasion of the painted surface. In the lower part of the cycle, especially in the middle part, there are some places where previous injections with a kind of injection mortar are visible. Here we can see some small holes that were made to inject the mortar. The major damages of the cycle, especially in the upper part of the north wall, is in the areas near the windows and in the south and west walls, that have been already filled and plastered during previous restoration interventions.

## Previous interventions

By Marta Bensa, IPCHS Nova Gorica

The most important available documentations about previous restoration interventions implement between the years 1955 and 1979. In these years the frescoes are discovered, and a uncovering campaign begins. In the journal of Monument Protection (Varstvo spomenikov), n. VI of 1955-57, Ljubljana, at p. 73, about the Church of St. Helen in Gradišče pri Divači, the art historian M. Zadnikar wrote this: “Under the plaster (lime plaster applied in the past) on the north inner wall of the nave is painted the March of the Magi, on the south wall the Passion scene, and the west wall is also painted. The paintings can undoubtedly be attributed to the circle of the painter Janez from Kastua, the period towards the end of the 15th century. There are no traces of paintings in the later vaulted presbytery. Since it is a valuable addition and an almost completely preserved scene of the tribute, it would be advisable to uncover the paintings to the end and to completely reconstruct the interior by opening the former Gothic windows and lowering the ceiling to the original Gothic height”.

In the manuscript of Restoration Diary of the Institute of cultural heritage of regional office of Nova Gorica, n. 12, p. 75-78, in the august 1966, it is written this: “The frescoes, discovered as early as 1965 (by the restorer France Kokalj) and further discovered in August 1966, covered all the walls of the nave. Today, part of these frescoes have been destroyed because windows have been opened in the North and South walls, furthermore by the construction of a new presbytery and the heavy infiltration of water in the west wall, to the right of the door.” In the Report of the state of conservation of the frescoes in Gradišče pri Divača, Franc Kokalj, Ljubljana, august 22, 1966, wrote the following: “In accordance with the Institute's annual plan, we also discovered the north wall of the nave in Gradišče near Divača. We also partially uncovered the south wall, but not completely, only to the extent that we could see what the frescoes on the south wall represent. Among other things, we also excavated a Gothic painted window on the south wall, which is very poorly preserved, and it is imperative that the frescoes in the window niche are preserved soon. The March of the Three Kings is almost entirely preserved, with the exception of Herod's head and some details in the lower part of the fresco. The entrance wall is poorly preserved, there is almost no fresco on the south side of the door, and on the north side is part of the scene of Jesus riding to the Temple. The paint layer is in very good condition, and only minor conservation intervention would be required to preserve the entire composition. The roof is leaking slightly in some places, and would be repaired by a new pastor.” In the journal of Monument Protection (VS, n. X), Ivan Komelj, 1966, p. 42 and p. 222 wrote: “Gradišče pri Divači, discovery and consolidation of the wall paintings in the nave. The ZVKDS Nova Gorica has extensively documented the frescoes (c. 15th century) from the circle of Vincent of Kastav. Frescoes were discovered on the north and south wall.” The same year, in the journal of Monument Protection (VS, n. XI), Franc Kokalj, 1966, p. 144 wrote: “The walls are very well preserved, disturbed only by baroque windows; shepherds and servants with domestic animals are lined up below the march. The Passion on the south wall is badly preserved, some panels almost completely destroyed. We also opened a painted Gothic window. The frescoes await their final restoration and presentation.” In the Journal of Monument Protection

(VS, n. XII), 1967, p. 116, the report says the following : "The rigth wall was finally discovered, but some scenes are only still in fragments. We also discovered side gothic windows. The scenes continue into the window niches. The upper scenes between the windows are almost completely destroyed, probably since the enlargement of the church. The rough plaster was already worn out due to the weak binder, and we removed it where there were no frescoes, we partially consolidated it where there are still, and we will finally finish it next year." The last report dates back 1979, when Franc Kokalj in the Journal of the Monument Protection (VS, n. XXII), 1979, p. 352 wrote this: "On 1976, experts from the restoration center consolidated the detached medieval frescoes. After the consolidation works on the frescoes, new windows should be made, a crumbling shed restored, and a slate roof repaired. There was no money anywhere for these works."

**Sources and literature**

Marijan ZADNIKAR, Gradišče pri divači, p. c. sv. Helene, Varstvo Spomenikov VI, Ljubljana 1955-57, str. 73.

Franc KOKALJ, Gradišče pri divači, p. c. sv. Helene, Restavratorski dnevnik, ZVKDS Nova Gorica, rokopis št. 12, Kras, avgust 1966, str. 75-78.

Franc KOKALJ,  Poročilo o odkrivanju fresk v Gradišču pri Divači, tiskopis, Ljubljana 22.8.1966.

Ivan KOMELJ, Gradišče pri Divači, p. c., odkrivanje in utrjevanje stenskih slik v ladji, Varstvo Spomenikov X, Ljubljana 1966, str. 42, 222.

Ivan KOMELJ, Dvajset let odkrivanja srednjeveških stenskih slik, Varstvo spomenikov XI, Ljubljana 1966, str. 39-76.

Franc KOKALJ, Gradišče pri Divači, Varstvo Spomenikov XI, Ljubljana 1966, str. 144.

Franc KOKALJ, Gradišče pri Divači Varstvo Spomenikov XXII, Ljubljana 1979, str. 352.

# Investigation and documenting

By Marta Bensa, Alberto Felici and Anka Batič

## Previous investigations

Between 2003-2005 a lot of investigations was carried out in the church of st. Helen in Gradišče, in view of a restoration project that never took place. Executed non-invasive analyses: georadar, architectural images, thermovision microclimatic monitoring (sept. 2004 – mar. 2005), algae type. Executed invasive analyses: optical microscopy (stratigraphy) on extracted samples (total samples 23, not all analysed) - FTIR on 9 samples – SEM/EDS (mapping, point analysis).

The georadar established that the church is located on a karstic limestone base, which was leveled with a backfill before construction. The shallow, uneven geological base is nicely visible on all the radar profiles inside the church. Below this geomorphological boundary, which is located at a depth of about 0.5 to 0.8 m, we get reflections from the horizontal layers which actually mean reflections from the limestone layer. Above this limit, however, we see bar reflections from the horizontal layers resulting from the levelling backfill. It is clear that the uneven karstic limestone base with smaller depressions was leveled by backfilling.

The microclimatic monitoring which was carried out from September 2004 to March 2005 shows that the relative humidity is most of the time above 50 % (second line from below), half of the time above 70 %, reaching up to 100 %. Surprisingly the inner wall temperature was always higher than the air inside the church – no condensation took place. Is this due to specific thermal properties of the walls, which could be changed by injecting consolidant?

In 2003 thermography was carried out by the terming company in Ljubljana: the purpose of the investigation was to determine the cracks and the detachment of the pictorial layers and the underlying mortar plaster. Instead of the classical determination of the extent of damage by knocking and visual observation, termography was used as a non-destructive method.

The Biotechnical faculty in Ljubljana, performed the necessary analyses of samples of microorganisms and algae taken on 9 august 2001 and the results was the presence of: *Trentephilia* sp., *Pleurococcus* sp., *Oscilatoria* sp.

The important stratigraphic analysis was caried out in 2005. The use of scanning electron microscopy / energy dispersive x-ray spectroscopy (SEM/EDS) shows that the majority of the binder is made up of calcium carbonate; there is also the presence of magnesium which can indicate that magnesium lime was used, which is common in this area.The SEM/EDS analysis carried out on a point of the surface of the samples indicates a high presence of gypsum. So, gypsum concentrates only on the surface and is not present in the inner layers.

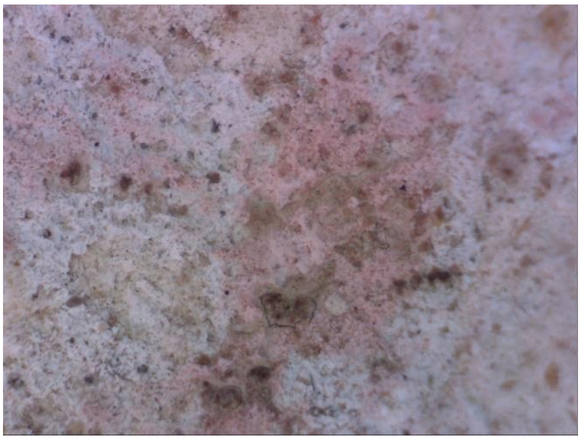
The static official of IPCHS Maribor inspected the church and write a static relationship on 10. 5. 2017. The purpose of the visit was to determine the general construction condition of the building. The findings of the tour are: the walls of the nave are built of crushed and worked stone of local origin, as is the bell tower. There are no large cracks on the walls that would endanger the stability of the building, but they are visible in the area of the entrance. The ceiling of the nave is flat, made of wood and then plastered. The ceiling of the presbytery is vaulted, lying on stone ribs. The arches are without cracks and no major deformations are observed. The vault of the triumphal arch is in stone and no major deformations are observed. The nave's roof structure is a reinforced cement and is relatively new and well preserved. This construction is inappropriate, as its weight presses on the outer walls, so there are cracks in the walls. The roof is made of slate-stone and is in relatively good condition. Conclusion: the condition of the building is stable, although the west and south walls of the nave are deformed. The peak of deformations is most likely in the reduction of the bond strength of the stone wall mortar and the increased load due to the concrete roof construction. Given that there are no built-in cross ties in the ship, it would make sense to install them (they would be anchored in the concrete structure and not in the walls).

**Investigation done by professors and students**

As a part of 2021 Summer School we conducted a number of non-invasive analyses where we roughly assessed the state of the wall paintings, presence of biological growth and salts, cohesion of mortars and paint layers which included: observation under portable digital microscope (Dino-lite), observation under UV light, observation under raking light, determining lack of adhesion with “knocking test”, absorption of water with “sponge test” and cohesion assessment with “swab test”.

1. Observation under portable microscope

Some parts of the wall painting we observed with portable digital microscope (Dino-lite) especially when certain questions arose: for example presence of certain pigments (azurite), decohesion of layers, *pentimenti*, preparatory drawing, biological growth, … The photographs were also made and are stored on MS Teams/General/Investigations/Portable microscope/Walls.

*Photos 9 and 10 : Decohesion of intonaco (left) and biological growth on the outside of the church (right) (by: Suzana Damiani).*

2. Observation under UV light

We also used UV light as an illumination tool and we came up with some very interesting results about binders of the wall painting and residues on the surface. To capture and document them we used *Fluocam UV/White lamp and camera, Bresciani art. 78131*. The photographs are stored on MS Teams/General/Investigation/Multispectral imaging/Walls.

*Photos 11: The same area photographed uner visible an UV light. Under UV light an animal is seen (by: Marko Odič).*

3. Observation under raking light

Observing and photographing the surface of the wall painting was crucial for the evaluation of the condition of the painting and used technique. We used a different angle of the lightening (a raking light) to observe cracks, flakes, bulges, salt crusts, brush strokes and *secco* finishings, infillings, etc.

*Photo 12: Photograph with the raking light (by: Andrej Jazbec).*

4. Lack of adhesion with "knocking test"

"To assess the state of adhesion – stability of the mortars underneath the painting – we decided to perform the "knocking test". We went along the wall, lightly knocking on the different parts of the wall and listened for anomalies of the sound, which informed us of difference in adhesion of underlying mortars. The test showed that the state of mortar adhesion is not as good as it seemed to the "naked eye". The most unstable areas could be found near the floor of all walls and near the corners, where there are the contacts between different mortar layers. In these areas the immediate conservation intervention is needed."[1] The test was performed by professor and two students with extreme carefulness.

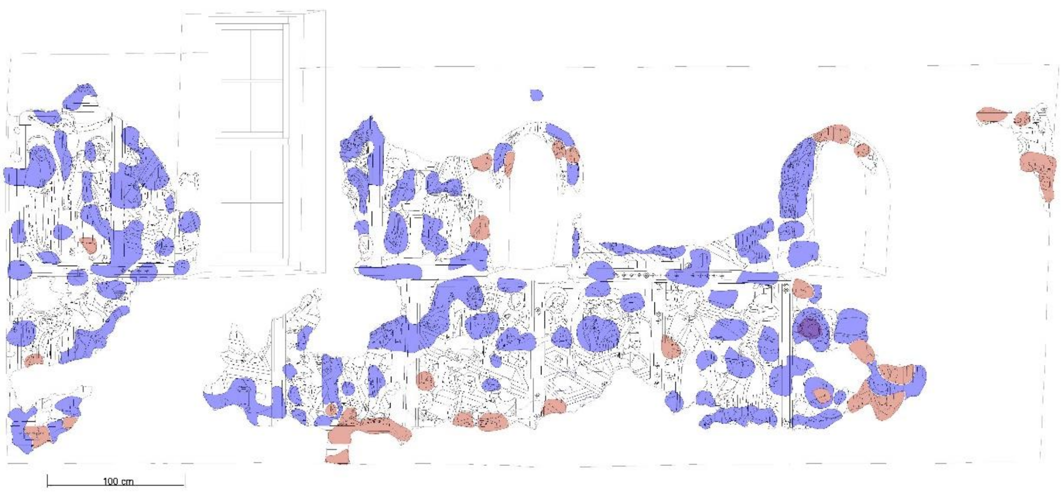



*Photo 13: Lack of adhesion (mild as blue areas and severe as red areas) in South wall (Mapping: Anka Batič, Melissa Cannizzo, other students).*

[1] Katarina Bartolj, Summer School Gradišče – Report, August 2021.

5. Absorbtion of water with sponge test

"We were very interested to find out the water absorption potential of the walls. This characteristic is very much connected to the porosity, pore size and distribution, adhesion of the plaster of wall structure, ...[2] This data can give us very significant information, that need to be considered, when we will perform cleaning and other conservation-restoration procedures. This data is quite hard to measure, because it is very dependent on the condition of the wall structure, temperature, air humidity, etc. but we can get the general idea, by performing this non-invasive test.

We performed the "*sponge test*" on site.  For this purpose we used the Contact sponge kit (CTS srl.). We wetted the sponge with water, weighted it and then pressed it to the surface of the wall. After one minute we took it away and weighted it again. We observed the difference in weight of the sponge. The difference is the final result and the measurement we were after. We compared the final measurements to each other to get the general picture of the absorption state of the wall.

The results showed that the south wall absorbed the highest amount of water, but not significantly more than northern wall. The least amount of water was absorbed by the western wall, at some parts there was even no water absorbed. The test also showed, that the higher the measurement point is up the wall, more water is absorbed. Interesting results gets us also the comparison of the "sponge test" results to the "adhesion assessment test" results. We can quite clearly see the connection between the state of adhesion and absorption potential. As a general rule we could state, that where is severe lack of adhesion of wall structure, the water absorption potential is also quite high. Our results confirm this thesis."[3]

*Photos 14 and 15: Sponge test on the North wall (by: students of Summer School).*

[2] Lecture notes on *Mineralogy in conservation/restoration* course.
[3] Katarina Bartolj, Summer School Gradišče – Report, August 2021.

4. Cohesion assessment with “swab test”

Cohesion assessment of the paint layer was carried out by swab test – carefully rinsing the surface with a cotton swab wetted with distilled water. We divided into groups and examined the cohesion of all different colours on North, West and South wall. This way we determined the stability of the painting for the following trials and possible necessity for pre-consolidation process.

“On most swabs we could find yellow or brown impurities, regardless of the colour area and position on the wall we were testing. General results showed that the most impurities were washed off on the southern wall. There was also the most noticeable difference between tested and untested surface. On northern wall, there were impurities detected on the cotton swabs, but there was very little noticeable difference on the surface of the wall before and after the testing with distilled water. On the western wall there was a visible difference, but not as strong as on the southern wall.”[4]

The colours that were more sensitive were: some violet and red especially on the north wall, also some green. Some lack of adhesion was present on the paint layers that were thicker with a large quantity of pigment. The overall assessment was that the paint layer is stable enough for cleaning trials with water and ammonium carbonate/ammonium bicarbonate.

**Documenting**

Documenting process was carried out all through on site and online part of Summer School. With on site part of the Summer School we were focused on photographing and examining with other instruments. Students drew their findings about painting technique, deterioration phenomena and previous interventions on printed orthophotos[5] and then in AutoCad programm (the online part of the Summer School). They also worked on Visual Glossary where they put their findings about the wall paintings.

Documentation of Summer School consists of:

1. File tree

2. Glossary

3. Mapping

4. Photodocumentation

All documentation documents are found in the Annexes of the Report.

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[4] Katarina Bartolj, Summer School Gradišče – Report, August 2021.

[5] Poročilo o izvedenem 3D dokumentiranju poslikav v cerkvi sv. Helene v Gradišču pri Divači, Gašper Rutar, univ. dipl. arheolog, maj 2021.

# Practical activities: Cleaning and consolidation trials

By Anka Batič, IPCHS Restoration center

After cohesion assessment tests on the paint layers and mortars we started working on cleaning trials. The intention of these trials was to find a right methodology to remove the residues of calcium sulfate (gypsum)[6] and other residues (salts[7], dirt) on the surface of the wall painting as well as whitewash residues.

## Cleaning with water

Firstly we divided four areas of wall painting to execute our trials: a part of the painting on the South wall (S1), two parts of North wall (N1 and N2) and a part of West wall (W1). Then we cleaned these areas carefully with distilled water, brush and sponge through japanese paper.[8] The visual examination of this process proved that we did not remove any of the paint layer, just the residues of dirt, spider webs and surface dust.

Student Katarina Bartolj wrote about the effect of the water cleaning: "The water cleaning had an interesting effect on the West wall and North wall. Right after the application of water the colours became very vibrant and visible. Around ten minutes after, on some spots appeared white veil, which was very visible and almost overpowered and concealed underlying colours. We left the paintings to dry overnight and then checked the state of the white veil the next day. The veil appeared to be more translucent and less visible, but still more noticeable than before water cleaning. Even though the appearance of white veil on both areas was caused by application of water, it is possible that there is a difference in chemical structure between veils on different areas.

When compared to each other, veils appeared to differ in thickness, gloss and over all general appearance. During the tests it was concluded, it is possible, that the white veil on W1 area could be a result of previous deposit of consolidant (*Calaton*), on area NW2 it is more likely to be due to sulfation or are simply limewash residues."[9]

[6] Gradišče pri Divači, Church of St. Helen (EŠD 1565) Non-invasive analysses, Ljubljana, August 2021.
[7] Gradišče pri Divači, Cerkev svete Helene (EŠD 1565) Poročilo naravoslovnih raziskav, Ivo Nemec, Ljubljana, 2010.
[8] We used brush to connect japanese paper to the surface, firstly we cleaned with sponges through the japanese paper (roughly five times) and then removed the japanese paper and cleaned the surface directly.
[9] Katarina Bartolj, Summer School Gradišče – Report, August 2021.

**Cleaning with ammonium carbonate, ammonium bicarbonate and anionic exchange resin**

We started the cleaning trials on Area S1 by applying ammonium bicarbonate through two layers of japanese paper. We applied the 20% solution of ammonium bicarbonate with brush until saturation (approximatly 10 min, 4 – 7 applications). Then we used distilled water and sponge to rinse the surface, firstly through japanese paper and than directly on the surface. We did this on all the chosen areas.

Since the application of the 20 % solution of ammonium bicarbonate did not result in any kind of damage to the wall painting and proved (visually) to clean the surface, we continued with the trials and applied ammonium bicarbonate mixed in a poultice.[10] The intention was to compare the results with different methods of application of ammonium bicarbonate and also contact time with the surface. We applied it on two layers of japanese paper and removed it after half an hour. For cleaning the treated surface we used distilled water and sponge. We continued the trials with applying ammonium carbonate the same way as ammonium bicarbonate: one trial with brush and one with poultice through two layers of japanese paper. We tried this method because we wanted to see if there will be any difference on the surface because of the different pH of the cleaning agent.

We also applied anion exchange resin (CTS OH strong) on wall painting (area S1) through japanese paper. The contact time was half an hour and we removed it with distilled water and sponges. We chose to do this trial in case the *secco* finishings (with possible organic binder?) on the wall painting are in any way susceptible to cleaning with ammonium carbonate or bicarbonate.

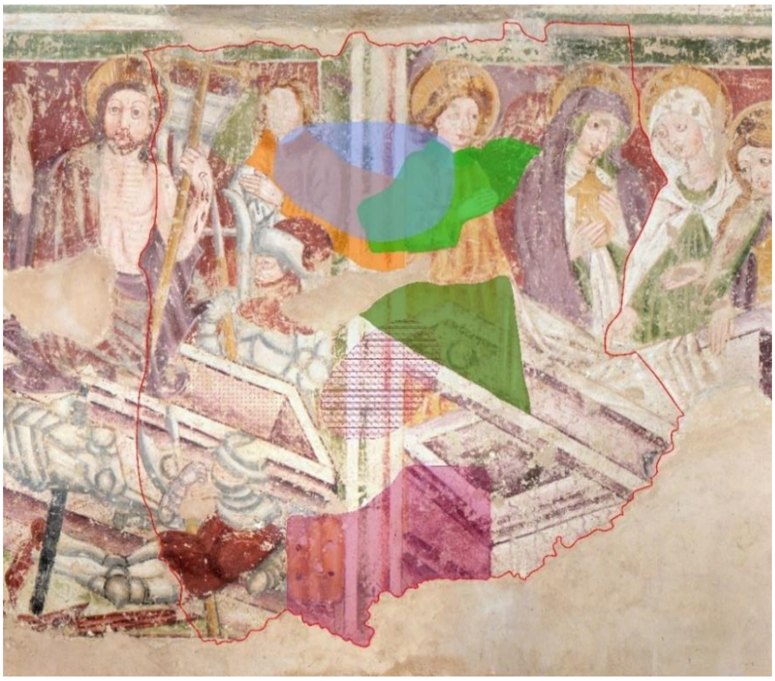
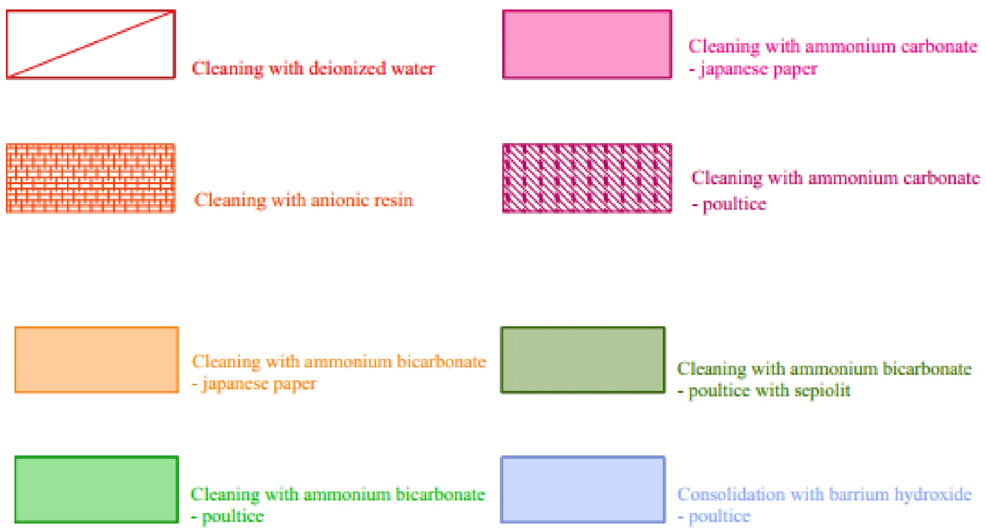


*Photo 16: Area S1 (by: Anka Batič, Melissa Cannizzo, other studetns)*

[10] Poultice was made by mixing the solution with supporting agent: cellulose Arbocel 40 and Technocel 200 (ratio 1:1).




**The results of the cleaning trial**

1. The cleaning of the surface with distilled water beforehand proves to be unproblematic for the paint layer. It can cause whitening on some parts (mainly west and north wall) probably due to residue of a consolidant.

3. The cleaning process has better results when the cleaning agent is used in a poultice with a longer contact time (40 minutes).

4. "There were some problems on the north wall when cleaning with ammonium bicarbonate: there appeared a white veil almost instanteniously when applied by brush and by poultice. It was extremely visible and quite thick, but fragile. While still wet, we decided to try different removal methods – mechanical and chemical. We got good results with the usage of rubber and trimmed brush. As a chemical removal agent we used 5 % solution of *triammonium citrate* (TAC) in water and hot water. Both cleaning agents were working, but the best removal results we got with the TAC. After the removal of the veil, the surface seemed cleaned and the colours more vibrant.

This also appeared in proximately the same area after cleaning with ammonium carbonate. We also used TAC to remove the white veil."[11]

5. After examining the cleaned surfaces under UV light we spotted a difference in treated and untreated surface with ammonium bicarbonate in a poultice. The untreated surface reflects in a orange-ish colour meanwhile the treated surface does not. The difference is striking but it does not appear elsewhere.

6. "On the upper side of the area N1, there is unidentified grey/black-ish stain. Neither of the previous treatments did succeed in removing the stain. The ammonium carbonate with exposure time up to 40 min did remove the stain. The stain can be removed with mechanical action after the treatment. Possible future problem is, that the carbonate solution also influences the underlying colours, especially red, green and blue/black colour parts. These

[11] Katarina Bartolj, Summer School Gradišče – Report, August 2021.

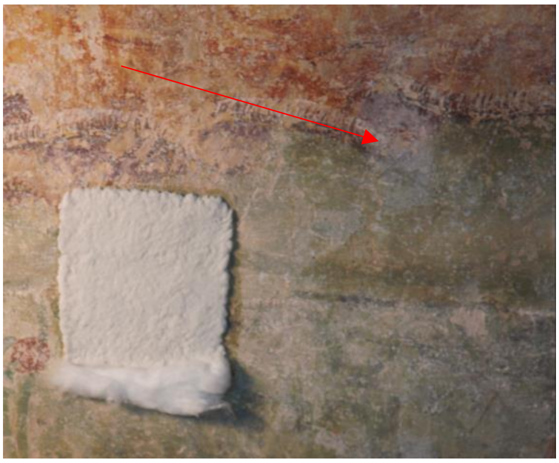
became very sensitive after the treatment and could be rubbed off the surface, when we are removing the stain with mechanical methods."[12]

7. The thicker whitewash residues can be removed after the treatment with ammonium carbonate/ammonium bicarbonate mechanically using scalpel.

*After cleaning with distilled water and sponges (Area S1).*

*Poulticing with ammonium bicarbonate.*

*After removal of a poultice the colours are more visible and vibrant.*



*Some whitening after the removal of poultice – it can be removed mechanically or with triammonium citrate.*

*Photos 17 - 20 by Anka Batič.*

[12] Katarina Bartolj, Summer School Gradišče – Report, August 2021.

**Consolidation trials**

As a consolidant material we tried barrium hydroxide, as it has proved to be an effecitve anorganic consolidant as well as a part of de-sulfating process combined with treatment with ammonium bicarbonate. We applied a 10% solution in a poultice throught two layers of japanese paper. The contact time was 4 hours. We removed it with distilled water and sponges. The trial was carried out on the surface of South wall (S1), partly treated beforehand with ammonium bicarbonate and partly untreated. It is useful to see (after some time) if there is a difference between treatment with ammonium bicarbonate (as a desulfation process) and without it. There were samples taken.

**Results of the consolidation trials**

The surface looked stable and colours vibrant after the treatment, there was no visible sign of negative alterations on the surface even after 3 months.

## Diagnostic investigations

By Katja Kavkler, IPCHS Restoration center

Diagnostic investigations in Church of St. Helen in Gradišče pri Divači (EŠD 1566) started before 2021 Summer School and are still in progress (microclimatic measurements), when writing this report. Investigations can be divided into several groups: on site investigations and laboratory investigations, material characterisation, state of preservation monitoring, cleaning and consolidation efficiency analyses as well as microclimatic monitoring. Additionally, past analyses, carried out between 2003 and 2010, were studied and repeated or additionally carried out if new information was required for selected samples.

To obtain as much of the above mentioned information as possible, several non-invasive as well as micro-invasive methods were applied: on site microclimatic monitoring using data loggers, thermography, on site Raman and XRF non-invasive analyses, whereas on extracted micro samples optical and scanning electron microscopies as well as infrared (FTIR) and Raman spectroscopies.

**Microclimatic conditions** are (still) measured in four positions – on each wall. The measurements can be compared to environmental monitoring at nearby Park Škocjanske Jame. Measurements show that conditions vary only slightly in different parts of the church. The highest temperatures are, as expected, on the southern wall. They vary considerably more than on other sides of the church, on daily basis as well as within longer time periods. Temperature fluctuations can affect different materials, especially by changing volume of the objects (for composed objects this is especially endangering, since various materials respond differently to heat changes). Temperatures have also great influence on relative humidity (RH).

The RH never reached 100% but came close several times, especially in winter months. Humidity fluctuations in the church follow temperature fluctuations – after raising temperature, RH drops – and are slightly more intensive on southern side of the church. Comparing our measurements with weather reports, we can say that external conditions have important influence to RH within the church. Most of the time RH in the church exceeded 68%: 77% of time on southern wall and even 90% of time on northern wall. Such conditions are favourable for microbial growth, metal corrosion and salt efflorescence on walls. As observed by example from beginning of June, opening of the church on warm and dry days can substantially lower the RH in the church. This should be a recommendation for locals taking care of the church. Should passive airing not help, active mechanical ventilation or wall heating should be considered.

**IR thermography** was carried out on parts of the southern and northern walls. Preliminary thermographic analyses do not show colder walls close to the ground, which would suggest capillary water rising from the floor. Larger areas of blistering were observed by this method, as well as position of stones and mortars under paint layers.

**Plaster** is made from calcite binder with silicate aggregate. No soluble salts were observed in plaster.

**Pigment analyses** were carried out on site as well as on extracted samples, in both cases with Raman spectrometers. Following pigments were detected in the painting: haematite (possibly in some areas caput mortuum), goethite, green earths, magnetite, carbon black and quartz, maybe also vermilion. Additionally, XRF analyses revealed presence of copper on dark green garment of Wise Man on the white horse, possibly revealing presence of malachite. Calcite was detected in all analysed samples, as expected, since painting technique is fresco. An unidentified material occurs in Raman spectra (both on site and cross-sections) at 1049 $cm^{-1}$.

Additional pigment analyses were carried out on extracted micro-samples, where each different pigment grain can be analysed. Additionally to non-invasive analyses, kaolinite was identified and vermilion confirmed, laying over haematite layer.

Different **degradation products** were observed on paintings. Gypsum salt was observed on site spectra on most of the analysed surface areas on both, southern and northern wall. Interestingly, it was observed only in few micro-samples with Raman spectroscopy. SEM EDS analyses on micro sample cross-sections revealed that it is present in untreated samples, mainly on northern wall, in thin surface layer, whereas from on site analyses it seems that there is more gypsum on southern wall, which is not very probable.

Beside gypsum salts, also nitrates were observed in some analysed samples as well as sodium chloride.

Relatively scarce presence of calcium oxalates suggests that despite high RH values, biodegradation is not widespread on paintings.

**Organic materials** were analysed by FTIR spectroscopy in selected micro-samples. Two surface stains were analysed. In one wax was identified with certainty, however the other shows presence of carboxylates which hints to presence of organic materials, containing carboxylic acids (wax, resin or oil). In some analysed samples, presence of either proteins or calcium oxalates were identified. To specify the results, immunofluorescence microscopy was performed at IPCHS Research institute for ovalbumin on three samples, extracted in 2003. Analysis confirmed presence of proteins in two samples (GDC 4 and 5), but not on the third one (GDC 10). Samples with ovalbumin were both extracted from green areas and show presence of proteins in plaster layers and in paint layers. It is not clear, whether this was due to consolidation or original material.

Interesting features are (mainly) black surfaces, which under UV light **fluoresce orange**. The orange fluorescence is visible not only with naked eye, but also in cross-sections under the microscope. It seems that there is a fluorescent binder, which connects black particles, but could be also remnants of a coating layer. FTIR spectra of the sample did not give a conclusive information about the fluorescent material.

Beside material identification, aim of the analyses was to support observations from cleaning tests and asses the efficiency of the consolidation trials. **Cohesion assessment** was observed on selected cotton swabs. On the analysed swabs, mainly calcite and salts were present.

Although some of them were coloured and single pigment particles were observed, no pigments could be identified by FTIR spectroscopy.

**Cleaning tests** were evaluated on white frame on southern wall. Area cleaned with pure water and the one cleaned with barium hydroxide did not reveal presence of gypsum. Untreated sample revealed only some aggregates and in the area treated by ammonium bicarbonate and barium hydroxide with poultice thin surface layer of sulphate salts (probably gypsum) was observed. Research on single samples without parallels cannot always be regarded as reliable. Since in cross sections more gypsum was observed on northern wall, a comparison of the same group of treatments would be interesting.

Due to properties of different **consolidants**, only the samples treated with barium hydroxide could be monitored for depth of penetration. The SEM EDS mapping revealed that barium remained mainly in the surface layers of the paint (it penetrated to approx. 50 µm depths), however in more porous areas (possibly cracks) it penetrated deeper, up to 200 µm.

From the above results, we can conclude that analyses revealed information about material composition and presence of degradation products. However, not all questions were satisfactory answered so far.

# Proposal for the intervention

By Alberto Felici, Marta Bensa, Anka Batič

### No need for preconsolidation

There are some areas (reds, violet, green) where paint layer is unstable – as shown during trials for lack of adhesion. On this areas a conservator-restorer should be careful with the next processes (using a sheet of japanese paper, observing the surface while cleaning, etc.).

### First cleaning

The surface of the wall painting should be cleaned beforehand to remove dirt, spider webs and other residues dusting with soft brushes. The first cleaning is carried out with deionized water trough japanese paper. The application of japanese paper is done with brush and deionized water, the cleaning with sponges: firstly through japanese paper and then directly on the surface (if the paint layer is stable).

There is a need for two sheets of japanese paper where there is a lack of cohesion of the paint layer.

### Final cleaning

There is a small presence of salts on the surface (See the Report on investigations by Katja Kavkler) so the main aim of the cleaning is decontamination, the removal of previous aged fixatives, coatings and other residues on the surface. There are two options for this procedure:

First option: **Ammonium bicarbonate**

Saturated solution of ammonium carbonate (25 % solution) is applied by brush through two sheets of japanese paper. The areas of application are small, for example 20 x 20 cm and following the shape of the painting. For the cleaning 2 or 3 applications by brush are needed in a 10 – 20 minutes interval – depending on the absorption of water.

If there are some areas where coatings and residues are largely deposited, repetition of the process with brush is needed or application of the saturated solution of ammonium bicarbonate with supporting agent - poultice ( Arbocel or a mixture of Arbocel and Sepiolit in porpotion 1:1). After described application of ammonium bicarbonate, the surface is rinsed with deionized water using soft sponges.

Where the poultice is used, it is required to apply a sheet of japenese paper with deionized water after the cleaning – to allow absorption of some additional substances coming from the mortar of the wall painting during the drying. It needs to be left on the surface until next day.

Second option: **Anionic exchange resins**

The anionic resins as a poultice can be used for the removal of old fixatives, dirt and other residues on the surface. It is applied by brush, left for half an hour and then cleaned using sponge and deionized water. One should be careful with not leaving the residues of resins on the surface.[13]

For the wall paintings in Gradišče the **First option** is regarded as favorable.

## Consolidation

The paint layer is quite stable with certain exceptions. The consolidation of the paint layer is needed but in a smaller extent. Also the presence of sulfation is very weak but still there are some areas especially on the Northern wall where there are more deposits. These areas have to be determined before procedure. For the consolidation process there are more options;

<u>Nano-lime for example NanoRestore</u>

Application is done by brush through japanese paper in several repetitions.

<u>Barium hydroxide</u>

Application of 10 % of barium hydroxide is done with supporting agent Arbocel applied on one sheet of japanese paper and contact time from 2 hours to 3 hours. After two weeks a cleaning with deionized water is needed.

The presence of the magnesium hydroxide should be investigated so it can be determined if the process is appropriate for these paintings.

<u>CFW (“Consolidant formulation Water”)</u>

There are some new consolidants available on the market in Slovenia, such as CFW made by Slovenian National Institute Building and and Civil Engineering Institute in Ljubljana.[14] It can be used for trial versions. It is a solution applied by brush through japanese paper.

<u>Combination</u>

Combinations of the consolidants is also possible such as consolidating with nano-lime and Barium hydroxide.

[13] The UV light can be used after cleaning to check for them, they reflect differently.
[14] It was made during EU Project HEROMAT.

**The lack of adhesion of mortars**

There are some areas where the adhesion of mortars is compromised. Some parts are in cricial conditions reflecting in losses. The intervention is needed in that areas with stabilization with injection grout, for example Ledan TB1, Calxnova.

Before the beginning of the 2022 Summer School some areas must be cleaned beforehand so the students can try the consolidation procedure, some ares must be left untreated so the students can try the cleaning processes. The areas and processes will be determined after the selection of students as it depends on their experiences.

The focus of the workshop Consolidation of wall paintings – Gradišče 2022, which be held in fall 2022, is consolidation therefore the wall paintings should be cleaned and decohesion of mortars stabilized before the start.

# 2022 Summer School: Draft of the next activities

By Summer School organizers

**Activities and general program**

The Summer School will offer on site activities and online lessons:

- lectures on the methodological and interdisciplinary approach for the conservation of wall paintings and on intervention techniques;
- direct experience and work on site;
- visits on site to see other wall paintings of the area comparable in age and character to the wall paintings of church of St. Helen and, if possible, other conservation-restoration projects;
- presentation of the work carried out to the local population in order to share the significance of the site and the steps to be taken to guarantee its preservation.

2022 Summer School will be presented over three weeks:

First week: 3 days, 31. 8. 2022 – 2. 9. 2022 online lectures.

Second week: 5 days, 5. 9. 2022 – 9. 9. 2022, on site work, cleaning and consolidation.

Third week: online work, 3 days, 12. 9. 2022 – 14. 9. 2022 online, working on summaries and final report.

**Aim of the 2022 Summer School**

The main objective of 2022 Summer School is to assess and document the conservation condition of the wall paintings, understand what has been done so far, carry out cleaning and consolidation work, and write a report on the activities carried out.

**1. Preparatory week online 31st of August – 2nd of September 2022**

General presentation of the partners, participants and organizers:

presentation of IPCHS (Martina Kikelj, Anita Kavčič Klančar); presentation of SUPSI (Giacinta Jean); presentation of ALUO (Blaž Šeme); presentation of ALU Zagreb (Suzana Damiani).

Presentation and introduction about the site and history of the church / Slovenian wall paintings/ Wall painting monuments of the Karst region (Marta Bensa, Minka Osojnik, Andrej Jazbec, IPCHS NG);

Techniques and materials of Slovenian wall paintings (Martina Kikelj, Anita Kavčič Klančar, IPCHS RC);

Lectures on the methodological and interdisciplinary approach for the conservation of wall paintings (Alberto Felici, SUPSI);

Data collection and data management (Stefania Luppichini, SUPSI);

Visual glossary (Giulia Russo, SUPSI)

Scientific investigation for the study of wall paintings (Francesca Piqué, Patrizia Moretti, SUPSI)

Scientific investigation carried out in Gradišče (Katja Kavkler, IPCHS RC);

Illustration of the work already carried out on the church's wall paintings (Anka Batic, IPCHS RC);

Results of 2021 Summer School: Students' work Katarina Bartolj (MA student, UL ALUO)

Participants of the workshop 'The Consolidation of Wall Paintings' organised by IPCHS, which will take place in the church from the 3rd to the 7th October 2022, will also be present for the online activities.

**<u>2. Work on site: 5th of September 2022 – 9th of September 2022</u>**

Activities:

Presentations held by the professors (evening hours) Neva Pološki – Case Study: Medieval Wall Paintings in the Church of St. Mary of Pond in Gologorica; Researches and treatments;

Discussion about previous analytical investigations;

Observation of the technical aspects and materials, former interventions, and decay phenomena of the wall paintings;

Practical work on site;

Writing the draft of a final assessment report for the conservation-restoration of the wall paintings. The final report will be concluded the week after the end of the work on site.

Presentation of the work carried out during the Summer School to the officers of the Ministry of Culture of Slovenia.

**<u>3. Follow-up week 12th of September 2022 – 14th of September 2022 (online)</u>**

Discussion of analytical results and further steps to be taken;

Writing up the final report and complete documentation of the activities carried out.

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Dipartimento ambiente costruzioni e design
SUPSI

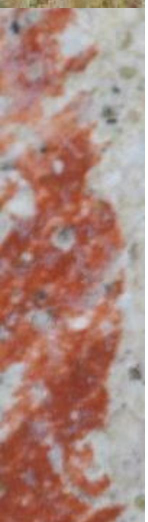
University of Ljubljana
Academy of Fine Arts and Design

Sveučilište u Zagrebu
Akademija likovnih umjetnosti

# REPORT: SUMMER SCHOOL GRADIŠČE PRI DIVAČI (SLOVENIA)

2nd to 27th of August 2021

CHURCH OF ST. HELEN
CONSERVATION-RESTORATION OF WALL PAINTINGS



## ANNEX n. 1
## Summary of the Summer School by attending student


**Author:** Katarina Bartolj

**Mentors:** Alberto Felici, Neva Pološki, Suzana Damiani, Blaž Šeme, Anka Batič.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# Report

## Summer school Gradišče pri Divači

Katarina Bartolj

August 2021

# Index



# Abstract

In this report I sum up our work on site in the Church of Saint Helen in Gradišče pri Divači during 2021 Summer school. First, I explain, what we learnt about paintings, their creation technique, used materials and special treats. Next, there is my observation of the current state of the conservation of wall paintings. In the last part of the report there can be found descriptions of tests we performed and results we got during testing. In comments under the text, can be found some detailed information about used materials, possible explanations about occurring happenings and sources of citations/claims.

## PAINTING TECHNIQUE

We started our examination of the wall paintings in Gradišče by general, superficial examination. There are gothic wall paintings left on Northern, Sothern and Western wall. These are also the areas we examined in the most detail.

Firstly, we observed, what can just "naked eye" method tells us about the paintings, their creation technique, used materials and special treats. Let's start from the base – support layer.

Stone wall serves as a support layer. It is made of robust ashlar stone masonry. The origin of the stone is quite possibly one of many local quarries. The support stone layer is visible on the outside of the church. It is necessary to add, that there is clearly visible the difference in stone processing. During the church's history, the church was elevated. This occurred after the gothic frescos were applied. On the lower side to the three quarters of the heights of the church, the wall is made by robust ashlar stone, later elevation was made by smaller, inferior samples of stone. The joints between different masonry blocks are filled by mortar – joints are very thin and delicate, visible just on the outside of the wall. The overall thickness of the wall is circa 80 cm.

Usually on the rough stone support layer was applied the first, thicker mortar layer (*arriccio*) for levelling the unevenness of the support. *Arriccio* layer is visible on more damaged parts, where the paint layer and the other mortar layers were abraded or damaged. Mostly this is the case on the lower parts of the frescos (by the floor) and on the corners. For precise location see maps in Annex n. 4: 1, 2 and 3.

Visible is also finishing layer of mortar (*intonaco*), also on parts, where the paint layer was abraded or damaged. It is the last, fine-grained, thin and well-evened layer of mortar on which the wall painting is applied in *buon fresco* technique.

It is not clear, if there is another mortar layer between the two, because it is not possible to distinguish between different layers by the "naked eye" method, this is why there are needed further investigations.

On the *intonaco* we can usually find preparatory drawing. An artist created this drawing to help himself with the different motives, to see the whole picture. Preparatory drawing was used as a sketch. The examples can also be found in Gradišče. On the more abraded parts of a paint layer there are visible some examples of author's preliminary sketch. Great example was found on the northern wall on the lower part, where one of the human figures is playing a flute. The sketch was made in light red color tone, applied most likely by brush.

The occurrence of the preparatory drawing led to the examples of *pentimento*. It is the correction of the motive on painting made by the artist. We can see the form, that was sketched or after lightly painted with first paint layer, that was later corrected by the artist with deposit of final paint layer (possibly in *secco* technique). The occurrence of *pentimento* is mostly a result of abrasion or damage of paint layer. Very illustrative example can be found on the south wall in the scene of *Three Marys at the grave*, where it is visible the author's correction of the shoulder of one of the *Marys*.

During the examination of a paint layer, it was concluded the wall paintings are probably executed in *buon fresco* with *secco* finishing. *Buon fresco* is a wall painting technique in which pigments are mixed with clear water or with lime milk and applied to a fresh and still damp lime plaster (*intonaco*); pigments are fixed inside a thin layer of calcium carbonate formed on the plaster surface during carbonation process. *Secco* technique is a wall painting technique, where author applies pigments mixed with binder on dry mortar.

Difference of techniques can be seen by the difference of thickness of paint on different parts of paint layer and by the gloss of the colours.

Before the gothic frescos there were other wall paintings. On the south wall on the left upper side, there were found some remains of an older wall painting. Such remains we categorised as *palimpsest*. It is also visible that the earlier wall paintings were scratched for better adhesion for the next layer with the purpose of making a new wall painting.

They applied wet *intonaco* in parts, they were able to work on in a one day time or till the mortar was dry. In Gradišče me have large areas called *pontata*-s. The lines between different *pontata*-s are still visible, when you illuminate the wall with raking light. When they applied wet mortar, they also carved same forms in mortar, to decorate the painting or to outline some shapes to help themselves , when they will later paint on that layer. Under the raking light we found different carvings made by different techniques. We distinguish between direct incisions, *puncunatirua*-s and snapped line technique.

Direct incision technique can be described as a preparatory drawing technique using a pointed tool or other sharp instrument to scratch a plaster surface. In our case it was applied on wet plaster[1]. On frescos we found examples of the technique, mostly on the edges of painted jewellery, aureoles, dresses etc.

We also found examples of *punzonatura-s*/imprints. It is a technique, where you use different tools to press them into the wet mortar to get different imprints on the surface. Technique is mostly used to imprint different forms on jewellery, décor and dresses. This is also the case in this church. The most representative example is found on the crown of the *Virgin Mary* on the northern wall.

In Gradišče we can also find examples of usage of snapped line technique. This technique was mostly used for creating straight lines. It is a method of applying a straight line on plaster by stretching a piece of string, pulling back and releasing it, so that it snaps against the painting, leaving a mark. In Gradišče it is most likely that they used that technique, when the mortar was still wet, because we can see little pieces of mortar on the areas, where the possible string was snapped. That would suggest, that they had used this technique before they started to paint. The frescos on the south wall are divided in different scenes, each scene is mobbed by frame. The straight lines, which create the frames, were most likely made by snapped line technique.

When we examined the final paint layer, we found an interesting example of usage of stencil decorative technique. To finish and decorate some parts of the painting the artist used stencil, that was intricately shaped and he used it to make the ornamental pattern on his painting. Usually the stencil was used to create different patterns on dresses, table cloths, … The example of usage of stencil can be found on northern wall on the dress of the *King/Magi* in the middle of the scene.

[1] Likewise, indirect incision technique is defined as preparatory drawing technique using a pointed tool or other sharp instrument to scratch a plaster surface through some kind of stencil (paper, linen, …).
You can distinguish between direct and indirect incisions by assessing the state of the edges of incisions – direct incisions leave rough and sharp edges with small mortar pieces accumulated around edges. On the contrary, indirect incisions leave edges nicely rounded, form the inside to the outside of the incision – this phenomenon is caused by stencil used to made incision – it was almost imprinted on the edges on the surface.

## STATE OF CONSERVATION / TRY-OUTS

We performed different examinations to find out the current condition of the painting.

We examined the whole painting in detail and mapped different deterioration phenomena, that affected the painting. We can divide the deterioration phenomena that affected just the painting layer and colour respectively and phenomena, that affected the layers underneath. We also made a category for salts deposits and one for other deposits, that can currently be found on the paint layer.

### COLOUR CHANGES

The category of colour changes includes colour saturation, darkening, yellowing and whitening. We were interested to find out, what paint changes can be detected simply by the "naked eye" and are therefore the most visible and noticeable to anyone, who looks at the painting. Therefore, we marked areas, where colours were severely saturated, the areas, where paint seem to be whitening or fading, parts that seem to be darkened or yellowed. The criteria for assessing the changes were decided by the observers and depend on comparison of different colour parts to each other and to the wall painting as a whole. There is no particular rule for the changes, we found them on all areas of the paintings.

### ABRASION

The painting layer was heavily affected also by abrasion. There are a lot of places (for precise location see maps in Annex n. 4: 7 - 12), where we could clearly see abraded parts, which were caused by mechanical friction or process of rubbing away the surface/paint. Most heavily affected were parts that are easily accessible, the most abraded areas can be found on the southern wall.

### COLOUR COHESION

We also checked, what is a state of the cohesion of the colour. We were especially interested to find out, if there are some colours that are more stable than others. It is very important assessment for future conservation and restoration procedures. We checked the state of the cohesion of different colours with try-outs with water-wet cotton swabs. Each colour area was wiped with three swabs. The remains on the cotton told us the state of colour area. If there were any pigment remains on the cotton swabs, the area is not stable, if not, the cohesion of the colour is satisfactory. The results showed, that most colours are stable, some cohesion problems only have yellow and red colour parts.

### DEPOSITS

There can also be different category for all the deposits, which can be found on the painting layer. It is very difficult to differentiate between white deposits, such as lime-wash residues, salt efflorescence and salt crust etc. without any investigations. This is why it had been decided to put them on the same map in graphical documentation. We mapped all the deposits and clearly labelled them in different categories just in areas, where the observers were convinced in their cause of origin. As a deposit we mapped also possible "wax stains" that were found on the surface and accredited by the inspection under the UV-light. In this map we also added the marks of different stains (leaking stains and others), we do not know the origin to or its chemical formula. Interesting observation can be made, if we look at the relief of the wall. Probably because of the weight of the roof, the walls became more rounded during the years. That resulted in very pronounced relief of the wall paintings' surfaces. A lot of deposits can be therefore found on convex parts of the relief structure.

### GLOSSY AREAS

Interesting finding was also the glossy areas. These are the areas that had particular shine under the raking light. We don't know the origin or the cause of the shine. It is to be determent later with some investigations. Glossy areas were found on all walls, mostly on the lower half of the painting.

## GRAFFITI

Caused by human action is also occurrence of graffiti. They can be found mostly on the southern wall, especially on the lower, more accessible side of the painting. They appear to be quite old, with possible historical value.

## BULGES, CRACKS AND CRAQUELURE

On wall painting in Gradišče we also found more structural damage. During the examination of the painting we detected some bulges, cracks and craquelure. Mostly, bulges were found on the lower parts of the painting, near the floor, where later we also detected severe lack of adhesion. The bulges were found on all walls without noticeable exceptions.

As structural damage we categorised also cracks and craquelure. As cracks we categorised visible separations of one part from another, that extends through one or more layers. On the painting in some areas we found whole networks of little cracks, which we categorised as craquelure. Cracks and craquelure networks can be found on all walls. For precise location see maps Annex n. 4: 7 - 12. The severity of different cracks varies, but most cracks are stable and non-threatening. The most severe and active crack is located in the middle of the northern wall by the *Magi* figure.

## LACUNAS

On the painting we also detected lacunas. They can be of different sizes and different depth. They were mostly conserved before our inspection. There do not seem to be the appearance of new ones.

## ADHESION

To assess the state of adhesion – stability of the mortars underneath the painting – we decided to perform the “knocking test”. The observer goes along the wall, lightly knocks on the different parts on the wall and listens for anomalies of the sound, which inform an observer of difference of adhesion of underlying mortars. The test showed that the state of mortar adhesion is not as good as it seemed to the “naked eye”. The most unstable areas are near the floor on all walls and near the corners, where are the contacts between different mortar layers. In these areas immediate conservation intervention needs to be done.

# INVESTIGATIONS / TRY-OUTS / TESTS

When we finished all the examinations of the paintings and got the general idea of their current state, we began to perform different investigations and try-outs. We were interested to find out the reasons behind the current state of the paintings and especially, how do they behave under different treatments and with usage of different materials. It is of most importance to find this out to know, how we will treat the paintings in the future and which materials are the most effective and non-threatening for the artwork.

## “SPONGE TEST”

We were very interested to find out the water absorption potential of the walls. This characteristic is very much connected to the porosity, pore size and distribution, adhesion of the wall structure etc.[2] This data can give us very significant information, that need to be considered, when we will perform cleaning and other conservation/restoration procedures. This data is quite hard to measure, because it is very dependent on the condition of the wall structure, temperature, air humidity, … but we can get the general idea, by performing one of the simpler, non-invasive tests, like “*sponge test*”.

We performed the “*sponge test*” on site. We wetted the sponge with water, weighted it and then pressed it to the surface of the wall. After one minute we took it away and weighted it again. We observed the difference in weight of the sponge. The difference is the final result and the measurement we were after. We compared the final measurements to each other to get the general picture of the absorption state of the wall.

The results showed that the south wall absorbed the highest amount of water, but not significantly more than northern wall. The least amount of water was absorbed by the western wall, at some parts there was even no water absorbed. The test also showed that the higher the measurement point is up the wall, more water is absorbed. Interesting results gets us also the comparison of the “sponge test” results to the “adhesion assessment test” results. We can quite clearly see the connection between the state of adhesion and absorption potential. As a general rule we could state, that where is severe lack of adhesion of wall structure, the water absorption potential is also quite high. Our results confirm this thesis.

## COHESION ASSESSMENT / WATER CLEANING TIRAL

When we earlier executed the test for cohesion assessment, we got yet another results from the same test – the results that told us about cleaning the surface with water. On cotton swabs we could see not only the remains of possible pigments, that came off the surface, but also the impurities that were gathered from the surface by cotton swab.

On most swabs we could find yellow or brown impurities, regardless of the colour area and position on the wall we were cleaning. General results showed that the most impurities were cleaned on the southern wall. There was also the most noticeable difference between cleaned and uncleaned surface. On northern wall, there were impurities detected on the cotton swabs, but there was very little noticeable difference on the surface of the wall before and after the cleaning. On the western wall there was a visible difference, but not as strong as on the southern wall.

[2] Lecture notes on *Mineralogy in conservation/restoration* course.

## WATER CLEANING TRIAL

To confirm and evolve the results stated by the cohesion assessment test, we decided to perform other cleaning tests. On each wall we selected one[3] or two areas[4], where we carried-out the cleaning tests. According to previous examinations and try-outs, we decided to try cleaning the selected areas with different cleaning agents, because we were quite certain, that we have different materials to clean off the surface. Different materials usually demand different cleaning agents, because of their different chemical structure[5].

We tried *distilled water*, *ammonium carbonate*, *ammonium bicarbonate* and *anion exchange resins*. At the beginning we also decided to try different methods of application (by brush through Japanese paper and with poultice, made of *Arbocel 200*, *Arbocel 1000* and *Sepiolite*) to see, if the prolonged time of exposure to the cleaning agent has any effect to the results.

Firstly, we cleaned selected areas with distilled water. We applied water cleaning agent 5× by brush through Japanese paper, then we cleaned the same areas around 3× with water-wetted sponge. The water came back a little dirty, the same colour as previous cotton swabs (orange and brown). It seemed that water agent did remove superficial impurities that were on the surface. The underlying colours became more vibrant and visible. The effect of water cleaning was most noticeable on S area, the least on N1.

The water cleaning had an interesting effect on western and northern wall. Right after the application of water the colours became very vibrant and visible. Around ten minutes after, on some spots appeared white veil, which was very visible and almost overpowered and concealed underlying colours. We left the paintings to dry overnight and then checked the state of the white veil the next day. The veil appeared to be more translucent and less visible, but still more noticeable than before water cleaning[6]. Even though the appearance of white veil on both areas was caused by application of water, it is possible that there is a difference in chemical structure between veils on different areas.

When compared to each other, veils appeared to differ in thickness, gloss and over all general appearance. During the tests we concluded that it is possible, that the white veil on W area could be a result of previous deposit of consolidant (*Calaton*)[7], on area N2 it is more likely to be due to sulfation or are simply lime wash residues[8]. It is to be checked with additional chemical investigation method, we also took some samples that will be tested at the lab.

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[3] On the southern and western wall (In report I use "S" and "W" areas).
[4] On the northern wall – in the middle of the wall, by the *Magi* figure (In the report I use "N1" area) and under the window (In report I use "N2" area).
[5] *Conservation of building and decorative stone* (ed. John ASHURST, Francis G. DIMES), Oxford 1999.
[6] It is possible, that the water caused at least partial swelling of unknown material, the swelling than induced the white veil to appear.
[7] It is known to be applied in the 1960s, during the conservation/restoration procedures. We concluded that it is possible, that the white veil is caused by consolidant, because of its appearance on the surface. It seemed, that it had been applied by brush, because we could almost see the brush strokes imprinted in remains of the substance.
[8] These are clearly visible on all walls, but are hard to distinguish between salt crust and other residues.

## AMONIUM BICARBONATE CLEANING TRIAL

To treat the white veil and further clean the surface, we decided to try *ammonium bicarbonate* solution. We made 20 % solution of *ammonium bicarbonate* in water[9] and then applied it by brush through Japanese paper on selected surfaces for 10 min. To keep the applied Japanese paper wet during the exposure time, we have to wet it up from 4× [10] to 7× [11]. After 10 min. we took the Japanese paper down and cleaned the surface with water-wetted sponge up to 4×.

The most severe reaction to the applied solution happened on area N2. After water cleaning of the treated surface, the white veil appeared almost immediately. It was extremely visible and quite thick, but fragile[12]. While still wet, we decided to try different removal methods – mechanical and chemical. We got good results with the usage of rubber and trimmed brush[13]. As a chemical removal agent we used 5 % solution of *triammonium citrate* in water and hot water. Both cleaning agents are working, but the best removal results we got with the *citrate*[14]. After the removal of the veil, the surface seemed cleaned and the colours more vibrant.

In the areas S, W and N1 the effect of the treatment was visible, but we wondered, if we can improve it further. That is why, we decided to prolong the exposure time and apply the same solution in a form of poultice. We mixed the *ammonium bicarbonate* solution with *Arbocel 200* and applied it on top of pre-water-wetted Japanese paper. We left the poultice to take an effect for 30 min. After the exposure time, we removed the poultice and cleaned wall surface with water-wetted cotton swabs and sponges. Before we left the surface to dry overnight, we applied a sheet of Japanese paper[15] on treated surface. During drying process all the impurities that would otherwise accumulate on the surface, could deposits themselves on the sheet of applied paper.

After drying through the night, the results are different on different areas. On area N1, before the treatment there was no sign of white veil, after the treatment there also is none. But a little more pronounced became some white wash residues, which are easier to remove after the *bicarbonate poultice* treatment by some mechanical action (scalpel, brush, …). On area W and N2, the results are very visible. During the treatment more of white veil appeared. It seems, that a lot of impurities and also a bit of the material, that caused the appearance of white veil, did deposit themselves on either poultice or Japanese paper, or were simply removed by water cleaning after the treatment. After drying through the night, we could see some remains still on the surface, but these are easily removable by some mechanical methods or application of *triammonium citrate*. The difference before and after the treatment is especially visible on darker areas – dark blue and violet. These colour parts were severely covered by white veil, but now colours seemed more pronounced. We concluded, that on area W and N2 the results are better after the treatment with poultice, than after application of *bicarbonate solution* just through Japanese paper.

---

[9] We tried to prepare saturated solution. We decided to use ammonium solutions, because the ammonia parts can create easily soluble chemical compounds with salts and other residues in and on the surface of the wall or just cause swelling of unwanted material, so it is easier to remove.
[10] In area S.
[11] In area N2.
[12] It is possible, that the appearance of the veil occurred, because of the swelling of some unknown material, that was caused by its exposure to ammonium bicarbonate solution.
[13] We made a special brush, where we trimmed its bristles to get rougher cleaning accessory.
[14] *Triammonium citrate* is organic chemical compound, that is mostly used in water solution as a buffer or emulsifier. It is slightly acidic; this property can increase during exposure of *citrate* to air or other chemical compounds. Its core method of reaction is the same as of other weaker organic acids. Triammonium citrate, *pubchem.ncbi.nlm.nih.gov*, accessible at <Triammonium citrate | C6H17N3O7 - PubChem (nih.gov)> (3. 9. 2021). After the application of *triammonium citrate*, we cleaned the surface with distilled water.
[15] Japanese paper was applied with thin solution of *Arbocel* poultice in distilled water. This way we created loose layer, where all the possible impurities can freely accumulate.

The same could be said for area S. We took a closer look at this area's results. Under the UV-light, there could be seen an orange-ish coat on the surface, except on the part, that was treated with *bicarbonate poultice*. Even though before the treatment, there had not been very visible white veil in this area, absence of orange-ish coating on the surface tells us, that the treatment was somewhat successful[16].

## AMMONIUM CARBONATE CLEANING TRIAL

After we got such good results with *ammonium bicarbonate* treatment, we decided to try cleaning the surface also with *ammonium carbonate*. This reagent has a bit higher pH value and is slightly more reactive than *ammonium bicarbonate* solution[17]. That would suggest, that we could get even better results than with *ammonium bicarbonate*. Firstly, we mixed 20 % solution of *ammonium carbonate* in water. On chosen area, we applied two sheets of Japanese paper and fixed them on the wall with water-wetted brush. Than we covered them with pre-mixed *carbonate* solution. The exposure time was 10 min. During the treatment we wetted the sheets with solution up to 4× for papers to remain wet. After the treatment, we removed the Japanese paper and cleaned the areas with water-wetted cotton swabs and sponges.

After the treatment, on area N2 we could see high amount of "newly formed" white veil. The layer was rather thick. The water cleaning did nothing for removal of the veil. That is why, we also tried *ammonium citrate,* which worked, when the surface was completely dry. The white veil could also be removed with mechanical removal methods – rubbing, brushing, …

On areas S and W, there also white veil appeared, but the layer was thin and was easy to remove with just water cleaning after the treatment. The water come back a little dirty, the same colour as before (yellow/brown-ish tones), most significantly on N1 area. This is rather interesting, because in this area, there come the least amount of superficial impurities off the surface with other cleaning methods. All remains of the white wash or other white residues on these areas are, after the treatment, also much easier to remove with just some mechanical action.

[16] We inspected the edges of the processed surface and noticed, that the edges between cleaned and uncleaned surface are not sharp, but rather smooth and undefined. That occurrence could confirm our previously stated hypothesis about reaction method of the materials. If the *bicarbonate* solution would directly react with the material of the white veil, the reaction would create new compound. On the molecule level, that would mean, that there are some molecules, that collided, reacted and resulted in creation of new ones and molecules of the original materials, that did not collide with *bicarbonate* solution, did not react and, therefore, stayed intact. For reaction to occur, we need at least two reagents. This would suggest, that the reaction would took place only on the area, where the solution was applied. There would also be clear distinction between areas, where reaction was hold and where it was not. The new compound is easier to remove, so it would be cleaned off the surface with water cleaning or with some mechanical removal methods after the treatment. That would result in sharp edges between reactive and unreactive places, treated and untreated areas. But this is not our case.
The edges in our case are smooth and undefined. That is why, we could predict, that compounds did not chemically reacted to each other. This occurrence indicates to other kind of chemical reaction – swelling. Our reactive agent, *ammonium bicarbonate* solution, probably caused material of white veil to absorb extra liquid we applied, that induced increasing of volume of the material. That would explain sudden appearance of the white veil during and after the treatment. This sudden change of mechanical properties applied extra pressure between material and wall surface, which resulted in loosening the chemical bonds between them. That is why, the white veil was easier to remove after the reaction, simply by application of weak mechanical force, like brushing or cleaning with sponge. These mechanical methods removed the material in a way, that is the best explained like it was torn off the surface. That tarring of the material would explain uneven edges between treated and untreated surfaces.
Swelling effects in cross-linked polymers by thermogravimetry, *SpringerLink*, accessible at <Swelling effects in cross-linked polymers by thermogravimetry | SpringerLink> (3. 9. 2021).

[17] Ammonium carbonate, *pubchem.ncbi.nlm.nih.gov*, accessible at <Ammonium carbonate | (NH4)2CO3 - PubChem (nih.gov)> (1. 9. 2021).

We tested also what reaction we could get with prolonged exposure time. That is why we repeated the treatment with *ammonium carbonate* in a form of poultice. We mixed previously mixed solution with *Arbocel 200* and applied it on chosen area on two pre-water-wetted Japanese papers. The maximum exposure time was 40 min. After the treatment, we removed one Japanese paper sheet with poultice and cleaned the surface with water-wetted sponge through remained Japanese paper. After, we removed the other one too, and again cleaned the surface.

The prolonged exposure time got better results. On areas S, N2 and W, the white veil appeared in the same quantity as before, where the exposure time was just 10 min, but it was now much easier to remove. After the cleaning, the water come back a little dirty, but the same colour as before.

Interesting results appeared on area N1. On the upper side of the area N1, there is unidentified grey/black-ish stain. Neither of the previous treatments did succeed in removing the stain. The *ammonium carbonate* with exposure time up to 40 min did. The stain can be removed with mechanical action after the treatment. Possible future problem is, that the carbonate solution also influences the underlying colours, especially red, green and blue/black colour parts. These became very sensitive after the treatment and could be rubbed off the surface, when we are removing the stain with mechanical methods.

## IONIC EXCHANGE RESINS TRIAL

As stated above, there are multiple possible chemical compounds that could result as "white veil" on different surfaces. There are some areas, where we were quite certain, that the cause of the white veil is sulfation of the surface, the veil has plaster-ish appearance and quite possibly contain sulfate chemical group[18]. To test that theory and to try to soften the thick coating, we decided to try *ionic exchange resins*[19]. We hoped, that during ionic exchange we could remove sulfate from original material and change it for some other chemical element, which would result in breaking strong bonds that sulfate group forms and therefore tie the plaster-ish veil very strongly to the surface of the wall. The new chemical compound would be much looser and easier to remove.

We selected test place on area S. Because the resins are very fine grained and therefore quite hard for removal from very porous and rough surface as ours, we decided to use two sheets of Japanese paper. We applied them by water-wetted brush. Than we layed on them rather thick layer of pre-water-mixed *anionic exchange resins* paste. They work only, when they are wet, so we waited for them to dry and stop reacting. Then we removed the paste and Japanese papers and cleaned the surface with water-wetted sponge and cotton swabs.

Water came back a little dirty after the cleaning, but the same colour as before (yellow-ish/brown-ish). The results are not as good as predicted. The white veil is a bit easier to remove by mechanical action, but not significantly more than before the treatment[20].

---

[18] Sulfate, *pubchem.ncbi.nlm.nih.gov*, accessible at <Sulfate | O4S-2 - PubChem (nih.gov)> (1. 9. 2021).

[19] *Ionic exchange resins* are chemical substances, which work on the principle of exchanging their metallic or hydrogen ion with substance, they encounter. The substance than receive the metallic or hydrogen ion and give one of its core ion back to the *resins*. The substance during this process become loose and easier to remove, that is why, *ionic exchange resins* can be great substance for different cleaning treatments. Considering the ions, which resins exchange, we sort them on anionic, cationic and mixed (exchange both kinds of ions) *exchange resins*. P.W. ATKINS, *Physical chemistry*, Oxford 1997, p. 380-387.

[20] That would suggest, that the treatment was just partly successful. It is possible, that the results are these way, because the *resins* were not applied directly on the surface, so the Japanese papers could slow down and minimise reactive power of the *resins*. It would be interesting to test this hypothesis by applying the *resins* directly on the surface, to see, if they are really working.

## CONSOLIDATION TRIAL

During cohesion assessment we discovered, that some of the colour parts, mostly red and yellow, are in poor shape, their cohesion state is rather weak. At some point in the future, during conservation/restoration work it will be necessary to consolidate and stabilise those colour parts. This is why we made consolidation trials.

We tested how well as a consolidant works *barium hydroxide*. We mixed 10 % solution of *barium hydroxide*[21] in water, this solution we later mixed with *Arbocel 200* and *1000*. This poultice we later applied on a sheet of Japanese paper in area S. We left it to take an effect for 4 hours. After the treatment, we took down the poultice with Japanese paper and cleaned the surface with water-wetted sponge.

*Barium hydroxide* solution seemed to have the effect we wanted. Treated colour parts seemed to be stabilised and much more resistant to any mechanical action. It would be interesting to further evolve the results by changing saturation percentage of solution or to change the exposure/reaction time.

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[21] *Barium hydroxide* is chemical compound, that is widely used as an additive to different organic or inorganic materials to straighten their properties, such as improvement of their plastic properties, fusing of silicates, … In conservation/restoration it can be used as consolidant to straighten and renew effete bonds between different compounds, … R. C. Ropp, *Encyclopaedia of the Alkaline Earth Compounds*, Oxford 2013, accessible at <Barium Hydroxide - an overview | ScienceDirect Topics> (4. 9. 2021).

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*Conservation of building and decorative stone* (ed. John ASHURST, Francis G. DIMES), Oxford 1999.

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# REPORT: SUMMER SCHOOL GRADIŠČE PRI DIVAČI (SLOVENIA)

$2^{nd}$ to $27^{th}$ of August 2021

CHURCH OF ST. HELEN
CONSERVATION-RESTORATION OF WALL PAINTINGS

## ANNEX n. 2
## File tree

**Authors:** Mischa Hiltensperger and Lea Bianca Vollenweider.

**Mentors:** Alberto Felici, Neva Pološki, Suzana Damiani, Blaž Šeme, Anka Batič.

Summary

by Mischa Hiltensperger and Lea Bianca Vollenweider

A File tree is an algorithm for placing and locating files in a database. It`s a non-linear data structure. This has the advantage that data can be found and accessed more quickly than in a linear structure. Other reasons for using a folder system like this is to avoid losses of documents and improve the quality of the work that has been done. A File tree with its subfolders can be compared with a mindmap.

In 2021 Summer school we structured the File tree in eleven categories. These are:

0_Administration

1_Bibliography

2_Historical documentation

3_Building

4_Photo of the church

5_Sampling

6_Investigations

7_Reports

8_Presenations

9_Site information

10_File tree

11_Visual glossary

In the first three folders of our file tree, we have put in all input data. These are administrational informations which affect the Summer School and the site where we worked. Before the Summer school started, all the files which are in those three folders were already existing. They allowed us to get an overview of historical reports, photos of the site and similar case studies. It's important to take a look at the files in those File tree categories to gather general information's before start working on site. The following five Categories of our file tree are called the "*in itinere*" Data. They contain files which were developed during the first Summer School. The content of those files changed continuously during Summer school and information can still be changed or added until the work on site is finished. The last Folders of the File tree from 7- 11 contain output and results of our work on site. These are also folders, in which information still can be added and changed within the progress of conservation and restoration on site.
To conclude, the File tree is an important device for organizing the mass of information and administration. It is a time saving way of data management. If the work is done, there are lots of benefits for lecturers, students and peoples that are not included in the project. When you

have understood how it works, you may also project this type of data management to other projects.

The File tree we used was created by Stefania Luppichini from Supsi CR. She presented it in her lecture Data Manegement as a part of the on-line program of the 2021 Summer School.

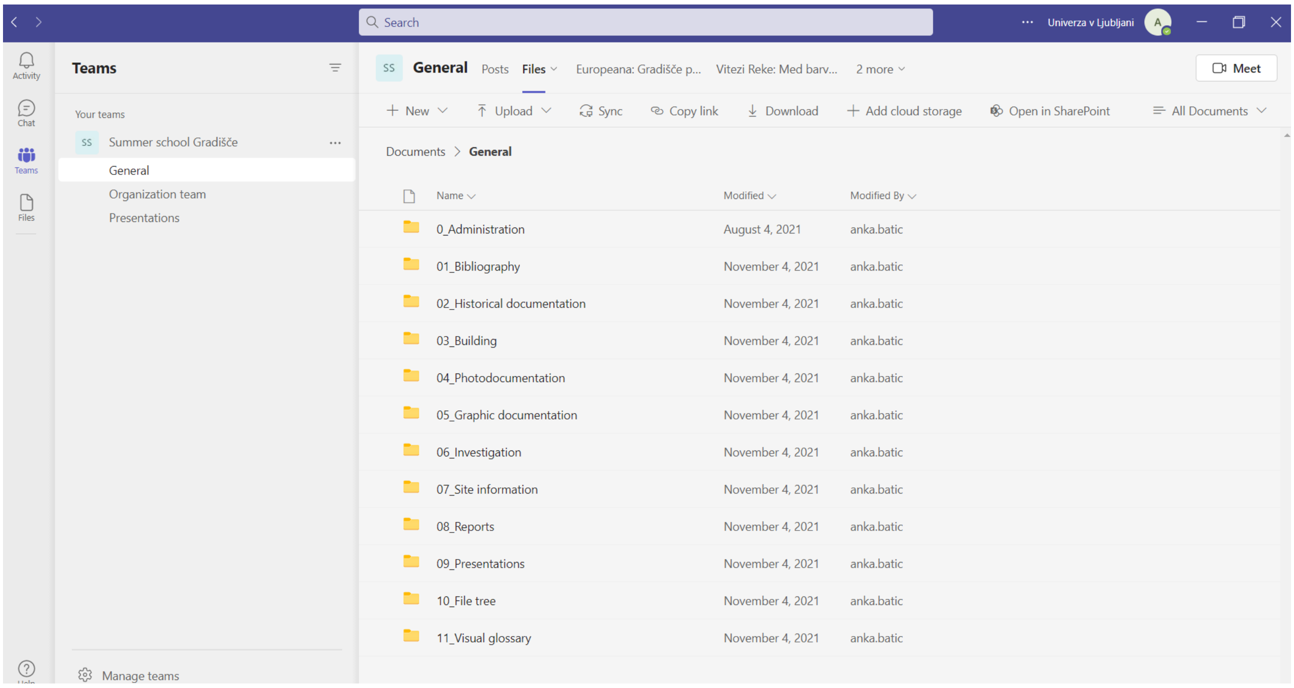


*Photo: Example of a File tree in MS Teams.*

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2nd to 27th of August 2021

CHURCH OF ST. HELEN
CONSERVATION-RESTORATION OF WALL PAINTINGS

## ANNEX n. 3
## Visual glossary

**Students/authors:** Katarina Bartolj, Eva Marija Fras, Marko Odič, Luka Ružić Stasiow, Mischa Hiltensperger, Lea Bianca Vollenweider, Melissa Cannizzo, Chiara Milazzo, Cecile Roulin.

**Mentors:** Alberto Felici, Neva Pološki, Suzana Damiani, Blaž Šeme, Anka Batič.

# Introduction

By Eva Marija Fras

To determine the state of conservation of the gothic wall paintings, we first made a survey on different phenomena characteristic to it. While we examined the painting, using visual light, UV light, raking light, portable microscope and spectroscopic methods, we started mapping all the phenomena and established definitions for all used terms. We prepared a Visual glossary, which enables us to understand each term used in the documentation. Visual glossary includes original painting techniques, decorative techniques and characteristics made during the creation of the wall paintings. The glossary also contains deterioration phenomena and previous interventions. The last part comprises of investigations that were carried out during the Summer School. Each description also includes a sample image and a chosen pattern which was used in the maps of the graphic documentation, carried out in AutoCAD.

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# GLOSSARY:
# WALL PAINTINGS IN CHURCH OF SAINT HELEN GRADIŠČE PRI DIVAČI, SLOVENIA

## SUMMER SCHOOL, August 2021

**Location:** Gradišče pri Divači, Slovenia
**Object:** Church of St. Helen
**Subject:** Wall paintings
**Owner:** Catholic church of Slovenia

**Mentors:** Alberto Felici, Neva Poloski, Suzana Damiani, Blaž Šeme, Anka Batič.
**Students:** Katarina Bartolj, Eva Marija Fras, Marko Odič, Luka Ružić Stasiow, Mischa Hiltensperger, Lea Bianca Vollenweider, Melissa Cannizzo, Chiara Milazzo, Cecile Roulin.

## ORIGINAL PAINTING TECHNIQUES

*Arriccio*

Direct Incision

*Fresco*

Ground

*Intonaco*

Joint

Masonry

*Palimpsest*

*Pentimento*

Plaster

*Pontata*

Preparatory drawing

*Punzonatura*

Sctratches

Snapped line

Stencil

## DETERIORATION PHENOMENA

Abrasion

Bulge

Color saturation

Cracks

Craquelure

Darkening

Deposit

Flakes

Glossy area

Graffiti

Lack of adhesion (Mild)

Lack of adhesion (Severe)

*Lacuna*

Leaking stains

Limewash residues

Pitting

Salt efflorescence

## DETERIORATION PHENOMENA

Salt crust

Stains

Traces of uncovering

Yellowing

Whitening

## PREVIOUS INTERVENTIONS

Consolidation

Infilling

Injection of Grout

Uncovering

Unknown material in lacunae

# 1. ORIGINAL PAINTING TECHNIQUES:

***Arriccio***

**Direct Incision**

***Fresco***

**Ground**

***Intonaco***

**Joint**

**Masonry**

***Palimpsest***

***Pentimento***

**Plaster**

***Pontata***

**Preparatory drawing**

***Punzonatura***

**Sctratches**

**Snapped line**

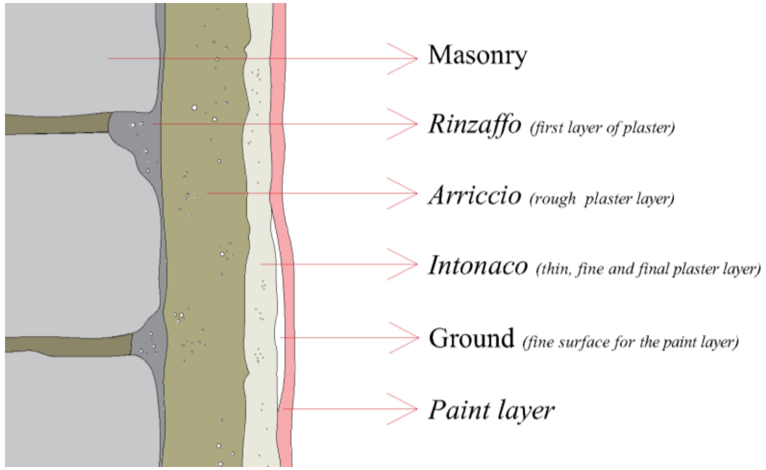
**Stencil**

| 1. | ORIGINAL PAINTING TECHNIQUES |
|---|---|
| | |
| 1. | ***ARRICCIO*** |

*Description:*

A relatively coarse plaster coat applied before the last plaster layer, the *intonaco*, for levelling the unevenness of the support.

*Source of the description:* EwaGlos,Vol.17, 2016, p. 72.




*Location:*

*Detail:*

*CAD reference:*

Arricio

AR-SAND (0.06-135)
RGB: 18,50,226

| | |
|---|---|
| 1. | ORIGINAL PAINTING TECHNIQUES |
| | |
| 2. | **DIRECT INCISIONS** |

*Description:*

Preparatory drawing technique using a pointed tool or other sharp instrument to scratch a plaster surface. It can be applied either to dry or fresh plaster. Sharp incisions are created while small mortar pieces accumulate on the edges.

*Source of the description:* EwaGlos, Vol.17, 2016, p. 134.

*Location:*

*Detail:*

*CAD reference:*

Direct incision

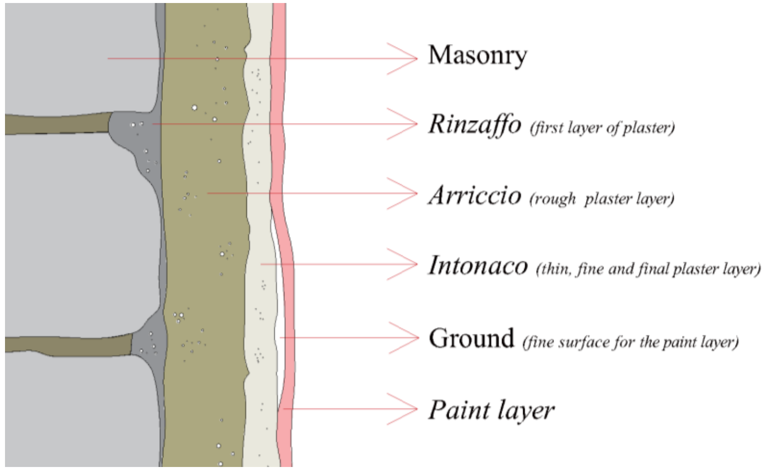
Spessore: default
RGB: 38,153,0

| 1. | ORIGINAL PAINTING TECHNIQUES |
|---|---|
| | |
| 3. | ***FRESCO*** |

*Description:*

*Fresco* is a wall painting technique in which pigments are mixed with clear water or with lime milk and applied to a fresh and still damp lime plaster (intonaco); pigments are fixed inside a thin layer of calcium carbonate formed on the plaster surface during carbonation process.

*Source of the description:* EwaGlos, Vol.17, 2016, p. 70.




*Location:*

*Detail:*

*CAD reference:*

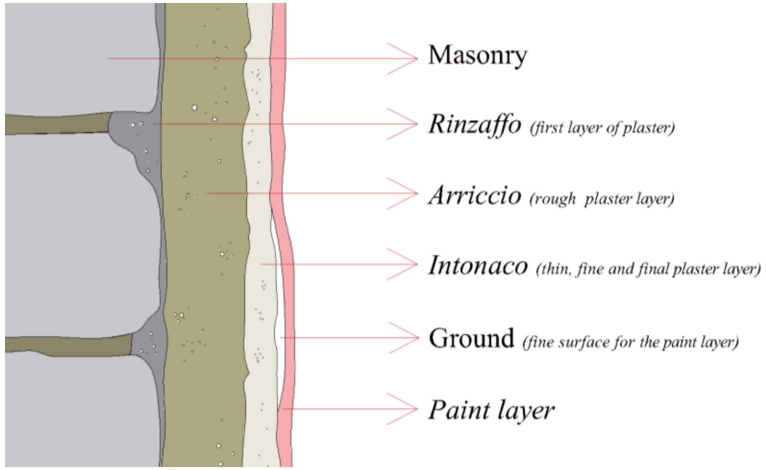
/

| 1. | ORIGINAL PAINTING TECHNIQUES |
|---|---|
| | |
| 4. | **GROUND** |

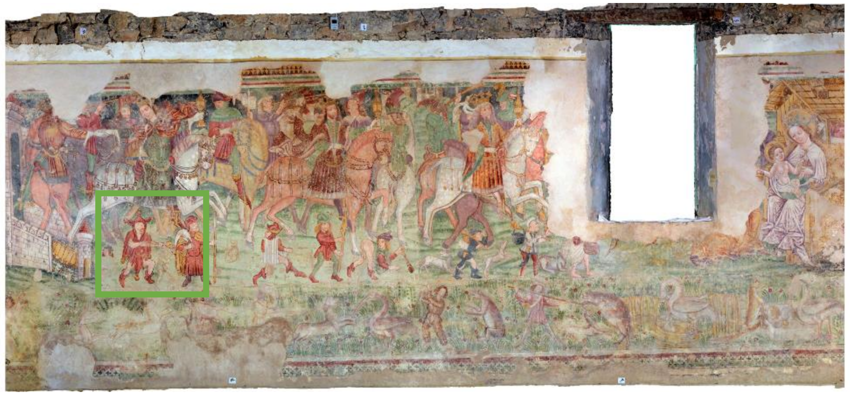
*Description:*

The first preparatory coat applied to an image carrier, to build a fine surface for the painting. In *fresco* technique ground (**limewash with oil binder**) can be applied on details (flesh tones) where prolonged painting is needed.

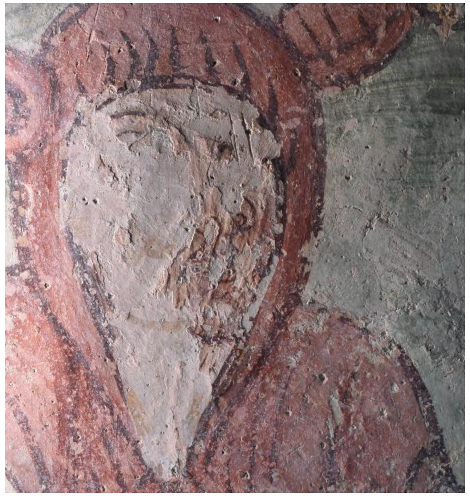
*Source of the description:* EwaGlos, Vol.17, 2016, p. 58.




*Location:*



*Detail:*



*CAD reference:*

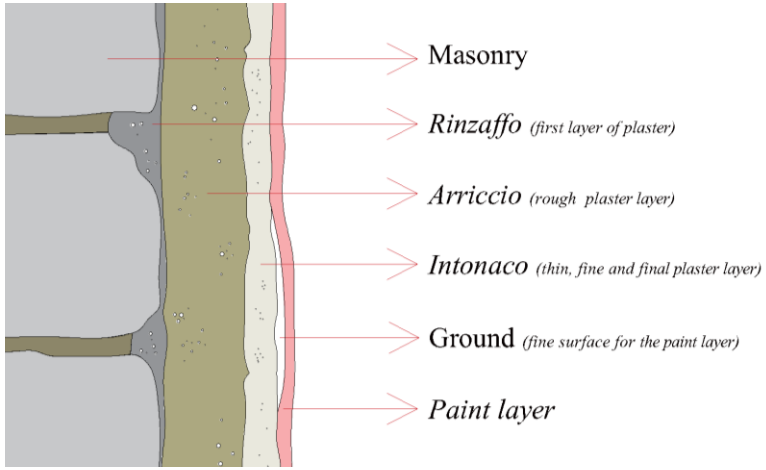
/

| 1. | ORIGINAL PAINTING TECHNIQUES |
|---|---|
| | |
| 5. | ***INTONACO*** |

*Description:*

The last, fine-grained, thin and well-evened layer of plaster on which the wall painting is applied in *fresco* technique.

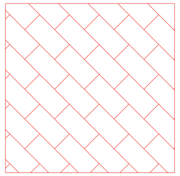
*Source of the description:* EwaGlos, Vol.17, 2016, p. 140.




*Location:*

*Detail:*

*CAD reference:*



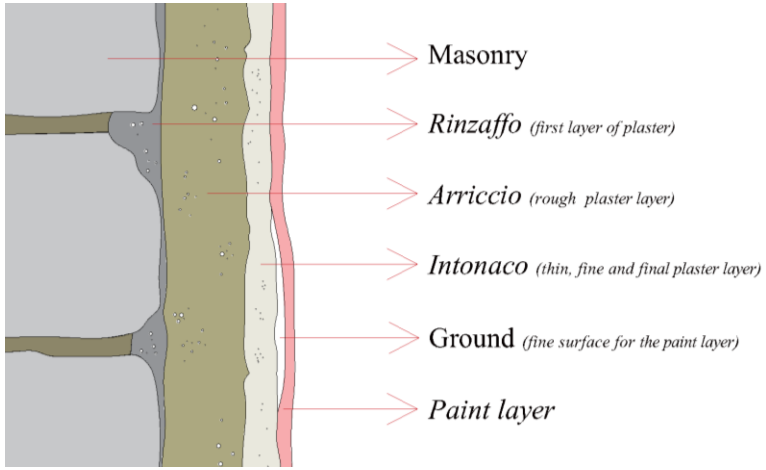
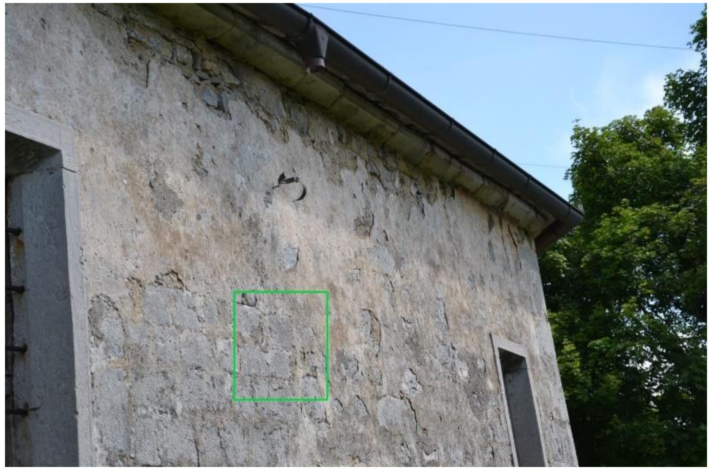
| 1. | ORIGINAL PAINTING TECHNIQUES |
|---|---|
| | |
| 6. | **JOINT** |

*Description:*

The space between masonry blocks which is filled with mortar. In the case of unplastered surfaces, mortar joints contribute to the overall appearance of the architectural surface.

*Source of the description:* EwaGlos, Vol.17, 2016, p. 38.

| *Location:* | *Detail:* | *CAD reference:* |
|---|---|---|
|  |  | / |

<table>
<tr><td>1.</td><td colspan="3">ORIGINAL PAINTING TECHNIQUES</td></tr>
<tr><td></td><td></td><td colspan="2" rowspan="4"></td></tr>
<tr><td>7.</td><td>MASONRY</td></tr>
<tr><td colspan="2">Description:<br><br>The art and craft of building which creates structures from building blocks (masonry units). These blocks can be extracted or manufactured, and include stone (rubble or ashlar), adobe, brick, and concrete. They are also bonded tagether with mortar, and possibly grout and/or reinforcement.</td></tr>
<tr><td colspan="2">Source of the description: EwaGlos, Vol.17, 2016, p. 26.</td></tr>
<tr><td colspan="2">Location:<br></td><td>Detail:<br></td><td>CAD reference:<br><br>/</td></tr>
</table>

| 1. | ORIGINAL PAINTING TECHNIQUES |
|---|---|
| | |
| 8. | ***PALIMPSEST*** |

*Description:*

Plaster and painting layers preserved under an existing wall painting.

*Source of the description:* EwaGlos, Vol.17, 2016, p. 108.

| *Location:* | *Detail:* | *CAD reference:* |
|---|---|---|
|  |  | Palimpsest<br>SOLID<br>RGB: 8,155,38 |

| 1. | ORIGINAL PAINTING TECHNIQUES |
|---|---|
| | |
| 9. | ***PENTIMENTO*** |

*Description:*

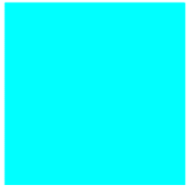
Correction of the painting done by the artist himself.

*Source of the description:* EwaGlos, Vol.17, 2016, p. 90.

*Location:*

*Detail:*

*CAD reference:*



Pentimenti

SOLID

RGB: 0,255,255

| 1. | ORIGINAL PAINTING TECHNIQUES |
|---|---|
| | |
| 10. | **PLASTER** |

*Description:*

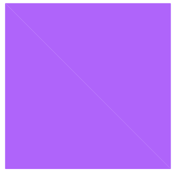
Protective and/or decorative coat which is applied to architectural surfaces. It is also used for molding and casting decorative elements.

*Source of the description:* EwaGlos, Vol.17, 2016, p. 50.

*Location:*

*Detail:*

*CAD reference:*



Infilling

SOLID
RGB: 175,100,250

| 1. | ORIGINAL PAINTING TECHNIQUES |
|---|---|
| | |
| 11. | ***PONTATA*** |

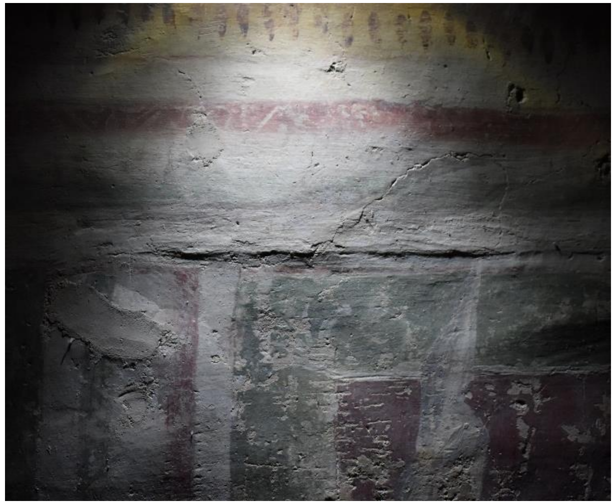
*Description:*

A wide area of plaster applied at the same high as the scaffolding, leaving horizontal seams in the finished work.

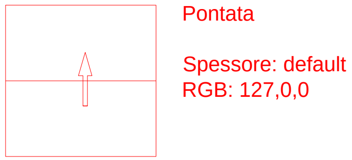
*Source of the description:* EwaGlos, Vol.17, 2016, p. 74.

*Location:*

*Detail:*



*CAD reference:*

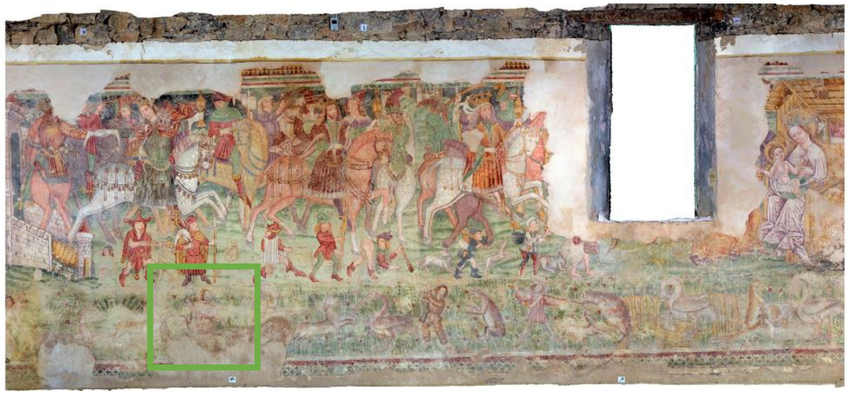
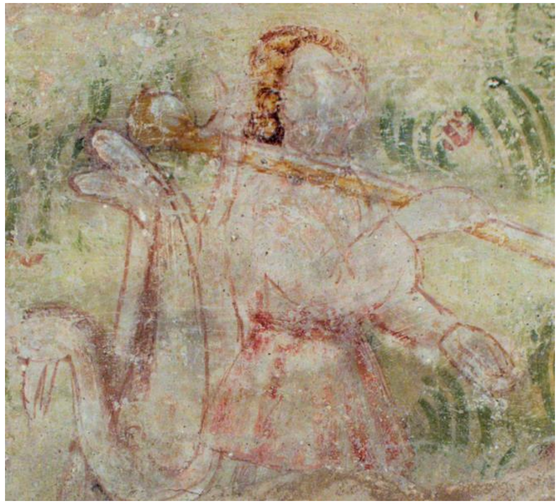
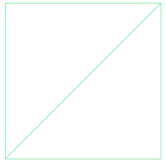


| | |
|---|---|
| 1. | ORIGINAL PAINTING TECHNIQUES |
| | |
| 12. | **PREPARATORY DRAWING** |

*Description:*

Preliminary drawing done before further work is undertaken, that is usually followed by work in a different medium. This is done on the intonaco in the case of murals.

*Source of the description:* EwaGlos, Vol.17, 2016, p. 130.

| *Location:* | *Detail:* | *CAD reference:* |
|---|---|---|
|  |  | <br>Preparatory drawing<br><br>Spessore: default<br>RGB: 73,228,135 |

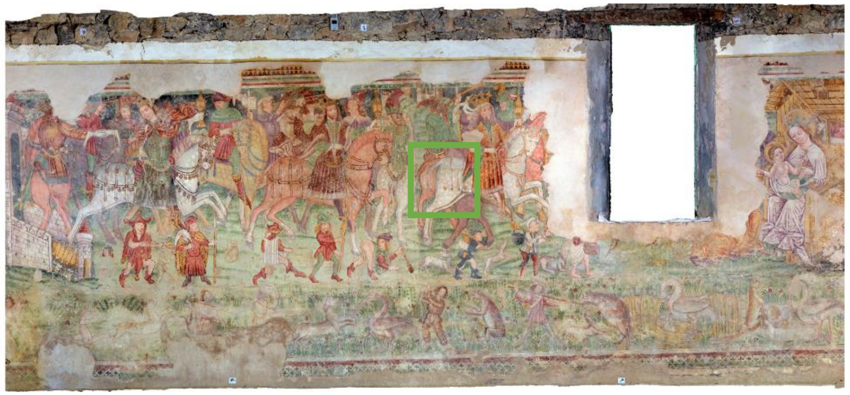
| | |
|---|---|
| 1. | ORIGINAL PAINTING TECHNIQUES |
| | |
| 13. | ***PUNZONATURA*** |

*Description:*

Decorative technique of pressing tools (*punze*) in fresh plaster. It is used in fresco technique on halos, crowns and other details.

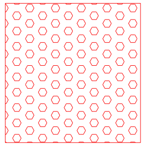
*Source of the description: Summer school Gradisce 2021.*

*Location:*



*Detail:*

*CAD reference:*



Punzonatura

HEX (0-1)
RGB: 250,0,0

| | |
|---|---|
| 1. | ORIGINAL PAINTING TECHNIQUES |
| | |
| 14. | **SCRATCHES** |

*Description:*

Roughening the surface due to achieve better adhesion for the next plaster layer.

*Source of the description:Summer school Gradisce 2021.*

*Location:*

*Detail:*

*CAD reference:*

Scratches

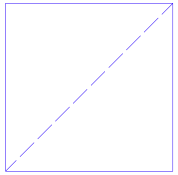
ANSI31 (0-4)
Spessore: default
RGB: 250,128,114

| 1. | ORIGINAL PAINTING TECHNIQUES |
|---|---|
| | |
| 15. | **SNAPPED LINE** |

*Description:*

A method of applying a straight line on plaster (can be coloured or without colour) by stretching a piece of string, pulling back and releasing it so that it snaps against the painting, leaving a mark.

*Source of the description:* EwaGlos, Vol.17, 2016, p. 126.

| *Location:* | *Detail:* | *CAD reference:* |
|---|---|---|
|  |  |  Snapped line<br><br>TRATTEGGIATA<br>Spessore: default<br>RGB: 255,127,0 |

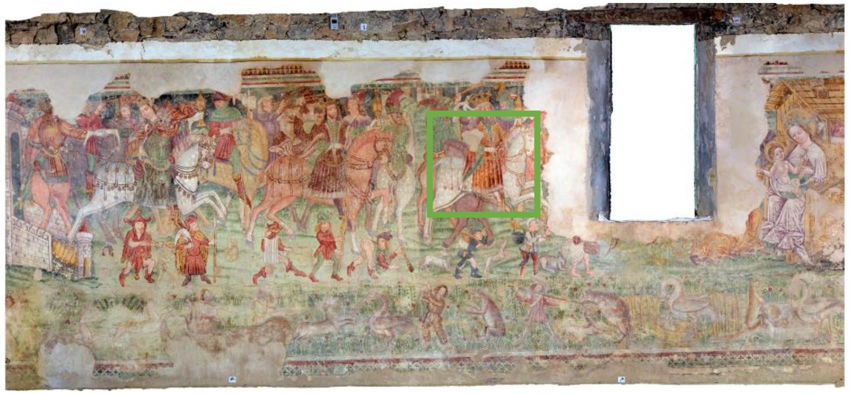
| 1. | ORIGINAL PAINTING TECHNIQUES |
|---|---|
| | |
| 16. | **STENCIL** |

*Description:*

Reproduction technique to produce an ornamental pattern, with the use of a template.

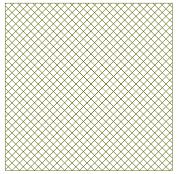
*Source of the description:* EwaGlos, Vol.17, 2016, p. 140.

*Location:*



*Detail:*

*CAD reference:*



Stencil

ANSI37 (0-2.5)
RGB: 127,0,31

## 2. DETERIORATION PHENOMENA:

| | |
|---|---|
| **Abrasion** | **Salt crust** |
| **Bulge** | **Stains** |
| **Color saturation** | **Traces of uncovering** |
| **Cracks** | **Yellowing** |
| **Craquelure** | **Whitening** |
| **Darkening** | |
| **Deposit** | |
| **Flakes** | |
| **Glossy area** | |
| **Graffiti** | |
| **Lack of adhesion (Mild)** | |
| **Lack of adhesion (Severe)** | |
| ***Lacuna*** | |
| **Leaking stains** | |
| **Limewash residues** | |
| **Pitting** | |
| **Salt efflorescence** | |

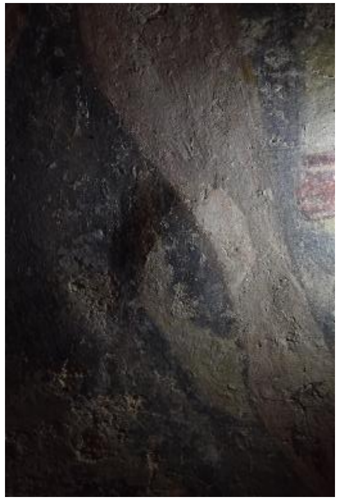
<table>
<tr><td>2.</td><td colspan="2">DETERIORATION PHENOMENA</td></tr>
<tr><td></td><td colspan="2"></td></tr>
<tr><td>1.</td><td colspan="2">ABRASION</td></tr>
<tr><td colspan="3">Description:<br><br>Superficial loss or damage as a result of mechanical action due to friction; the process of rubbing away the surface of the material.</td></tr>
<tr><td colspan="3">Source of the description: EwaGlos, Vol.17, 2016, p. 186; Cambridge dictionary; dictionary.cambridge.org/dictionary/english/abrasion.</td></tr>
<tr><td>Location:<br></td><td>Detail:<br></td><td>CAD reference:<br>Abrasion (paint layer)<br>SOLID<br>RGB: 212,212,212<br><br>Abrasion (paint layer)<br>SOLID<br>RGB: 212,212,212</td></tr>
</table>

| 2. | DETERIORIATION PHENOMENA |
|---|---|
| | |
| 2. | **BULGE** |

*Description:*

Localised rounded protuberance or swelling from within or underneath caused by pressure.

*Source of the description:* EwaGlos, Vol.17, 2016, p. 200.

| *Location:* | *Detail:* | *CAD reference:* |
|---|---|---|
|  |  | / |

| 2. | DETERIORIATION PHENOMENA |
|---|---|
| | |
| 3. | **COLOUR SATURATION** |

*Description:*

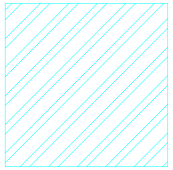
The intensification of colour of a surface caused by humidity or by the use of construction or conservation materials.

*Source of the description:* EwaGlos, Vol.16, 2016, p. 218.

*Location:*

*Detail:*

*CAD reference:*



Colour Saturation

ANSI 32 (0-1.3)
RGB: 0,255,255

| 2. | DETERIORIATION PHENOMENA |
|---|---|
| | |
| 4. | **CRACKS** |

*Description:*

A discontinuity in an architectural surface or wall painting, resulting in a visible separation of one part from another, that extends through one or more layers.

*Source of the description:* EwaGlos, Vol.17, 2016, p. 204.

*Location:*

*CAD reference:*

Cracks

Spessore: default
RGB: 255,0,63

| | |
|---|---|
| 2. | DETERIORIATION PHENOMENA |
| | |
| 5. | **CRAQUELURE** |

*Description:*

A network of fine minor cracks specific to secco paint layers.

*Source of the description:* EwaGlos, Vol.17, 2016, p. 208.

*Location:*

*Detail:*

*CAD reference:*

Craquelures

SOLID (Transparency 50)
RGB: 255,46,255

| 2. | DETERIORIATION PHENOMENA |
|---|---|
| | |
| 6. | **DARKENING** |

*Description:*

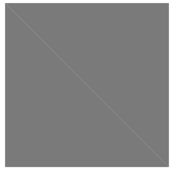
A change in the surface colour due to a decrease in hue (reduction of visible light reflection).

*Source of the description:* EwaGlos, Vol.17, 2016, p. 216.

*Location:*

*Detail:*

*CAD reference:*



Darkening

SOLID
RGB: 122,122,122

| 2. | DETERIORIATION PHENOMENA |
|---|---|
| | |
| 7. | **DEPOSIT** |

*Description:*

Accumulated (foreign) matter on the surface of the paint layer.

*Source of the description:* Summer school Gradišče 2021.

| *Location:* | *Detail:* | *CAD Reference:* |
|---|---|---|
|  |  | Deposit<br><br>SOLID (Transparency 60)<br>RGB: 26,110,8 |

| 2. | DETERIORIATION PHENOMENA | |
|---|---|---|
| | | |
| 8. | **FLAKES** | |
| *Description:*<br><br>The partial or complete detachment of fragments of the paint layer and/or the ground from an underlying layer (support, plaster). The detachment is parallel to the underlying surface and the fragments are usually small and thin. | | |
| *Source of the description:* Summer school Gradišče 2021. | | |
| *Location:*<br> | *Detail:*<br> | *CAD Reference:*<br><br>/ |

| 2. | DETERIORIATION PHENOMENA |
|---|---|
| | |
| 9. | **GLOSSY AREA** |

*Description:*

Reflectance of the light on the painting layer.

*Source of the description:* Summer school Gradišče 2021, redesigned from EwaGlos, Vol.17, 2016, p. 180.

| *Location:* | *Detail:* | *CAD reference:* |
|---|---|---|
|  |  | Glossy Area<br><br>SOLID<br>RGB: 245, 53, 10 |

| 2. | DETERIORATION PHENOMENA |
|---|---|
| | |
| 10. | **GRAFFITI** |

*Description*:

Usually damage caused by deliberate or unintentional human acts.

Graffiti can be written on the surface with the use of various materials (ex. pencil, spray paints) or scratched into the plaster.

*Source of the description:* EwaGlos, Vol.17, 2016, p. 173.

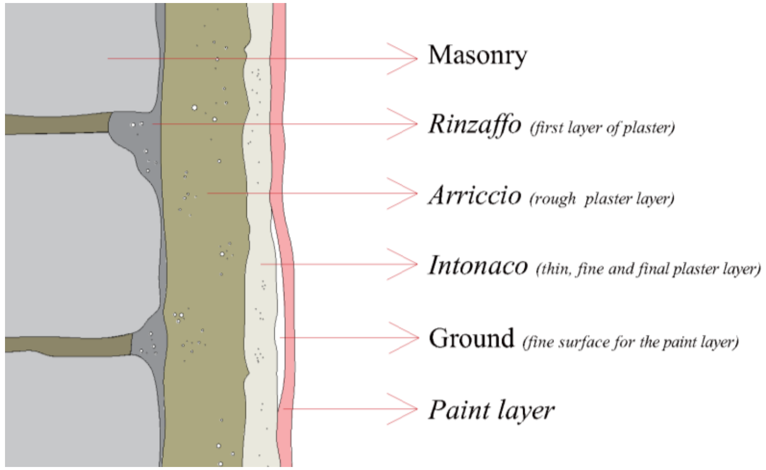
| *Location:* | *Detail:* | *CAD reference:* |
|---|---|---|
|  |  | / |

| 2. | DETERIORATION PHENOMENA |
|---|---|
| 11. | **LACK OF ADHESION (MILD)** |

*Description:*

Lack of adhesion between the plaster layers (rinzaffo, arriccio and/or intonaco) or between plaster and the support, resulting in hollow spaces and damages.

*Source of the description:* Summer school Gradišče 2021.




*Location:*

*Detail:*

*CAD reference:*

Lack of adhesion (Light)

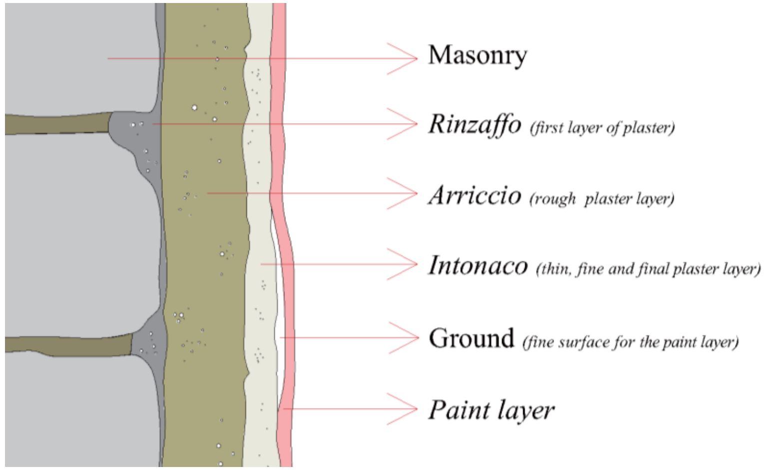
SOLID (Transparency 60)
RGB: 0,0,255

| 2. | DETERIORATION PHENOMENA |
|---|---|
| | |
| 12. | **LACK OF ADHESION (SEVERE)** |

*Description:*

Lack of adhesion between the plaster layers (rinzaffo, arriccio and/or intonaco) or between plaster and the support, resulting in hollow spaces and damages.

*Source of the description:* Summer school Gradišče 2021.




*Location:*

*Detail:*

*CAD reference:*

Lack of adhesion (Severe)

SOLID (Transparency 60)
RGB: 196,48,18

| 2. | DETERIORIATION PHENOMENA |
|---|---|
| | |
| 13. | ***LACUNA*** |

*Description:*

Missing part of a wall painting, discontinuity across a surface which can be of different sizes and depths (paint layer, plaster layers).

*Source of the description:* Summer school Gradišče 2021, redesigned from EwaGlos, Vol.17, 2016, p. 180.

| *Location:* | *Detail:* | *CAD reference:* |
|---|---|---|
|  |  |  |

| | |
|---|---|
| 2. | DETERIORIATION PHENOMENA |
| | |
| 14. | **LEAKING STAINS** |

*Description:*

Change in color due to infiltration of water.

*Source of the description:* Summer school Gradišče 2021.

*Location:*

*Detail:*

*CAD reference*

Leaking stains

SOLID
RGB: 210,185,80

| 2. | DETERIORIATION PHENOMENA |
|---|---|
| | |
| 15. | **LIMEWASH RESIDUES** |

*Description:*

Residues of lime wash on wall painting. After uncovering of wall painting residues of limewash can be found.

*Source of the description:* EwaGlos, Vol.17, 2016, p. 200.

| *Location:* | *Detail:* | *CAD reference: /* |
|---|---|---|
|  |  | / |

<table>
<tr><td>2.</td><td colspan="3">DETERIORATION PHENOMENA</td></tr>
<tr><td></td><td colspan="3"></td></tr>
<tr><td>16.</td><td colspan="3">PITTING</td></tr>
<tr><td colspan="4">Description:<br><br>Damage of intonaco caused by the volume change of the aggregates.</td></tr>
<tr><td colspan="4">Source of the description: Summer school Gradišče 2021.</td></tr>
<tr><td colspan="2">Location:<br></td><td>Detail:<br></td><td>CAD reference:<br><br>/</td></tr>
</table>

| 2. | DETERIORIATION PHENOMENA |
|---|---|
| | |
| 17. | **SALTS CRUST** |

*Description:*

Formation and surface accumulation of soluble salts of crystalline appearance.

*Source of the description:* Summer school Gradišče 2021, redesigned from EwaGlos, Vol.17, 2016, p. 166.

| *Location:* | *Detail:* | *CAD Reference:* |
|---|---|---|
|  |  | / |

| 2. | DETERIORIATION PHENOMENA |
|---|---|
| | |
| 18. | **STAINS** |

*Description:*

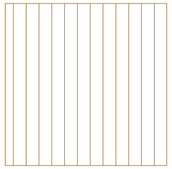
Damp stains on the wall due to the condensation process.

*Source of the description:* Summer school Gradišče 2021.

*Location:*

*Detail:*

*CAD Reference:*



Stains

ANSI 31 (90-2)
RGB: 111,127,63

| | |
|---|---|
| 2. | DETERIORIATION PHENOMENA |
| | |
| 19. | **TRACES OF UNCOVERING** |

*Description:*

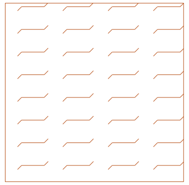
Mechanical damage on the surface of the paint layer caused in the process of uncovering (removal of the limewash).

*Source of the description:* Summer school Gradišče 2021.

*Graphic documentation of the detail*

*Detail:*

*CAD reference:*



Uncovering

FLEX (0-2)
RGB: 182,75, 17

| 2. | DETERIORIATION PHENOMENA |
|---|---|
| | |
| 20. | **YELLOWING** |

*Description:*

Chromatic alteration of the materials in a yellowish hue.

*Source of the description:* Summer school Gradišče 2021, redesigned from EwaGlos, Vol.17, 2016, p. 214.

*Location:*

*Detail:*

*CAD Reference:*

| 2. | DETERIORIATION PHENOMENA |
|---|---|
| | |
| 21. | **WHITENING** |

*Description:*

White film on an architectural surface due to the formation of a deposit (particles).

*Source of the description:* Summer school Gradišče 2021, redesigned from EwaGlos, Vol.17, 2016, p. 212.

*Location:*

*Detail:*

*CAD reference:*

Whitening

SOLID
RGB: 124,219,0

## 3. PREVIOUS INTERVENTIONS:

**Consolidation**

**Infilling**

**Injection of Grout**

**Uncovering**

**Unknown material in lacunae**

| 3. | PREVIOUS INTERVENTIONS |
|---|---|
| | |
| 1. | **CONSOLIDATION** |

*Description:*

Procedure aimed at re-establishing the loss of mechanical strength and improving the internal cohesion of different layers that make up an artwork. It is performed via the application, by impregnation or injection, of adhesive products within the voids of the structure or material.
Comment: There can be two types of consolidation: - Temporary consolidation: provisional application of an adhesive product, that will allow further treatments of the artwork. - Long-term consolidation: definitive application of an adhesive product that attempts to completely permeate the inner spaces of the original material of the artwork. The products used for this purpose must have good stability over time.

*Source of the description:* EwaGlos, Vol.17, 2016, p. 312.

*Location:*

*Detail:*

*CAD reference:*

/

| 3. | PREVIOUS INTERVENTIONS |
|---|---|
| | |
| 2. | **INJECTION OF GROUT** |

*Description:*

Adhesion of layers or fragments of mortars, plasters or renders with the injection of a fluid and fine-grained mortar (grout) inside small spaces, cracks and pores. Comment: in order to avoid potential risks to the object it is necessary to control the amount of water and other solvents in the injected grouts, their compatibility with the original materials and the adhesion between the treated layers.

*Source of the description:* EwaGlos, Vol.17, 2016 p. 316.

| *Location:* | *Detail:* | *CAD reference:* |
|---|---|---|
|  |  | Injection of grout<br><br>SOLID<br>RGB: 0,165,41 |

| 3. | PREVIOUS INTERVENTIONS |
|---|---|
| | |
| 3. | **INFILLING** |

*Description:*

To reestablish continuity between layers reinstating their structural and aesthetic properties. A lacuna in plaster layers can be infilled with a mixture consisting of a filler and a binder. Note: The lacunas in plaster layers are reinstated with new plaster.

*Source of the description: EwaGlos, Vol.16, 2016 p. 318.*

*Location:*

*Detail:*

*CAD reference:*

Infilling

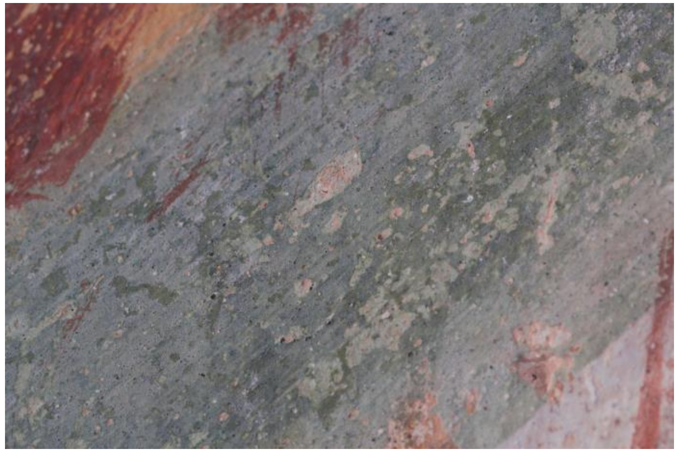
SOLID
RGB: 208,207,144

| 3. | PREVIOUS INTERVENTIONS |
|---|---|
| | |
| 4. | **UNCOVERING** |

*Description:*

Uncovering is the process of discovering or exposing a wall painting. It involves the controlled removal of various superimposed and overlaying layers. The removal of these layers can be seen on the paint layer.

*Source of the description:* Summer school Gradišče 2021, redesigned from EwaGlos, Vol.16, 2016, p. 326.

| *Location:* | *Detail:* | *CAD reference:* |
|---|---|---|
|  |  | / |

| 3. | PREVIOUS INTERVENTIONS |
|---|---|
| | |
| 5. | **UNKNOWN MATERIAL IN *LACUNA*** |

*Description:*

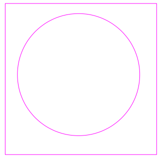
Unknown material in *lacuna* and cracks possibly to assist when injecting the grout.

*Source of the description:* Summer school Gradišče 2021.

*Location:*

*Detail:*

*CAD reference:*



Unknown material in lacuna

CIRCLE
Spessore: default
RGB: 255,0,255

Source of images, orthophoto and drawing:

*1. Source of images:* Summer School Archive, August 2021.

*2. Orthophoto:* Poročilo o izvedenem 3D dokumentiranju poslikav v cerkvi sv. Helene v Gradišču pri Divači, Gašper Rutar, univ. dipl. Arh., maj 2021.

3. Drawing of statigraphy: Anka Batič, Alberto Felici.

# REPORT: SUMMER SCHOOL GRADIŠČE PRI DIVAČI (SLOVENIA)

2nd to 27th of August 2021

CHURCH OF ST. HELEN
CONSERVATION-RESTORATION OF WALL PAINTINGS

## ANNEX n. 4
## Mapping

**Students/authors:** Katarina Bartolj, Eva Marija Fras, Marko Odič, Luka Ružić Stasiow, Mischa Hiltensperger, Lea Bianca Vollenweider, Melissa Cannizzo, Chiara Milazzo, Cecile Roulin, Anka Batič.

**Mentors:** Alberto Felici, Neva Pološki, Suzana Damiani, Blaž Šeme, Anka Batič.

## Introduction

By Mellisa Canizzo

During the 2021 Summer School in Gradišče pri Divači, Slovenia the mural paintings were well documented. One of the documentation processes was mapping out:

1. painting techniques
2. previous interventions
3. deterioration phenomena

As a first step, a visual analysis of the wall paintings was carried out using: raking light, visible light, UV light[1]; Dinolite portable microscope.

In order to map the lack of adhesion between the plaster layers, the knock test was carried out on the entire surface of the walls.
The results regarding the condition of conservation of the wall paintings were mapped on paper prints depicting painting; all the obtained results were also documented and photographed.
In addition to the execution techniques, previous interventions and degradation phenomena, the investigations carried out on the walls, the various tests to determine the cohesion of the pigments and the cleaning tests were also mapped.
The basis for this work was orthophotos and all the data was transferred from the paper printouts to the Autocad software,

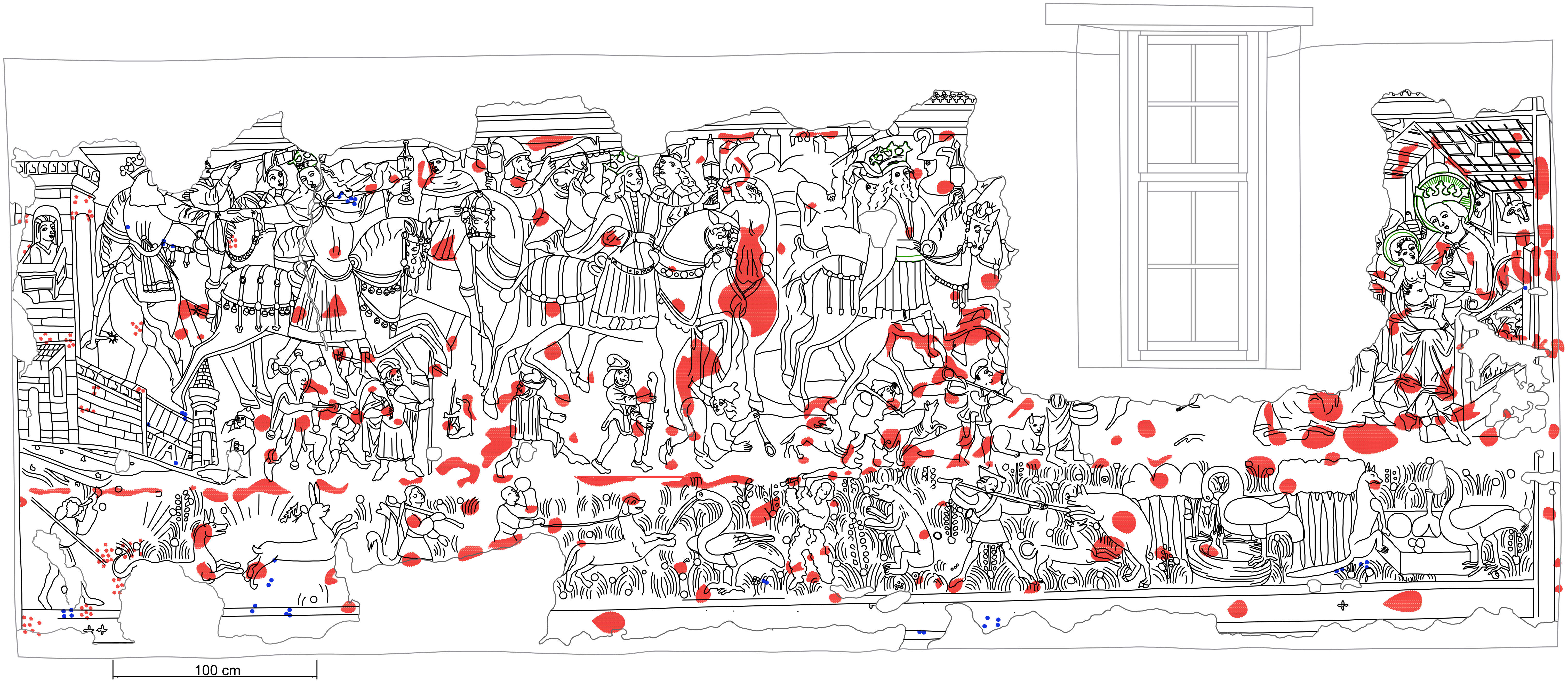
[1] A lamp was used that transmitted wavelengths in the UV but also in visible light, facilitating visual analysis.

creating legends with the Cad references in conjunction with the definitions in the visual glossary.
The graphic drawing of the wall paintings was done in the Autocad software. It was used as a background for the mapping.
Some students were not familiar with the Autocad, so this work has certainly enabled them to become more familiar with the software and understand its mechanisms.

Index

**Previous interventions**

Summer School Gradišče pri Divači, St. Helen, August 2021, **Mapping, Original Technique, Constituent material, Northern wall.**



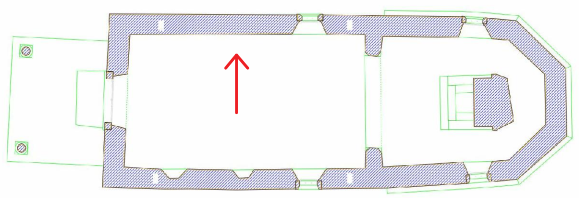

LEGENDA:

*Direct incision*

*Pentimento*

*Intonaco*

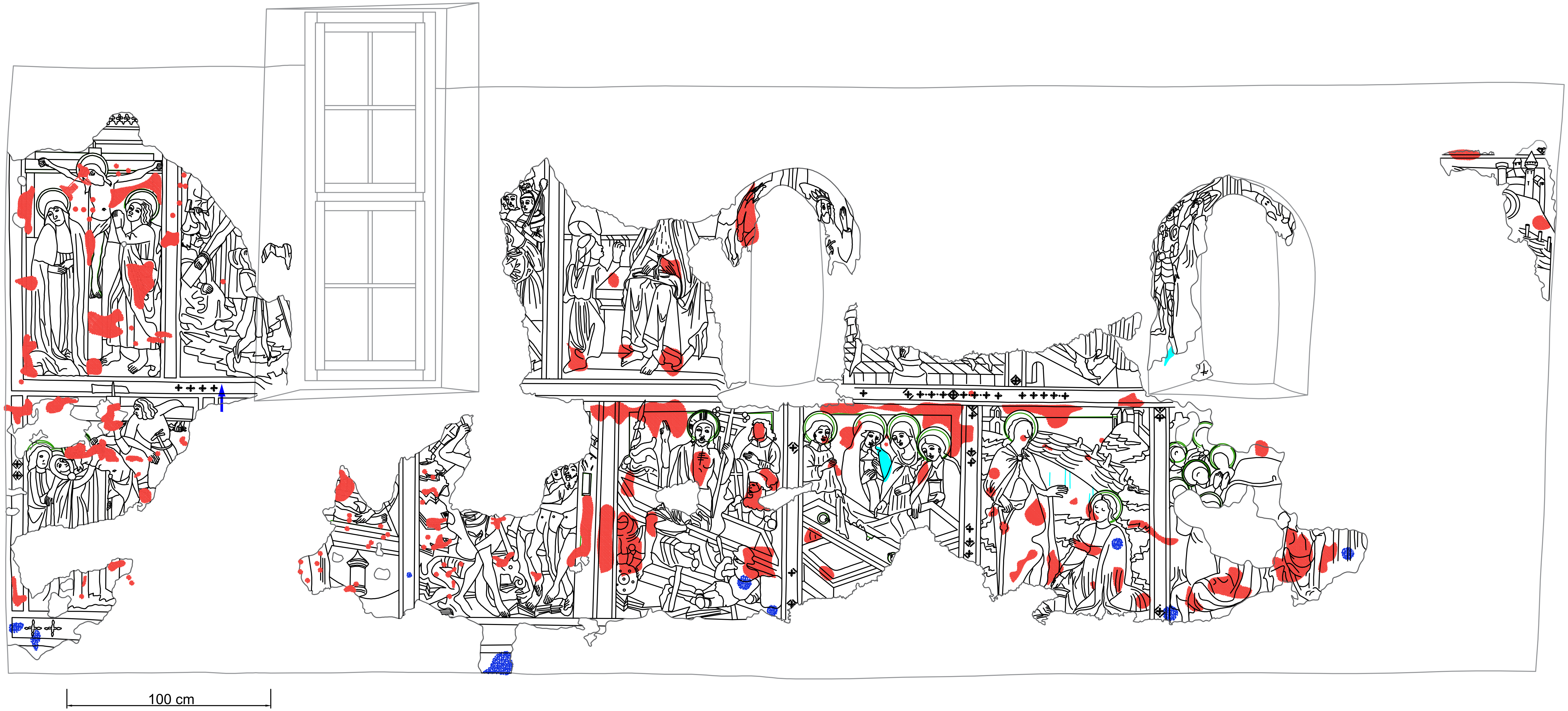
Direct incision



**Location:** Gradišče pri Divači
**Object:** Church of St. Helen
**Subject:** Wall painting

**Mentors:** Alberto Felici, Anka Batič.
**Students:** Katarina Bartolj, Eva Marija Fras, Marko Odič, Luka Ružić Stasiow, Mischa Hiltensperger, Lea Bianca Vollenweider, Melissa Cannizzo, Chiara Milazzo, Cecile Roulin.

Summer School Gradišče pri Divači, St. Helen, August 2021, **Mapping, Original Technique, Constituent material, Southern wall.**



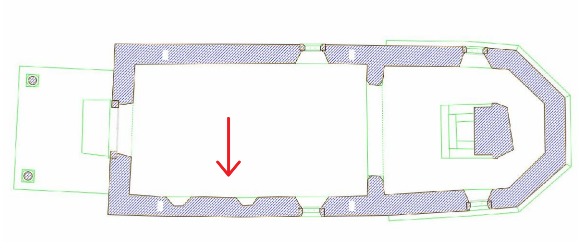

LEGENDA:

*Arriccio*

*Pentimento*

*Intonaco*

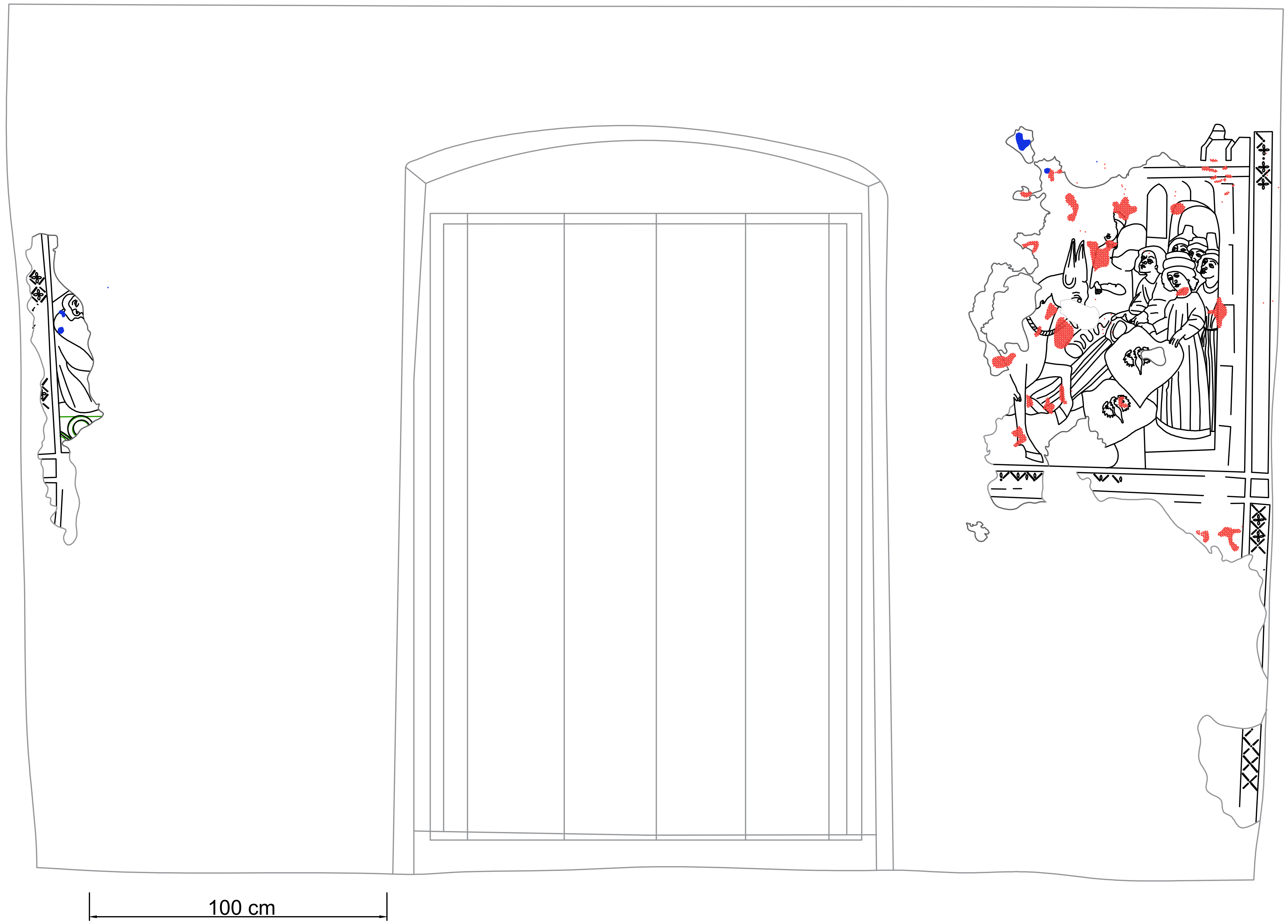
Direct incision



**Location:** Gradišče pri Divači
**Object:** Church of St. Helen
**Subject:** Wall paintings

**Mentors:** Alberto Felici, Anka Batič.
**Students:** Katarina Bartolj, Eva Marija Fras, Marko Odič, Luka Ružić Stasiow, Mischa Hiltensperger, Lea Bianca Vollenweider, Melissa Cannizzo, Chiara Milazzo, Cecile Roulin.

Summer School Gradišče pri Divači, St. Helen, August 2021, **Mapping, Original Technique, Constituent material, Western wall.**



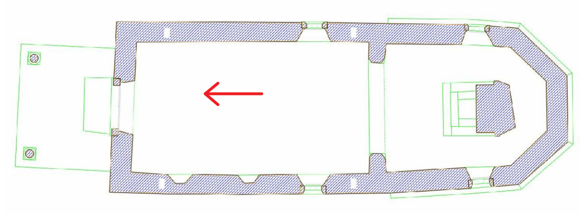

LEGENDA:

*Arricio*

*Pentimento*

*Intonaco*

Direct incision



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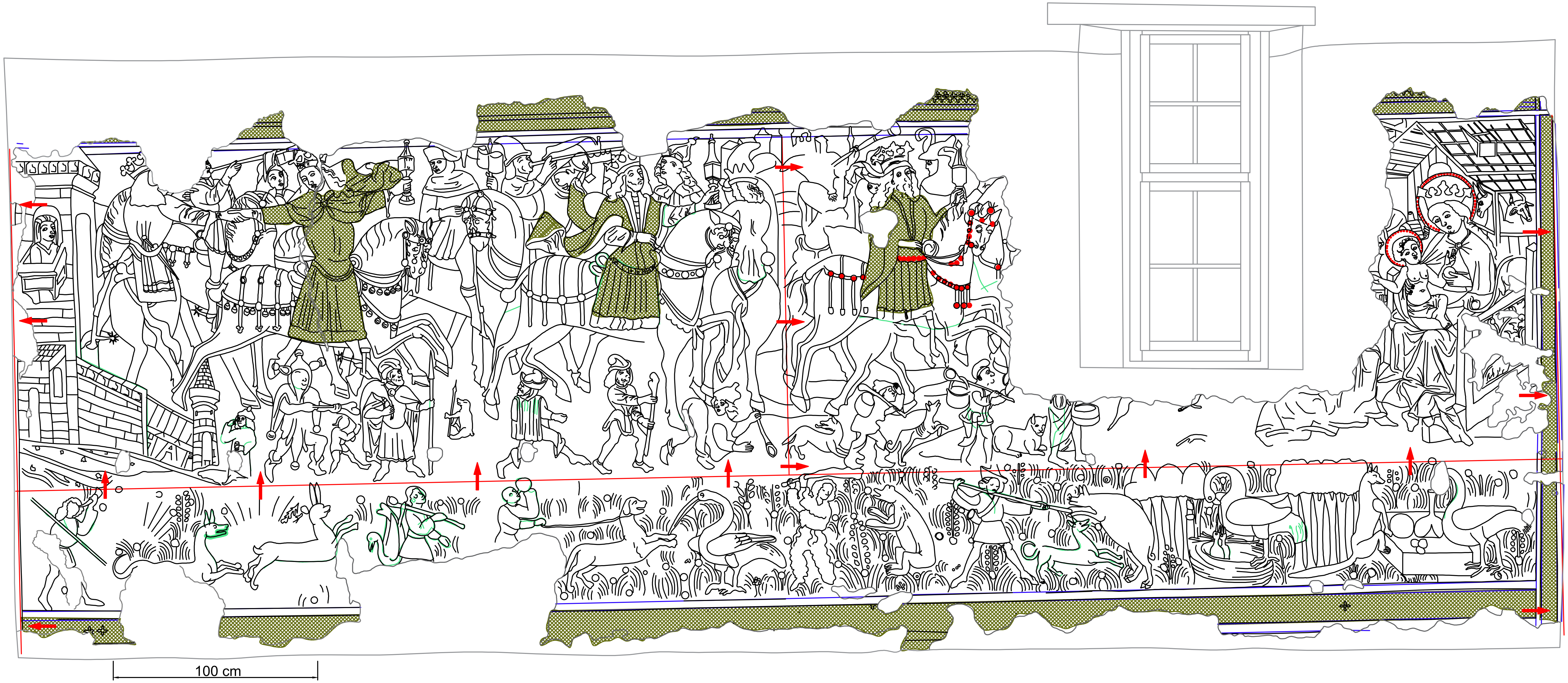
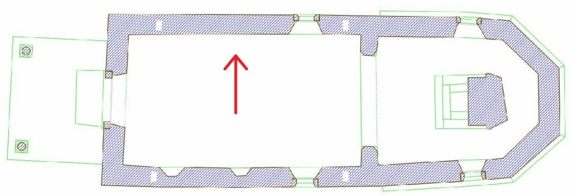



LEGENDA:

Snapped line

*Pontata*

Preparatory drawing



Stencil

Scratches

*Punzonatura*

**Location:** Gradišče pri Divači
**Object:** Church of St. Helen
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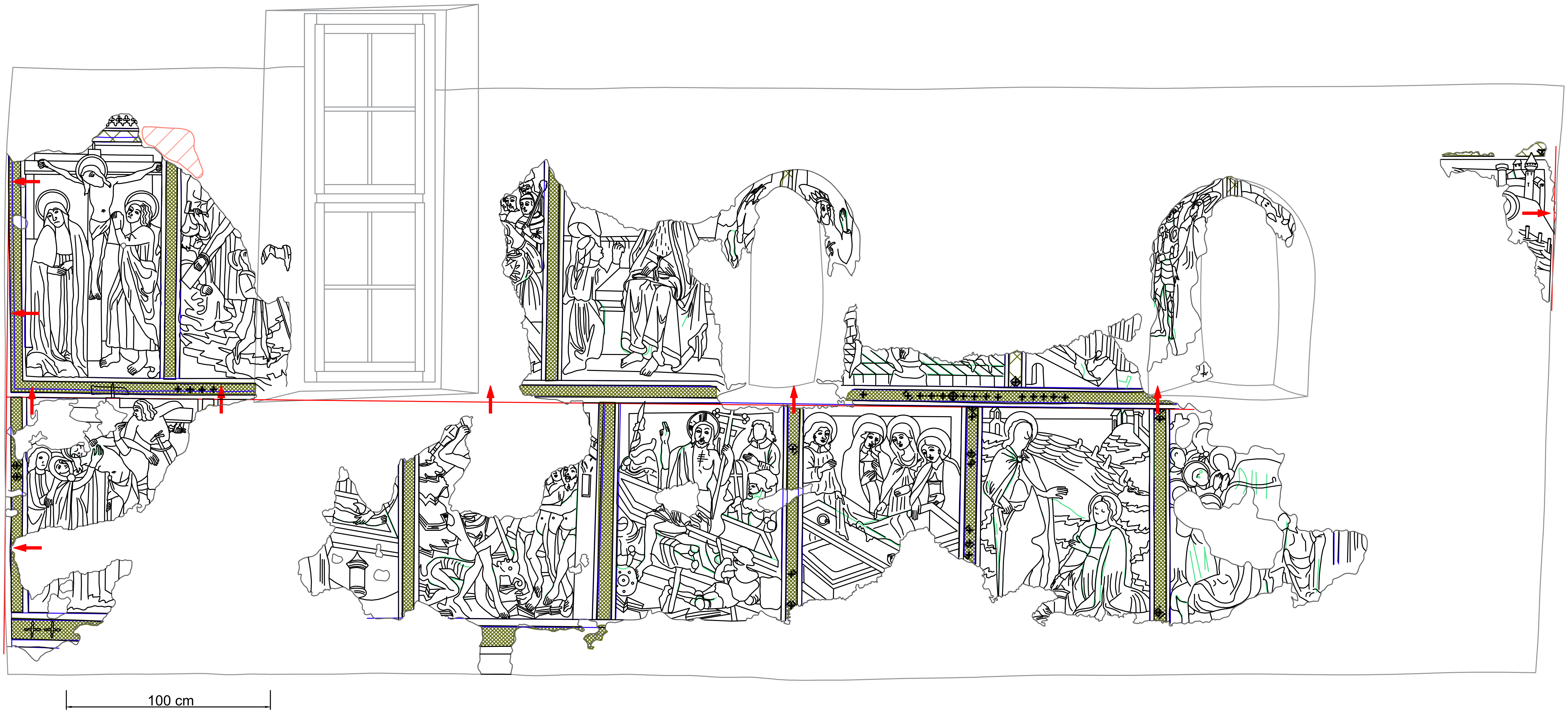
Summer School Gradišče pri Divači, St. Helen, August 2021, **Mapping, Original Technique, Constituent material, Southern wall.**




LEGENDA:

Snapped line

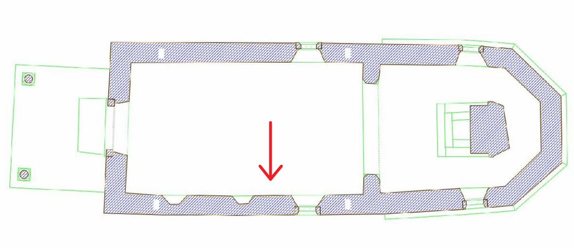
*Pontata*

Preparatory drawing

Stencil

Scratches

*Punzonatura*



**Location:** Gradišče pri Divači
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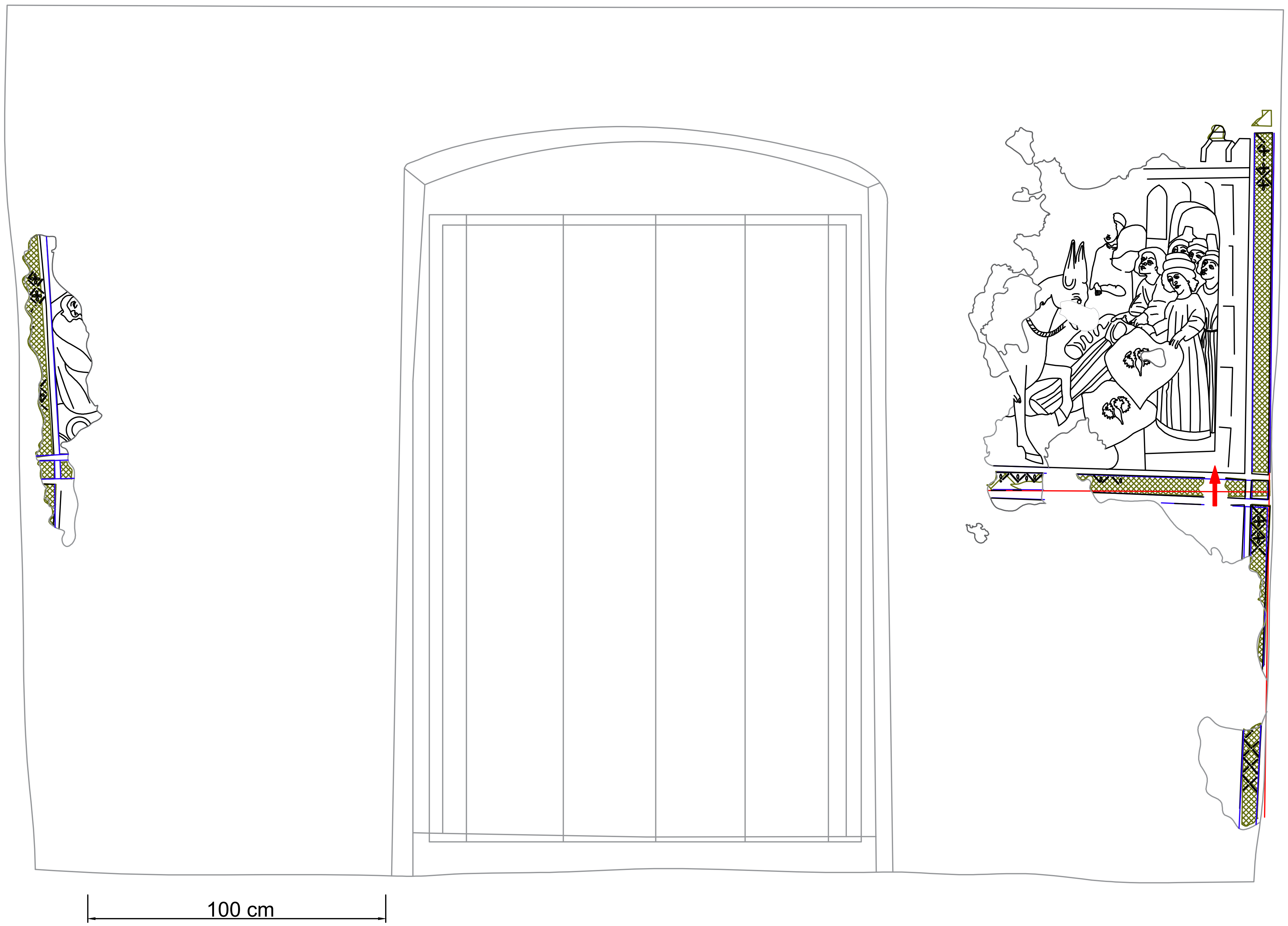



LEGENDA:

Snapped line

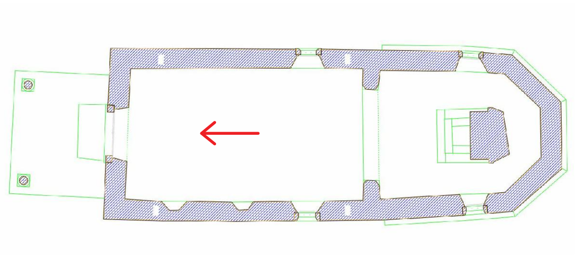
Pontata

Preparatory drawing

Stencil

Scratches

Punzonatura



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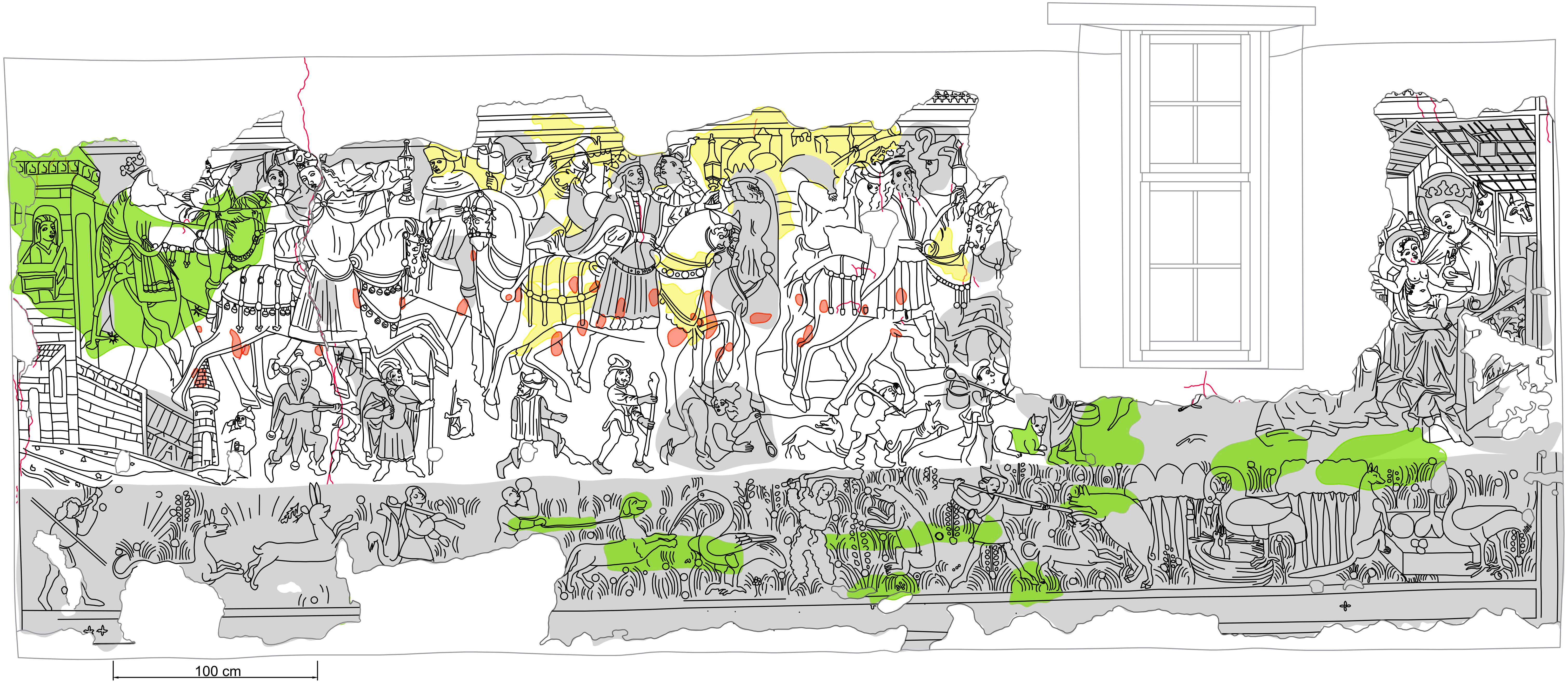
Summer School Gradišče pri Divači, St. Helen, August 2021: **Mapping, Deterioration phenomena, Northern wall.**




LEGENDA:

Glossy area

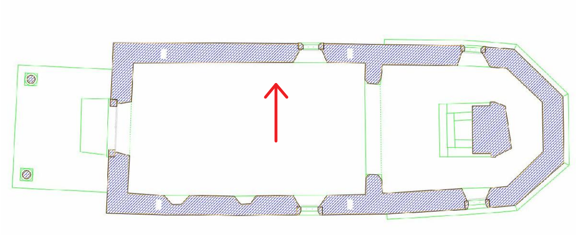
Cracks

Abrasion

Whitening

Uncovering

Yellowing



**Location:** Gradišče pri Divači
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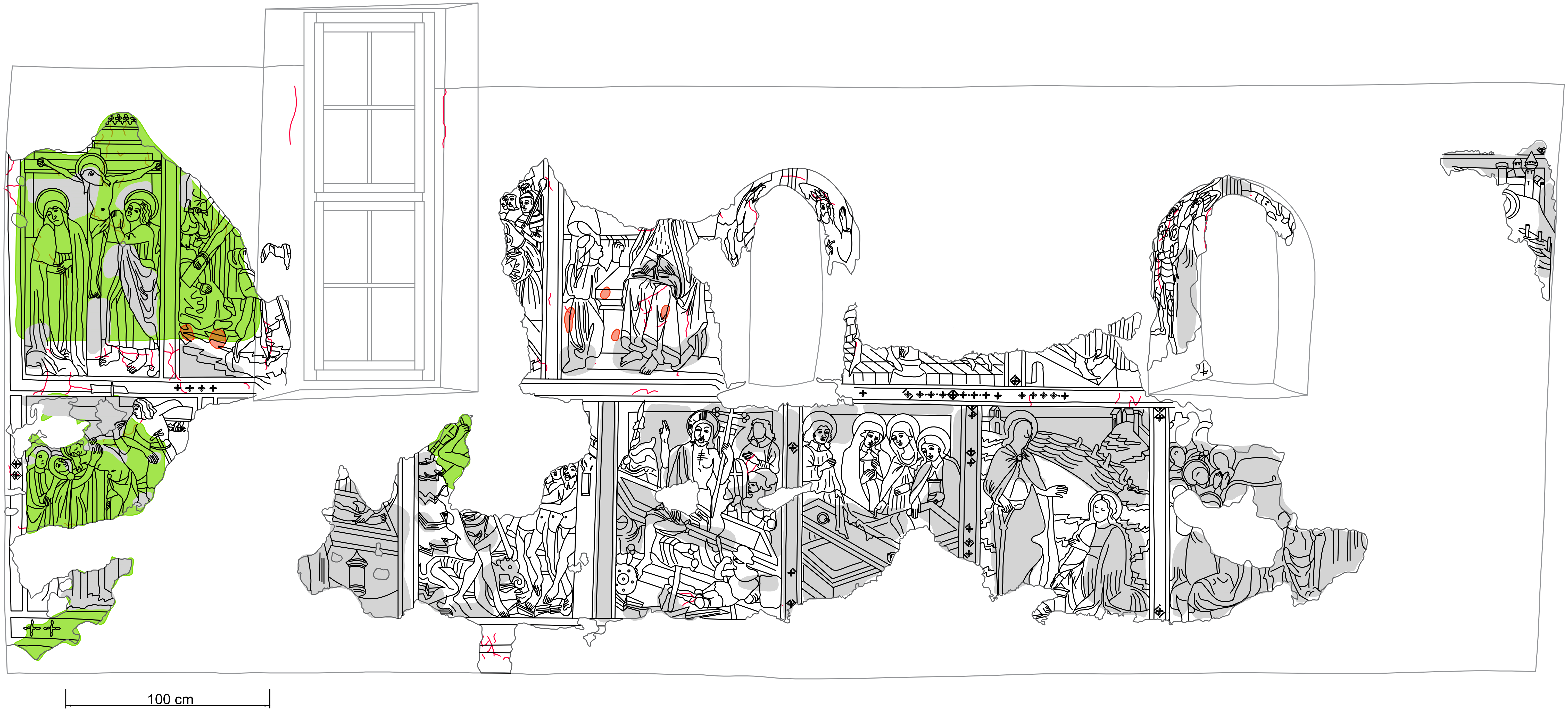
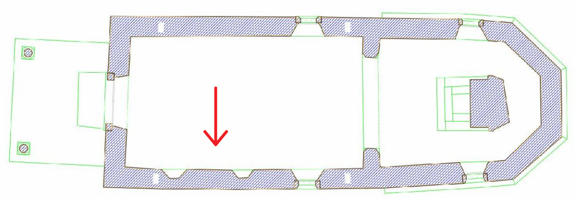



LEGENDA:

- Glossy area
- Cracks
- Abrasion
- Whitening
- Uncovering
- Yellowing



**Location:** Gradišče pri Divači
**Object:** Church of St. Helen
**Subject:** Wall paintings

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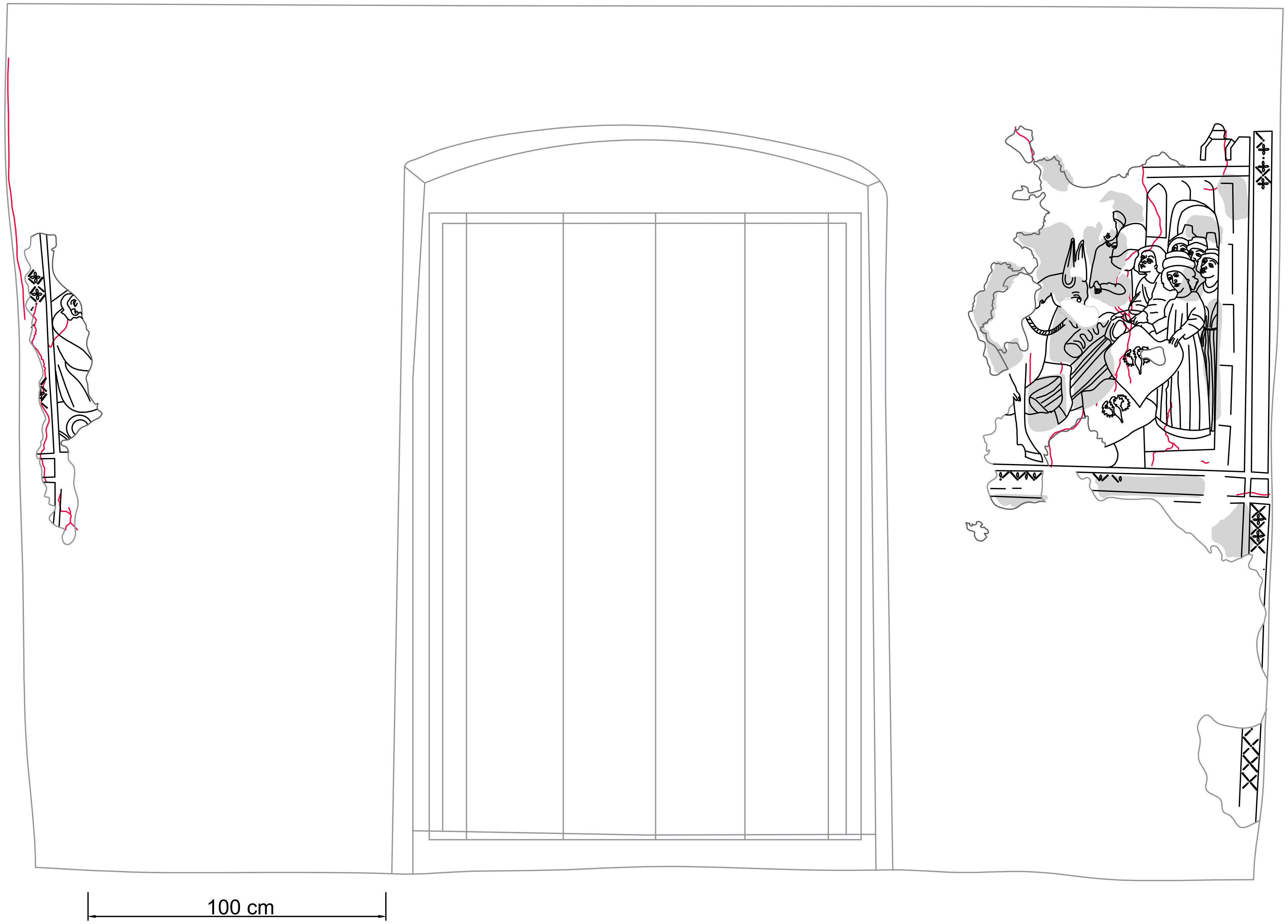



LEGENDA:

Glossy area

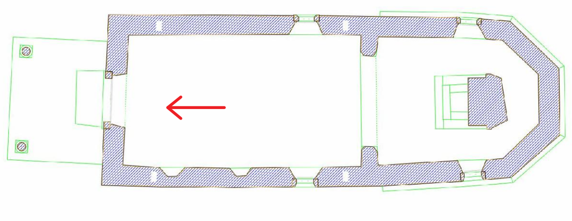
Cracks

Abrasion

Whitening

Uncovering

Yellowing



**Location:** Gradišče pri Divači
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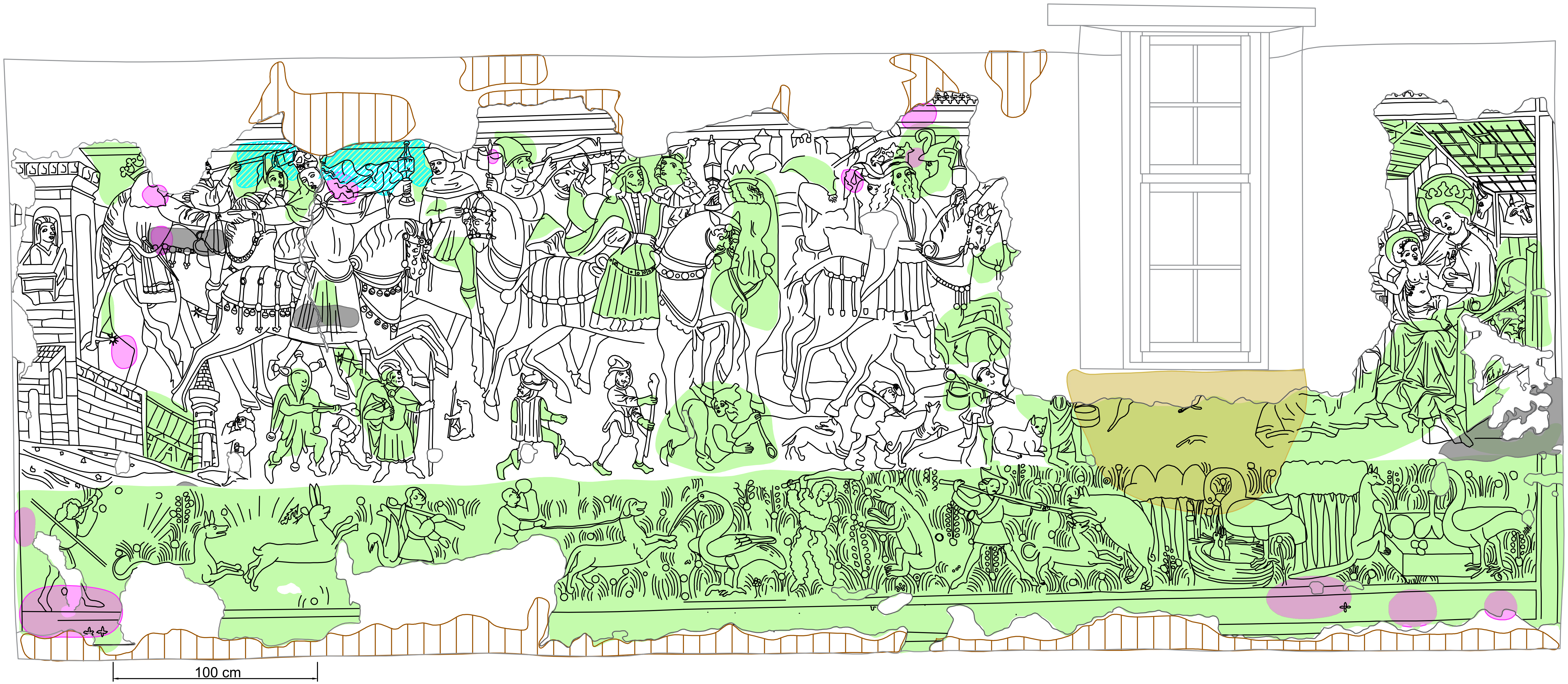
Summer School Gradišče pri Divači, St. Helen, August 2021: **Mapping, Deterioration phenomena, Northern wall.**




LEGENDA:

Abrasion

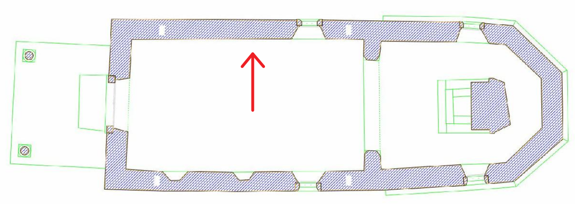
Stains

Colour saturation

Leaking stains

*Craquelure*

Darkening



**Location:** Gradišče pri Divači
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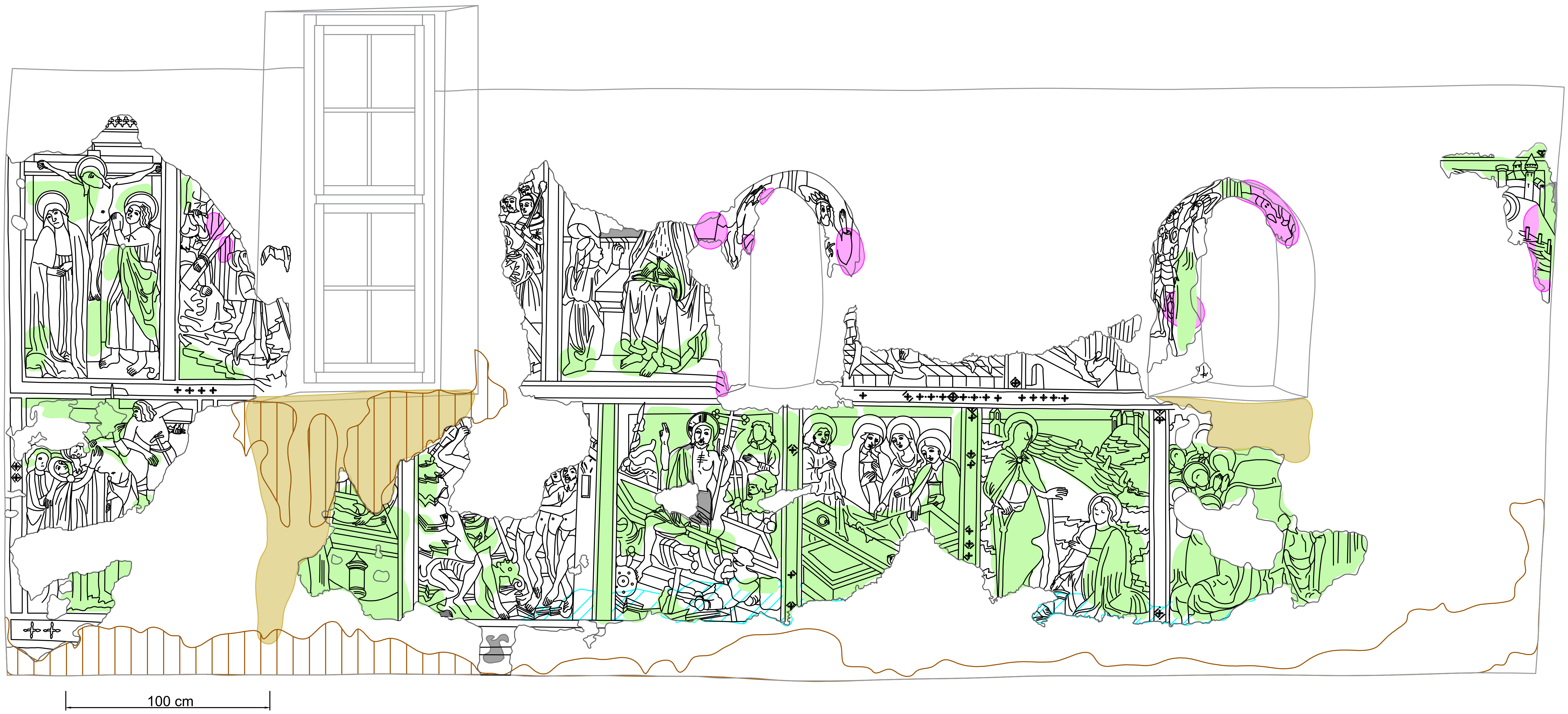
Summer School Gradišče pri Divači, St. Helen, August 2021: **Mapping, Deterioration phenomena, Southern wall.**




LEGENDA:

Abrasion

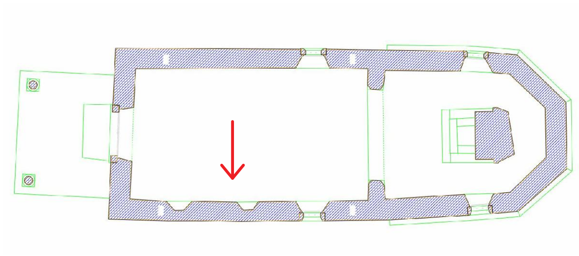
Stains

Colour saturation

Leaking stains

*Craquelure*

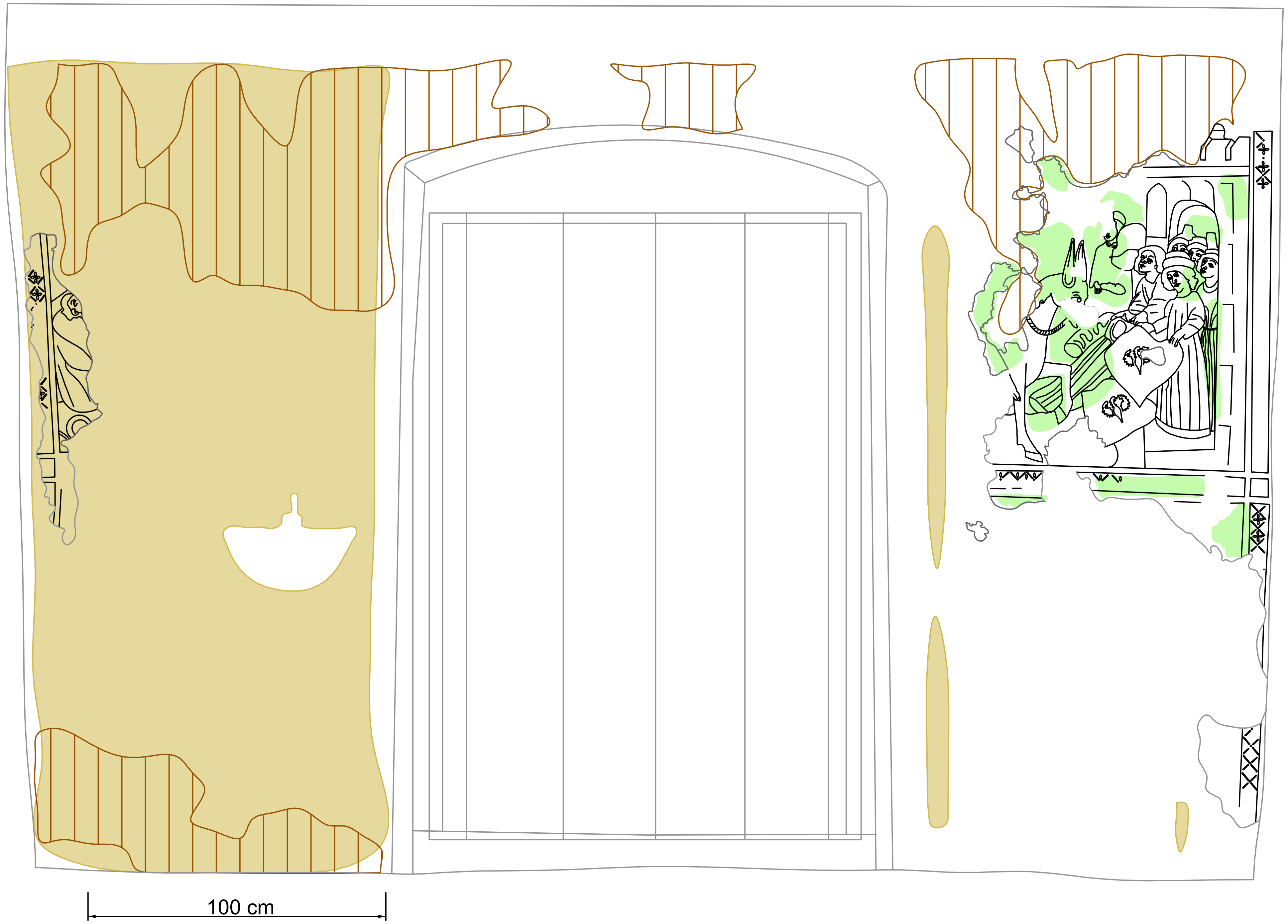
Darkening



**Location:** Gradišče pri Divači
**Object:** Church of St. Helen
**Subject:** Wall paintings

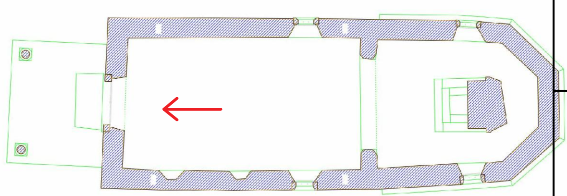
**Mentors:** Alberto Felici, Anka Batič
**Students:** Katarina Bartolj, Eva Marija Fras, Marko Odič, Luka Ružić Stasiow, Mischa Hiltensperger, Lea Bianca Vollenweider, Melissa Cannizzo, Chiara Milazzo, Cecile Roulin.

Summer School Gradišče pri Divači, St. Helen, August 2021: **Mapping, Deterioration phenomena, Western wall.**




LEGENDA:

- Abrasion
- Stains
- Colour saturation
- Leaking stains
- Craquelure
- Darkening



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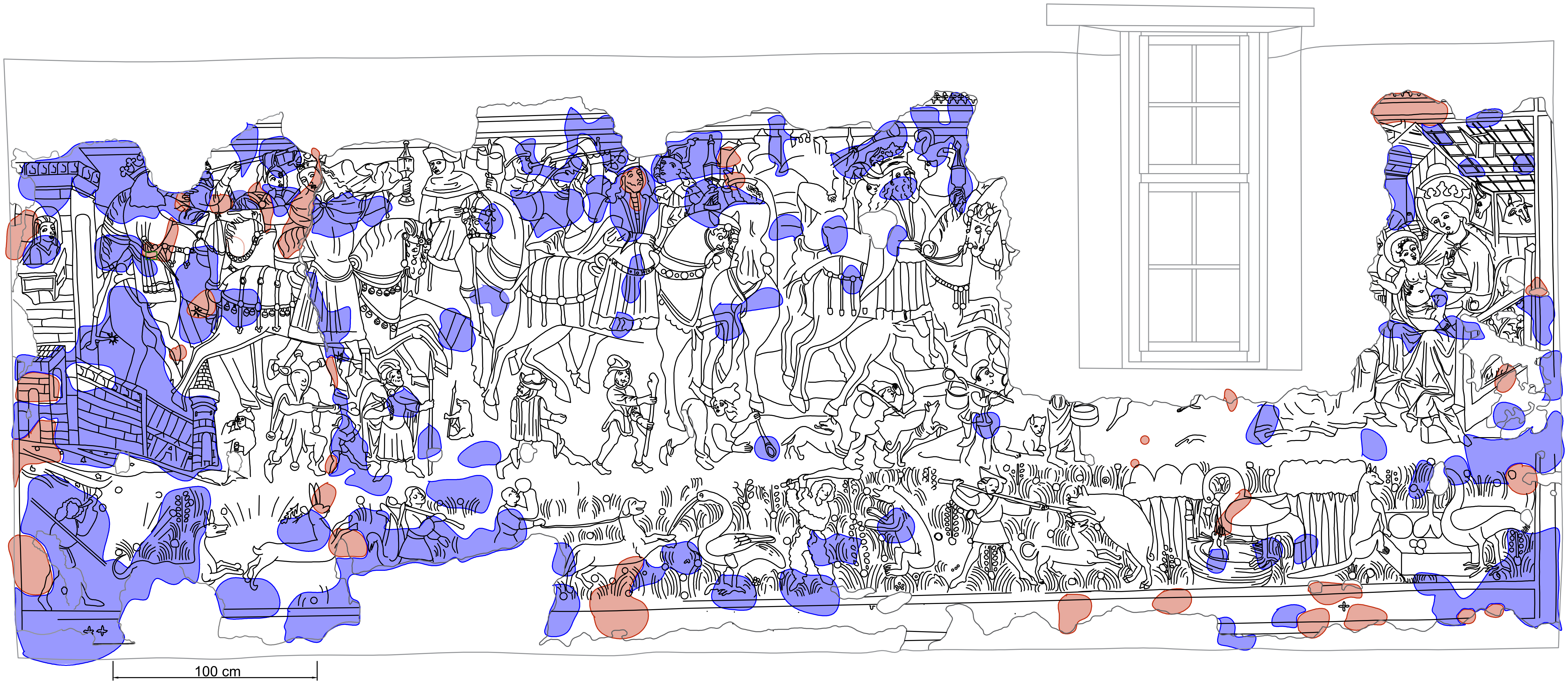
Summer School Gradišče pri Divači, St. Helen, August 2021: **Mapping, Deterioration phenomena, Northern wall.**

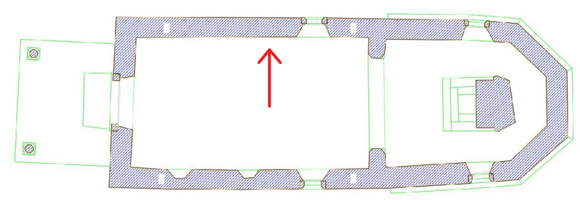



LEGENDA:

Lack of adhesion (Mild)

Deposit

Lack of adhesion (Severe)



**Location:** Gradišče pri Divači
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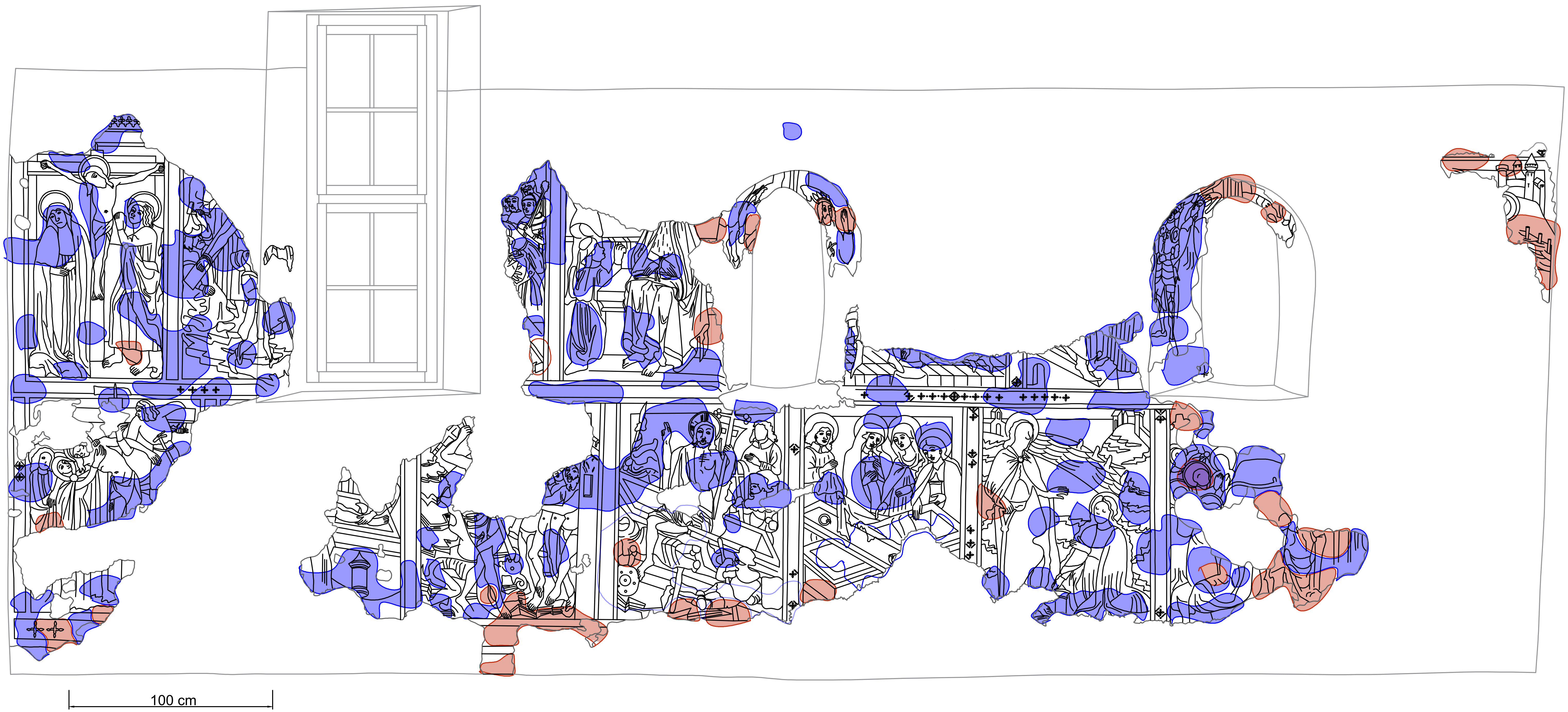
Summer School Gradišče pri Divači, St. Helen, August 2021: **Mapping, Deterioration phenomena, Southern wall.**

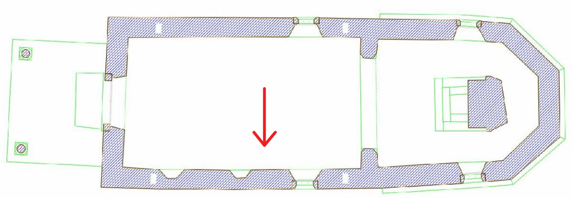



LEGENDA:

Lack of adhesion (Mild)

Deposit

Lack of adhesion (Severe)



**Location:** Gradišče pri Divači
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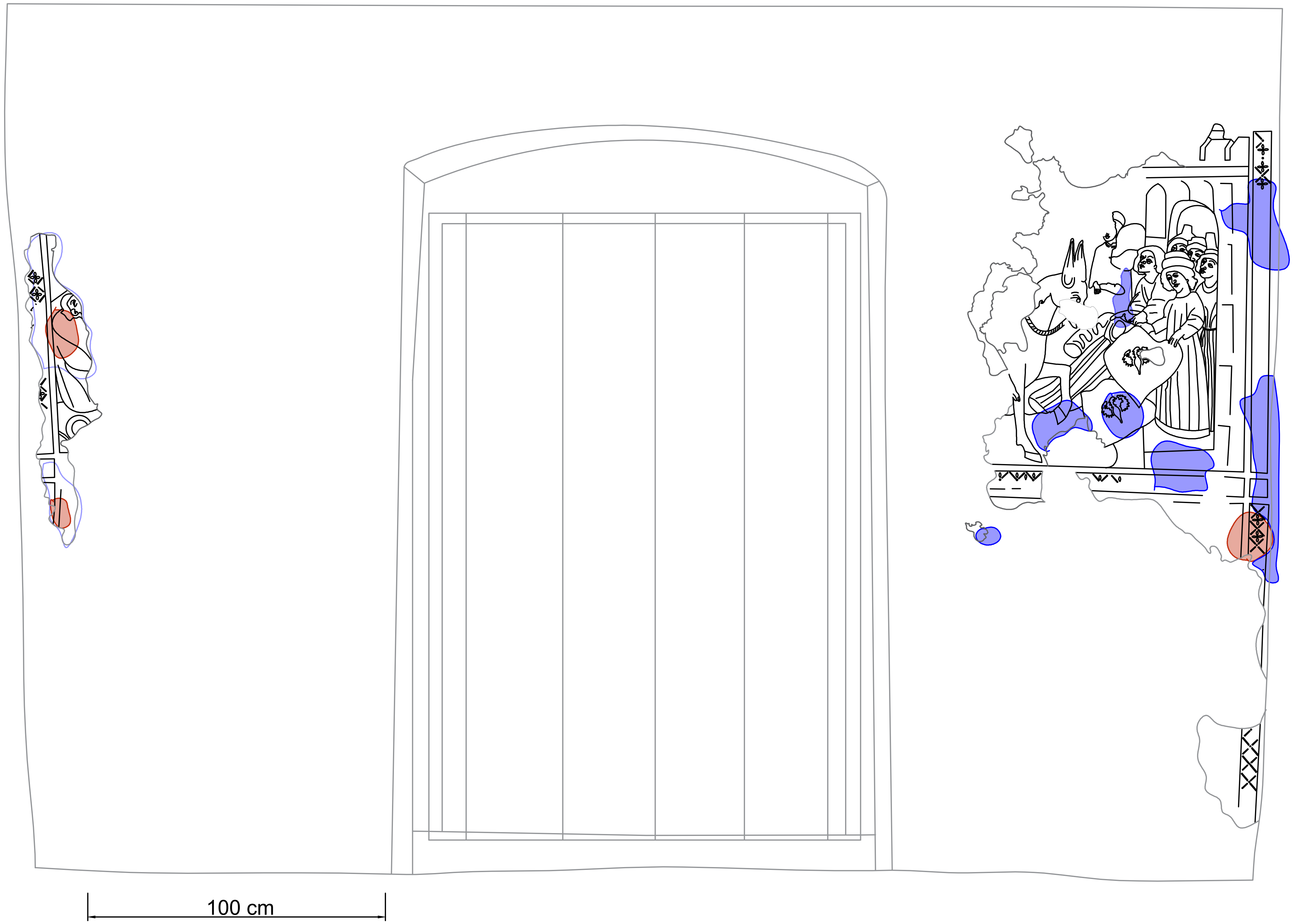
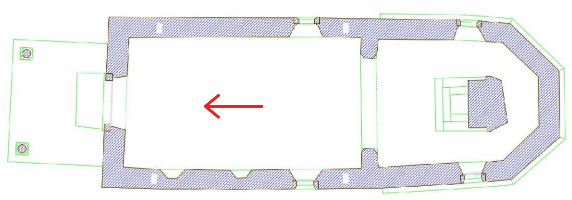



LEGENDA:

Lack of adhesion (Mild)

Deposit

Lack of adhesion (Severe)



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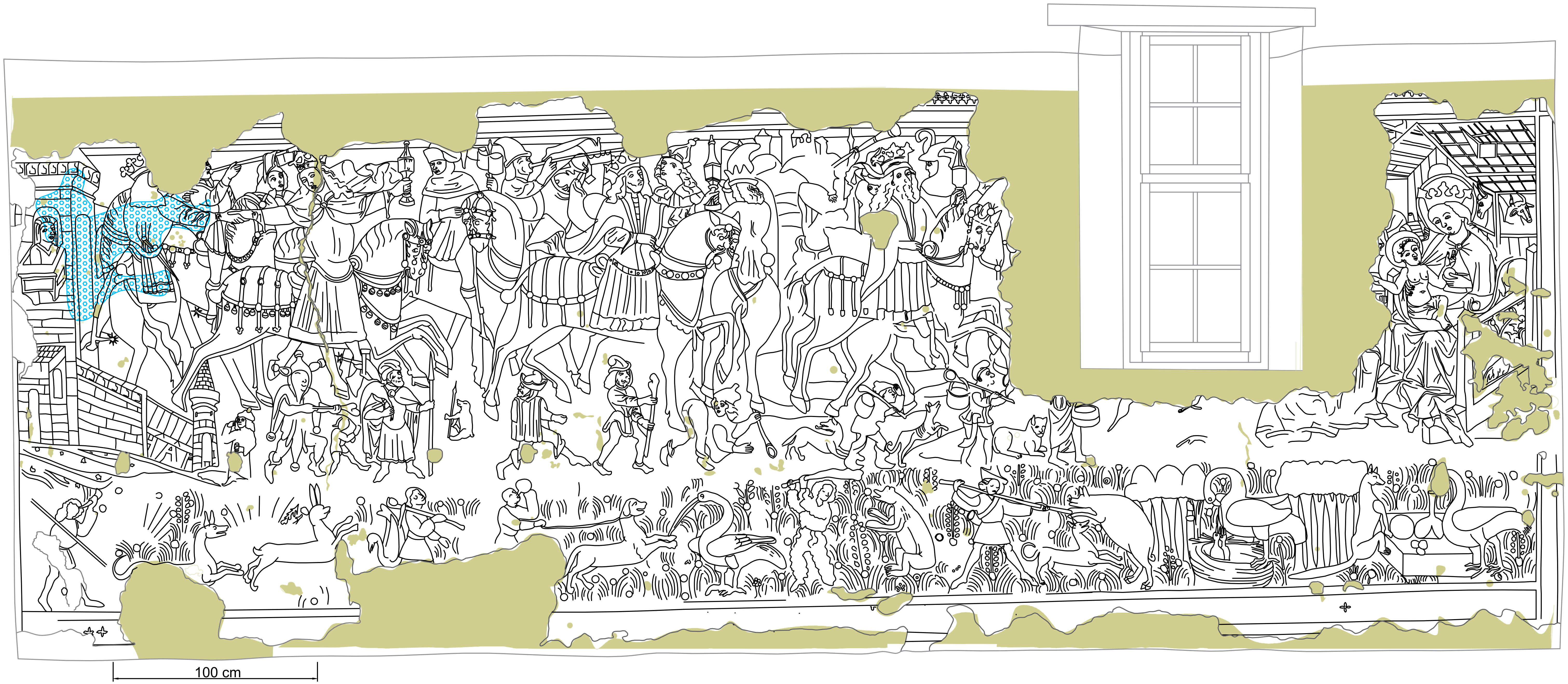
Summer School Gradišče pri Divači, St. Helen, August 2021: **Mapping, Previous interventions, Northern wall.**




LEGENDA:

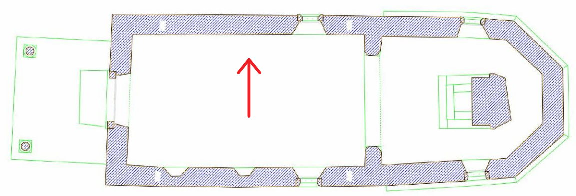
Consolidation

Injection of grout

Unknown material in *lacunae*

Infilling

Uncovering



**Location:** Gradišče pri Divači
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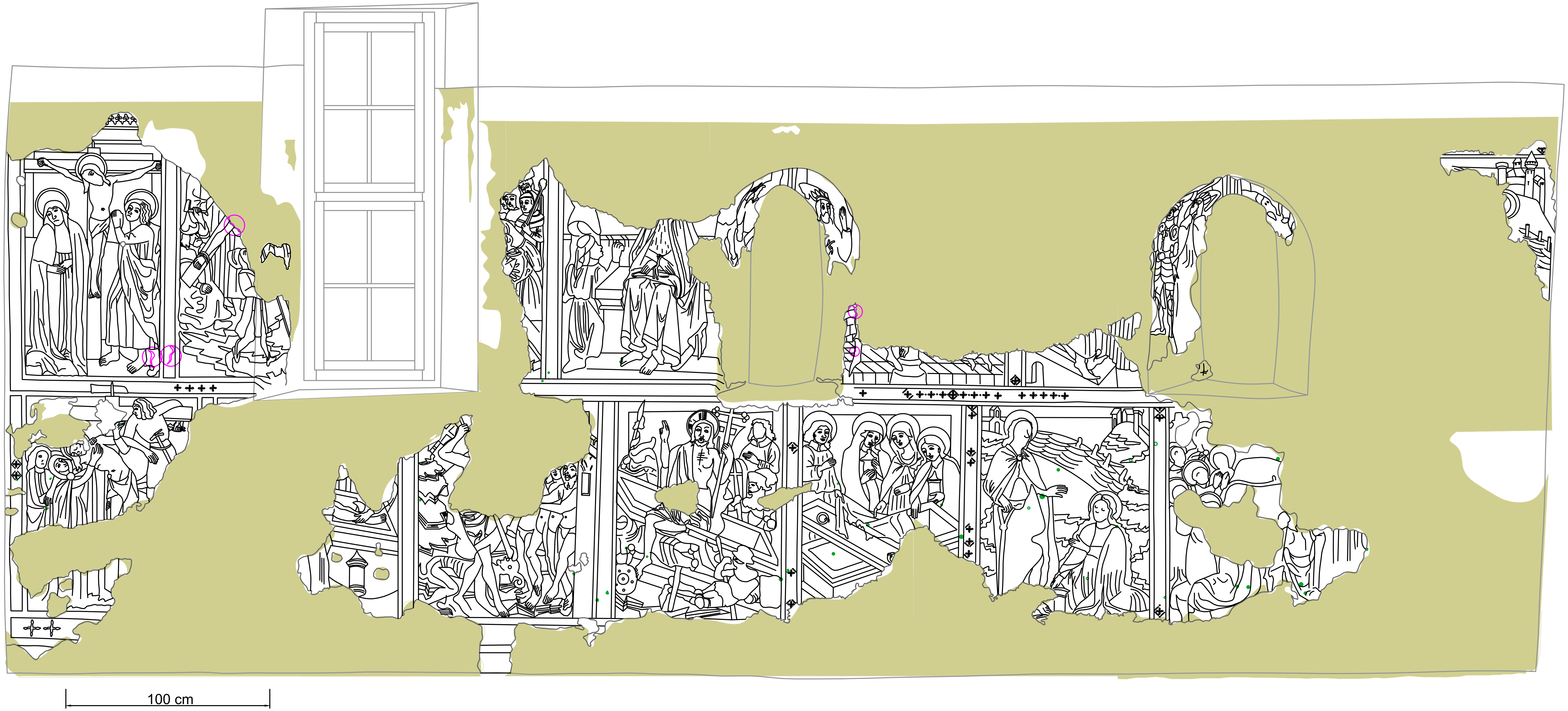



LEGENDA:

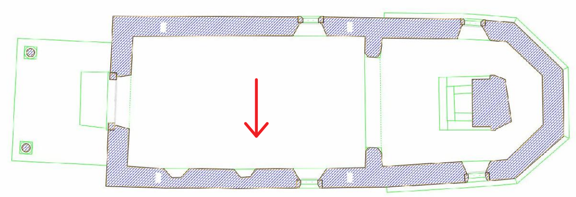
Consolidation

Injection of grout

Unknown material in *lacunae*

Infilling

Uncovering



**Location:** Gradišče pri Divači
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**Mentors:** Alberto Felici, Anka Batič.
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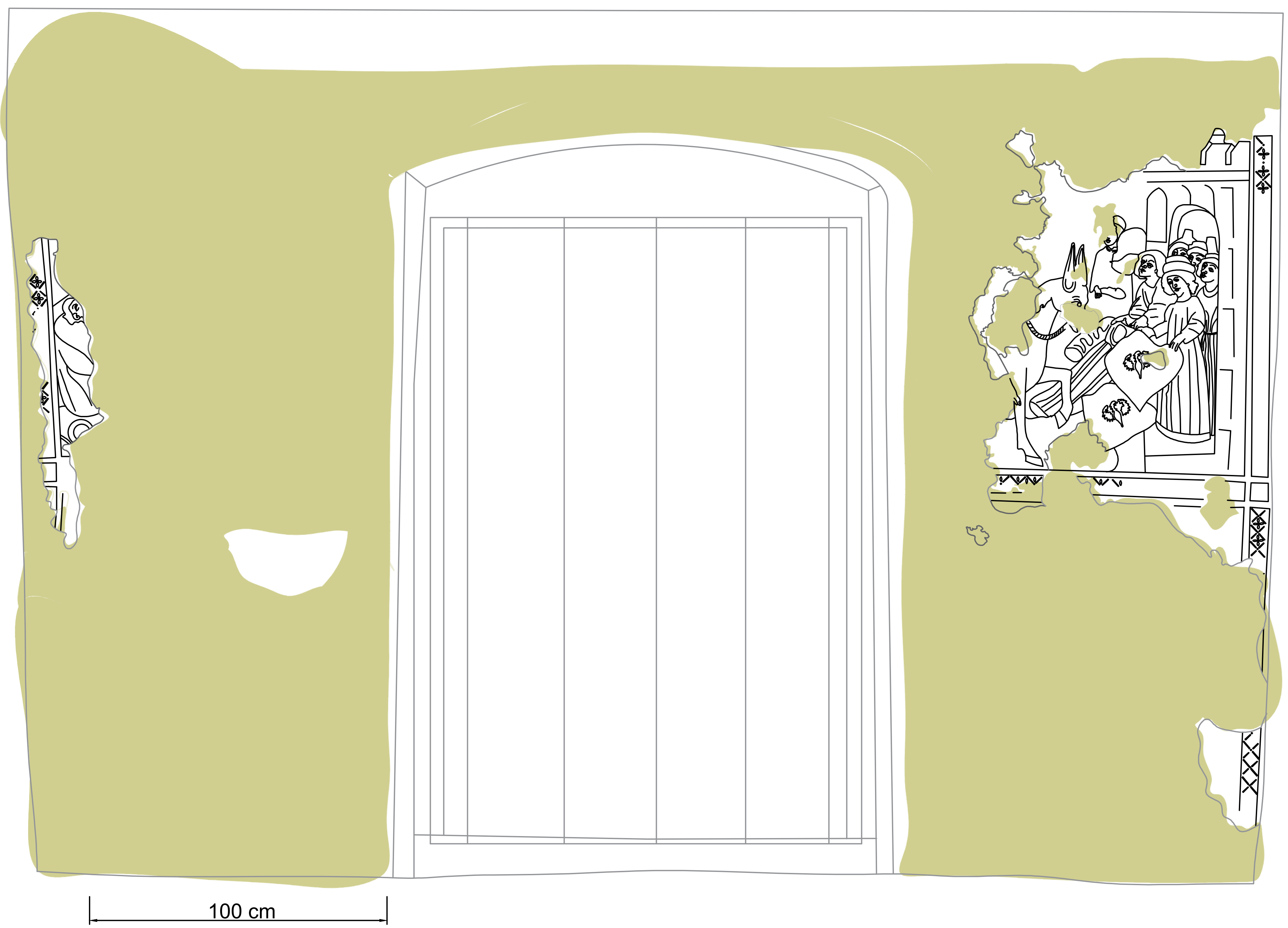



LEGENDA:

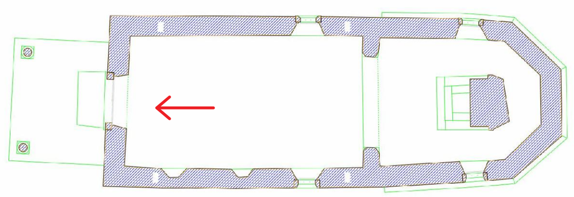
Consolidation

Injection of grout

Unknown material in *lacunae*

Infilling

Uncovering



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**Mentors:** Alberto Felici, Anka Batič.
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Sveučilište u Zagrebu
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# REPORT: SUMMER SCHOOL GRADIŠČE PRI DIVAČI (SLOVENIA)

2nd to 27th of August 2021

## CHURCH OF ST. HELEN CONSERVATION-RESTORATION OF WALL PAINTINGS

## ANNEX n. 5 Investigations


**Students/authors: Katja Kavkler,** Katarina Bartolj, Eva Marija Fras, Marko Odič, Luka Ružić Stasiow, Mischa Hiltensperger, Lea Bianca Vollenweider, Melissa Cannizzo, Chiara Milazzo, Cecile Roulin, …

**Mentors:** Alberto Felici, Neva Pološki, Suzana Damiani, Blaž Šeme, Anka Batič.


Summary

Luka Ružić Stasiow

There were several diagnostic investigations carried out in the church of St. Helen in Gradišče pri Divači, some dated as much as 20 years ago and some carried out in the last couple of years. The most recent investigations were executed last year, during 2021 Summer School, and during conservation-restoration project in the 2022. Here are the summaries of the investigations during 2021 Summer School.

NON-INVASIVE INVESTIGATIONS

UV light efflorescence

This investigation was obtained with UV lamps and by using a camera to capture results. Assessment under the UV light is preformed by both professors and students, same as other investigations except the ones where is noted differently. The aim of this investigation was to reveal all organic matter present on wall painting and hopefully determine some of the pigments used. No result is obtained about the kind of pigments with this method. Photos of UV fluorescence are stored on MS Teams. Some original painting techniques which efflorescence under UV light such as stencil are documented in Auto Cad.

Sponge test

Sponge test was carried out with sponges wetted with distilled water, beam scale and stopwatch. The aim of this investigation is to measure water absorption of a wall which can give us valuable information for further treatments, cleaning, consolidation, etc. For that reason this test was carried out before applying any treatments. After the appliance of future treatments it is possible to repeat the sponge test in order to compare results and to conclude if absorption has changed. The results of this investigation are present in writing reports and places of taking tests are documented in Auto Cad.

Raking light

Under the raking light configuration of wall surface can be observed, which can give us a lot of information about wall painting, on how it is made and its state. Photos taken under ranking light can be found on MS Teams.

Dino lite

Magnification of Dino lite reveals all the small details on wall painting which can not be seen by the naked eye. The aim of this investigation is to gather as much information as possible on every interesting point on wall painting for which its magnification would be beneficial. Dino lite photos are stored on MS Teams and points of taking them are noted in Auto Cad.

Knocking test

Knocking test was preformed with great care by professor and two students. This test depends on subjective experience of one individual so it was important that same group of people make through the end of this investigation. The aim of this assessment is to determine if there is delamination between plaster layers and how severe it is. This gives us information for future treatments, if the injection of grout is needed. Results are present in written reports and lack of adhesion is documented in Auto Cad.

XRF and Raman

XRF investigation was carried out by scientist dr. Katja Kavkler with Bruker ELIO HRF portable spectrometer. This particular machine can not detect elements from Na to U. As well dr. Kavkler performed another investigation with bruker BRAVO handheld Raman spectrometer which enables precise measurements of weak scattering, dark and flurescenting samples. The aim of both investigations is to determine which pigments are used, is gypsum removed with applied cleaning methods and if there are deterioration products present. Previous investigations showed the presence of sulphur so it was important to make sure of its removal. As well, information obtained gives us information for further interventions. Results of XRF and Raman can be found in the written report of dr. Kavkler.

## INVASIVE INVESTIGATIONS

### Swab test

Swab test was carried out by professors. In order to carry out swab test grate care must be taken and experience is needed. That is the reason why students were excluded from this investigation. Swab test was carried out before cleaning trials took place and before applying any treatments to the wall painting. The aim of this investigation is to assess cohesion of pigments and with information obtained it is concluded which cleaning trials paint layer can withstand and if the paint layer needs to be consolidated. Places where the test was executed are documented in Auto Cad and written reports are available.

### Sampling

In this Annex there is Glossary of the investigations carried out in the church and the Report of the diagnostic investigations carried out and described by dr. Katja Kavkler. Since this is an ongoing investigation the Report is a working version. All other documents are available in MS Teams to all the students, participants and organizers.

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# GLOSSARY:
# WALL PAINTINGS IN CHURCH OF SAINT HELEN GRADIŠČE PRI DIVAČI, SLOVENIA
## Investigations

## SUMMER SCHOOL, August 2021

**Location:** Gradišče pri Divači, Slovenia
**Object:** Church of St. Helen
**Subject:** Wall paintings
**Owner:** Catholic church of Slovenia

**Mentors:** Alberto Felici, Neva Poloski, Suzana Damiani, Blaž Šeme, Anka Batič.
**Students:** Katarina Bartolj, Eva Marija Fras, Marko Odič, Luka Ružić Stasiow, Mischa Hiltensperger, Lea Bianca Vollenweider, Melissa Cannizzo, Chiara Milazzo, Cecile Roulin.

# INVESTIGATIONS:

**Analysis on binding media**

**Biological examination**

**Building and site survey**

**FTIR**

**Georadar**

**Historical Investigations**

**Mapping**

**Monitoring**

**Non-invasive investigation**

**Object investigation**

**Pigment analysis**

**Raking light**

**Sampling**

**Stratigraphic investigation**

**Thermovision**

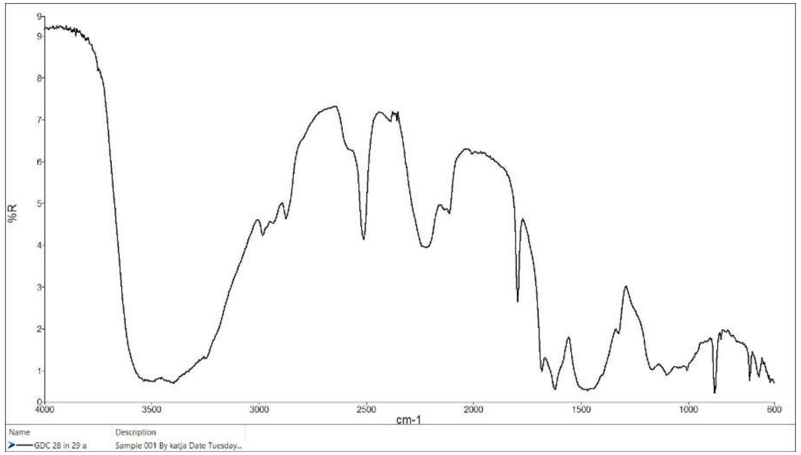
| 4. | INVESTIGATIONS |
|---|---|
| | |
| **1.** | **ANALYSIS ON BINDING MEDIA** |

*Description:*

Analysis of the continuous phase (“binder”) that holds inert particles together and adheres them to contiguous layers.

*Source of the description:* EwaGlos, Vol. 17, 2016, p. 280.

*Photo:*




*Source of image:* Katja Kavkler

| 4. | INVESTIGATIONS |
|---|---|
| | |
| **2.** | **BIOLOGICAL EXAMINATION** |

*Description:*

Studies in the field and in the laboratory of biological and microbiological colonisation (including bacteria, algae, fungi, lichens) that sometimes grow on wall paintings or architectural surfaces.

*Source of the description:* EwaGlos, Vol. 17, 2016, p. 326.

*Photo:*

*Source of image:* Poročilo o izvedenem 3D dokumentiranju poslikav v cerkvi sv. Helene v Gradišču pri Divači, Gašper Rutar, univ. dipl. arheolog, maj 2021.

| 4. | INVESTIGATIONS |
|---|---|
| | |
| **3.** | **BUILDING AND SITE SURVEY** |

*Description:*

An assessment of the state of conservation of a building or site and a study of its environment, based on observations and simple measurements.

*Source of the description:* EwaGlos, Vol. 17, 2016, p. 326.

*Photo:*

*Source of image:* Marta Bensa

| 4. | INVESTIGATIONS |
|---|---|
| | |
| **4.** | **FTIR** |

*Description:*

The FTIR uses interferometry to record information about a material placed in the IR beam. The Fourier Transform results in spectra that analysts can use to identify or quantify the material.

*Source of the description: https://www.innovatechlabs.com/newsroom/672/stuff-works-ftir-analysis/*

*Photo:*

*Source of image:* Katja Kavkler

## 4. INVESTIGATIONS

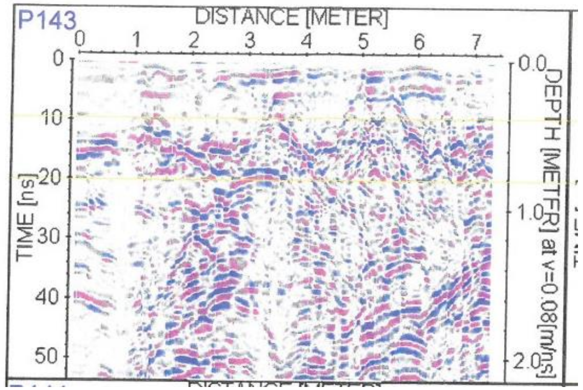
## 5. GEORADAR

*Description:*

Georadar works by sending a tiny pulse of energy into the ground then recording the strength of reflected signals and time it takes them to return to the receiver. A scan consists of a series of pulses over a single area. Main goal is to assess the archaeological potential of the church and uncover older construction phases in and around the church.

*Source of the description:* [https://en.wikipedia.org/wiki/Ground-penetrating_radar](https://en.wikipedia.org/wiki/Ground-penetrating_radar)
*Source of the photo:* Institute for the Protection of Cultural Heritage of Slovenija, Nova Gorica Regional Office, Marta Bensa, Nova Gorica, 2. august 2021.

*Photo:*




*Source:* Poročilo o georadarski raziskavi, Gradišče pri Divači, p.c. sv. Helene, dr. Branko Mušič, Oddelek za arheologijo, Univerza v Ljubljani, 14. 12. 2003.

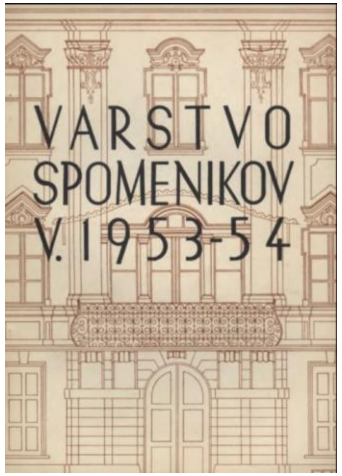
| 4. | INVESTIGATIONS |
|---|---|
| | |
| **6.** | **HISTORICAL INVESTIGATION** |

*Description:*

The collection and study of documents related to the material history of an art work and its context.

*Source of the description:* EwaGlos, Vol. 17, 2016, p. 232.

*Photo:*




*Source of Image:* Marta Bensa

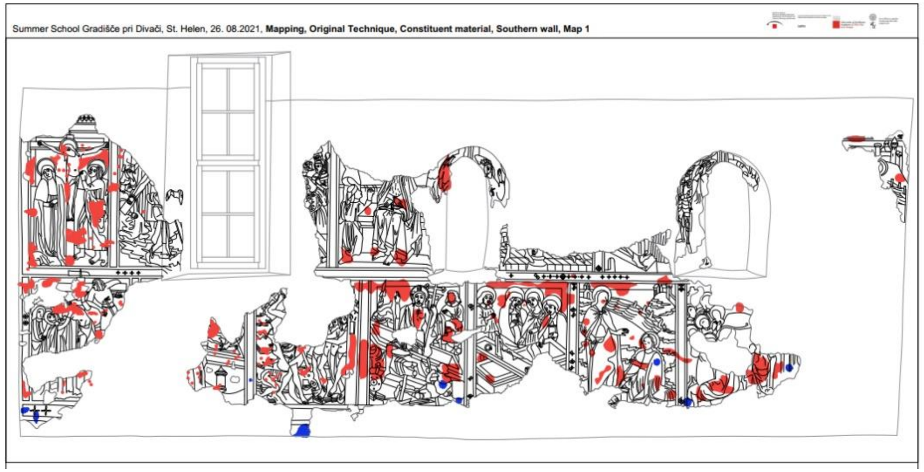
| 4. | INVESTIGATIONS |
|---|---|
| | |
| **7.** | **MAPPING** |

*Description:*

Graphic representation of a single or several patterns on an architectural elevation or equivalent. The represented patterns can refer to the painting techniques, deterioration patterns, or treatments that are visible on a wall painting. The information is reported and drawn according to a specific and codified symbol or colour. The map legend (or key) includes a short description for each represented pattern and gives a graphic symbol. The map produced must indicate when it was created. The digital format enables the easy superimposition of the graphic mapping results of different phenomena

*Source of the description:* EwaGlos, Vol. 17, 2016, p. 250.

*Photo:*




*Source of image:* SummerSchool Archive August 2021

| 4. | INVESTIGATIONS |
|---|---|
| | |
| **8.** | **MONITORING** |

*Description:*

Involves collecting data and checking for any visible signs of change that may affect wall paintings and their environment.

*Source of the description:* EwaGlos, Vol. 17, 2016, p. 294.

*Location:*

*Source of image:* Poročilo o izvedenem 3D dokumentiranju poslikav v cerkvi sv. Helene v Gradišču pri Divači, Gašper Rutar, univ. dipl. arheolog, maj 2021.

*Detail:*

*Source of image:* Poročilo o izvedenem 3D dokumentiranju poslikav v cerkvi sv. Helene v Gradišču pri Divači, Gašper Rutar, univ. dipl. arheolog, maj 2021.

| 4. | INVESTIGATIONS |
|---|---|
| | |
| **9.** | **NON-INVASIVE INVESTIGATION** |

*Description:*

The gathering of information on site using techniques that do not modify or damage the material at the contact point between the instrument or the beam emitted by the instrument and the object surface.

*Source of the description:* Ewa Glos, Vol. 17, p. 256.

*Photo:*
Datalogger Information

*Source of image:* Marta Bensa

| 4. | INVESTIGATIONS |
|---|---|
| | |
| **10.** | **OBJECT INVESTIGATION** |

*Description:*

A study in which information regarding the original form, materials and state of conservation of an object is obtained. For example observation under UV light and digital microscope (such as Dino-lite).

*Source of the description:* EwaGlos, Vol. 17, 2016, p. 326.

*Photos:*




*Source of Image:* Summer School August 2021

*CAD reference:* /

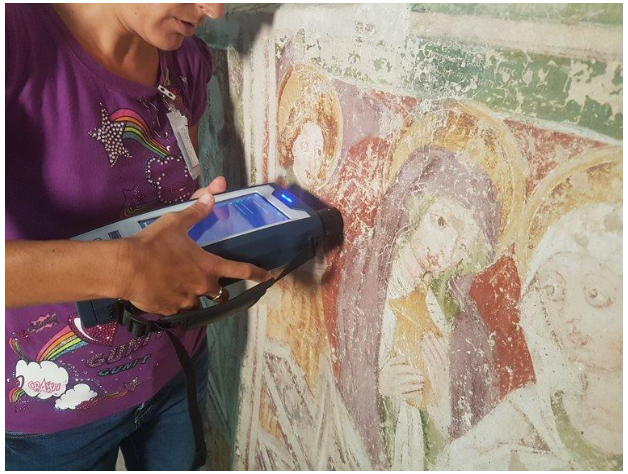
| 4. | INVESTIGATIONS |
|---|---|
| | |
| **11.** | **PIGMENT ANALYSIS** |

*Description:*

Determination of the nature of fine coloured insoluble materials (known as pigments).

*Source of the description:* Ewa Glos, Vol. 17, p. 248.

*Photos:*



*Source of Image:* Summer School August 2021

*CAD reference: /*

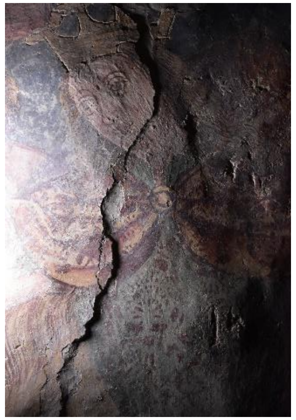
| 4. | INVESTIGATIONS |
|---|---|
| | |
| **12.** | **RAKING LIGHT** |

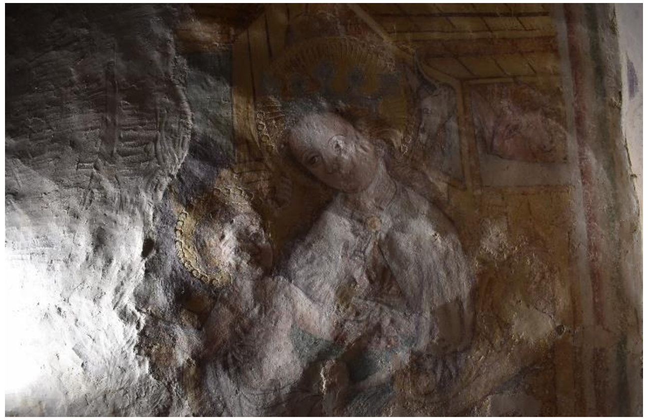
*Description:*

The surface is lit, preferably using daylight-spots at a specific angle, in order to show the relief through shadow effects.

*Source of the description:* EwaGlos, Vol. 17, 2016, p. 262.

*Photos:*





*Source of Image:* Summer School August 2021

| 4. | INVESTIGATIONS |
|---|---|
| | |
| **13.** | **SAMPLING** |

*Description:*

When material is extracted from a work of art or building for analysis or observation.

*Source of the description:* Ewa Glos, Vol. 17, 2016 p. 266.

*Photo:*

*Source of Image:* Anka Batič and Katja Kavkler

*CAD reference:* /

| 4. | INVESTIGATIONS |
|---|---|
| | |
| **14.** | **STRATIGRAPHIC INVESTIGATION** |

*Description:*

The stepwise removal of covering paint layers for analysis and determination of the chronological order of successive paint layers.

*Source of the description:* EwaGlos, Vol. 17, 2016, p. 248.

*Photo:*

*Source of image:* Poročilo o izvedenem 3D dokumentiranju poslikav v cerkvi sv. Helene v Gradišču pri Divači, Gašper Rutar, univ. dipl. arheolog, maj 2021.

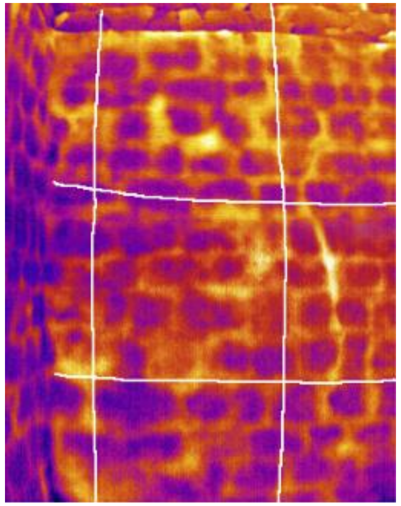
| 4. | INVESTIGATIONS |
|---|---|
| | |
| **15.** | **THERMOVISION** |

*Description:*

The camera converts that infrared data into an electronic image that shows the apparent surface temperature of the object being measured. Thermovision shows differenc in conductivity of materials, it can show air pockets in wall structure.

*Source of the description:* [https://www.flir.com/discover/rd-science/how-do-thermal-cameras-work/](https://www.flir.com/discover/rd-science/how-do-thermal-cameras-work/)
*Source of the photo:* Institute for the Protection of Cultural Heritage of Slovenija, Nova Gorica Regional Office, Marta Bensa, Nova Gorica, 2. august 2021.

*Photo:*



*Source of image:* Termografsko poročilo, p.c.sv. Helene, Gradišče pri Divači, Bojan Težak, univ. Dipl. Inž. El., 5. 11. 2003.

Zavod za varstvo kulturne dediščine Slovenije
Center za konservatorstvo
Restavratorski center

**Gradišče pri Divači - Succursal church of St. Helen, EID 1-01566**
**Wall paintings**

# ANALYSES REPORT

Ljubljana, February 2024

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e-pošta: **info@rescen.si, www.zvkds.si**

## GENERAL DATA

| | |
|---|---|
| LOCATION: | Gradišče pri Divači |
| OBJECT: | Succursal church of St. Helen |
| EID (EVIDENCE HERITAGE NUMBER): | 1-01566 |
| SUBJECT: | wall paintings in nave |
| AUTHOR / DATATION: | Workshop Johannes from Kastav, end of 15th cent. |
| HERITAGE TYPE: | sacral heritage |
| TECHNIQUE / MATERIAL: | fresco |
| OWNER: | Divača Parish |
| DIRECTION: | Municipality of Divača |
| INVESTITOR: | / |
| ORDERED BY: | / |
| WORKING NUMBER: | 20705168A |
| AUTHORITATIVE ORGANIZATION/ LEADER: | ZVKDS Nova Gorica/ Ernesta Drole |
| RESPONSIBLE CONSERVATOR: | dr. Minka Osojnik |
| SUPERVISION: | dr. Minka Osojnik, Marta Bensa |
| REPORT BY: | Katja Kavkler, Maja Gutman Levstik |
| LEADER: | Katja Kavkler |
| CO-WORKES WITHIN RC: | Sonja Fister, Anka Batič, dr. Ajda Mladenovič, Anita Kavčič Klančar |
| OTHER CO-WORKERS: | Marta Bensa, Alberto Felici, Neva Pološki, Suzana Damiani, Blaž Šeme, Jonas Roters |
| ISSUE NUMBER/ ALL ISUES: | *1 2 / **2*** |

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*stamp*

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## 1. ABSTRACT

Succursal church of St. Helen at Gradišče pri Divači (EID 1-01566) was sampled and analysed using non-invasive and invasive methods. Materials of mortars and paintings were identified, as well as water-soluble salts and other degradation products. Conservation-restoration treatments were monitored by non-invasive Raman spectroscopy, by analysis of some extracted samples and by analysis of cotton swabs.

Additionally to material analyses, microclimatic monitoring was executed, showing relatively high RH within the church. Some tests were carried out by infrared thermography.

## 2. INTRODUCTION

Succursal church of St. Helen at Gradišče pri Divači (EID 1-01566) was sampled and analysed using non-invasive and invasive methods. Additionally to analysis of original materials, cleaning efficiency was monitored.

## 3. SAMPLING, SAMPLE PREPARATION AND METHODS

### a) *Sample preparation*

Samples extracted by scalpel were examined by stereomicroscope MIZSM-30BL. Selected particles of paint layers were embedded into polyester resin, ground and polished to obtain cross section of paint layers to use with different analyses methods.

### b) *Optical microscopy (OM)*

Optical microscopy of cross- and thin-sections was performed in visible (VIS) and ultraviolet (UV) light to obtain information of stratigraphy and mineral composition of selected samples.

**Cross sections** were examined by microscope Olympus BX-60 and digital camera SC50 (Olympus) in reflected light at 200x to 500x magnification in visible and ultraviolet light.

**Polished thin-sections** were examined with transmitted polarised light by optical microscope Olympus BX-60 and digital camera SC50 (Olympus).

### c) *Fourier transform infrared spectroscopy (FTIR)*

Raw samples were analysed with spectrometer Spectrum 100 connected with microscope Spectrum Spotlight 200 (PerkinElmer). Layers were separated by scalpel and in some cases solvents of different polarity were used to extract materials form the mixtures. All samples were analysed in transmission mode, compressed in diamond anvil cell. Spectra were scanned using MCT detector in the range between 4000 $cm^{-1}$ and 600 $cm^{-1}$ with spectral resolution 4 $cm^{-1}$, averaging 32 scans for each spectrum.

*d) Raman spectroscopy*

Cross-sections and raw samples were analysed by Raman spectrophotometer LabRAM HR800 (Horiba Jobin-Yvon), connected to microscope Olympus BXFM, using laser with wavelength 785 nm and CCD detector in the range between 80 $cm^{-1}$ and 1800 $cm^{-1}$ at spectral resolution 1 $cm^{-1}$. Calibration was performed using Si crystal. Time and filter were adapted to each sample.

e) *Raman spectroscopy with portable spectrophotometer*

Raman analysis was carried out *in situ* with Bruker BRAVO handheld Raman spectrophotometer. The spectrophotometer features Duo LASER™ excitation with two wavelengths and enables precise measurements in material identification (including dark, fluorescing and weak scattering samples).

f) *X-ray fluorescence spectroscopy (XRF)*

X-ray spectroscopy was carried out with Bruker ELIO XRF portable spectrophotometer, which enables detection and quantification of elements from Na to U.

g) *Immunofluorescence microscopy (IFM)*

It was carried out on Research Institute of the IPCHS by applying ovalbumin rabbit primary antibodies and secondary FITC fluorocrome conjugated antibodies.

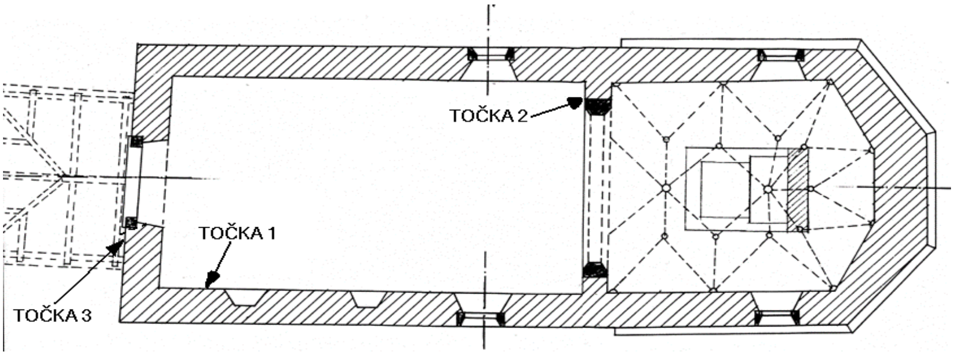
*REMARK: Colours on photographs can differ from the real colours due to microscope or printer settings.*

# 4. MICROCLIMATIC MONITORING

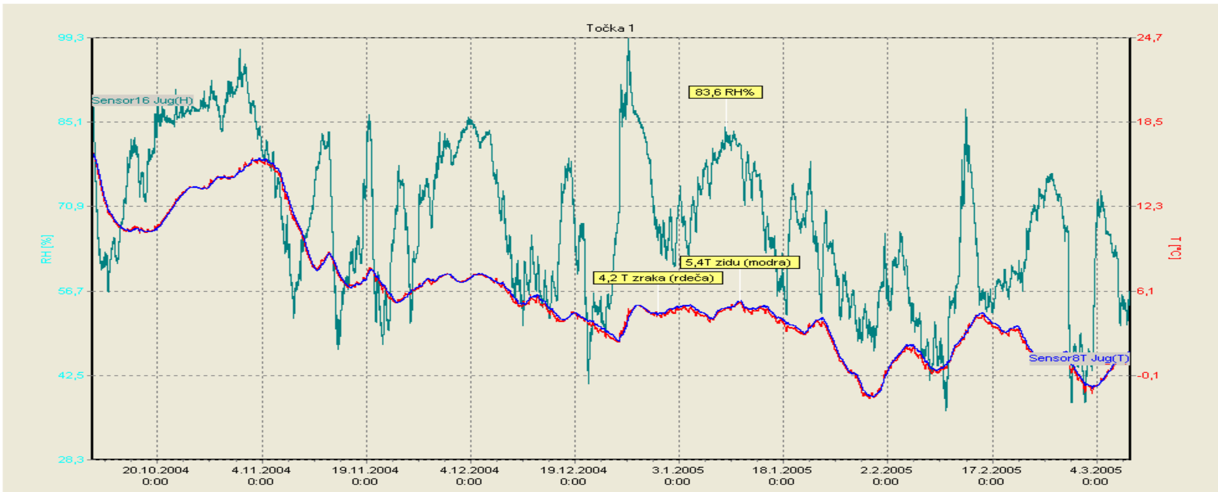
## *a) October 2004 to March 2005*

Sensors positions:

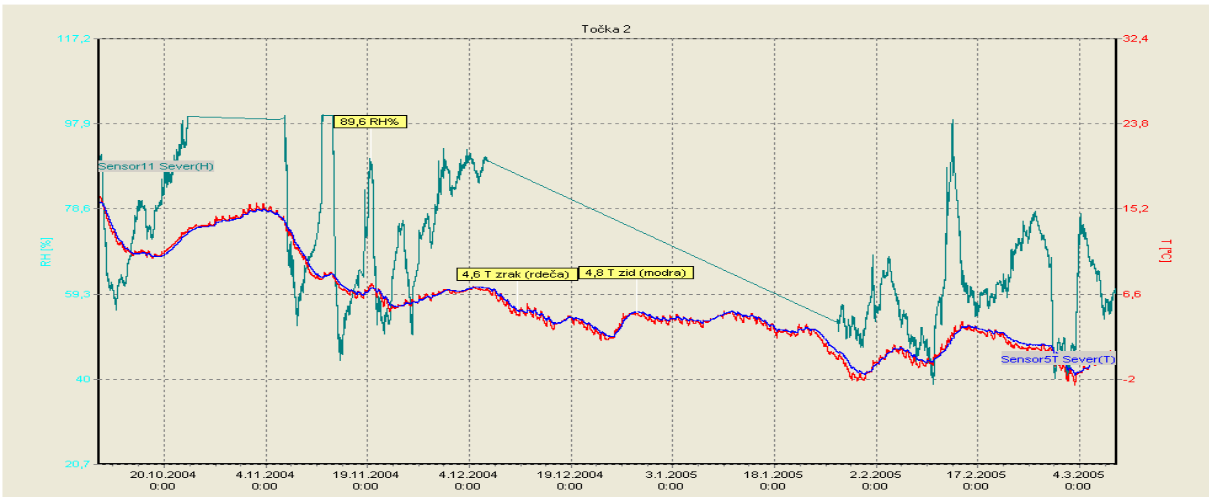



LEGEND: T air, T wall, RH

Southern wall ("TOČKA 1")




Northern wall ("TOČKA 2")




* Certain results are copied from older report on analyses of the Church St. Helen (GDC).

***b) December 2020 to August 2023***

Sensors positions:

West (13)

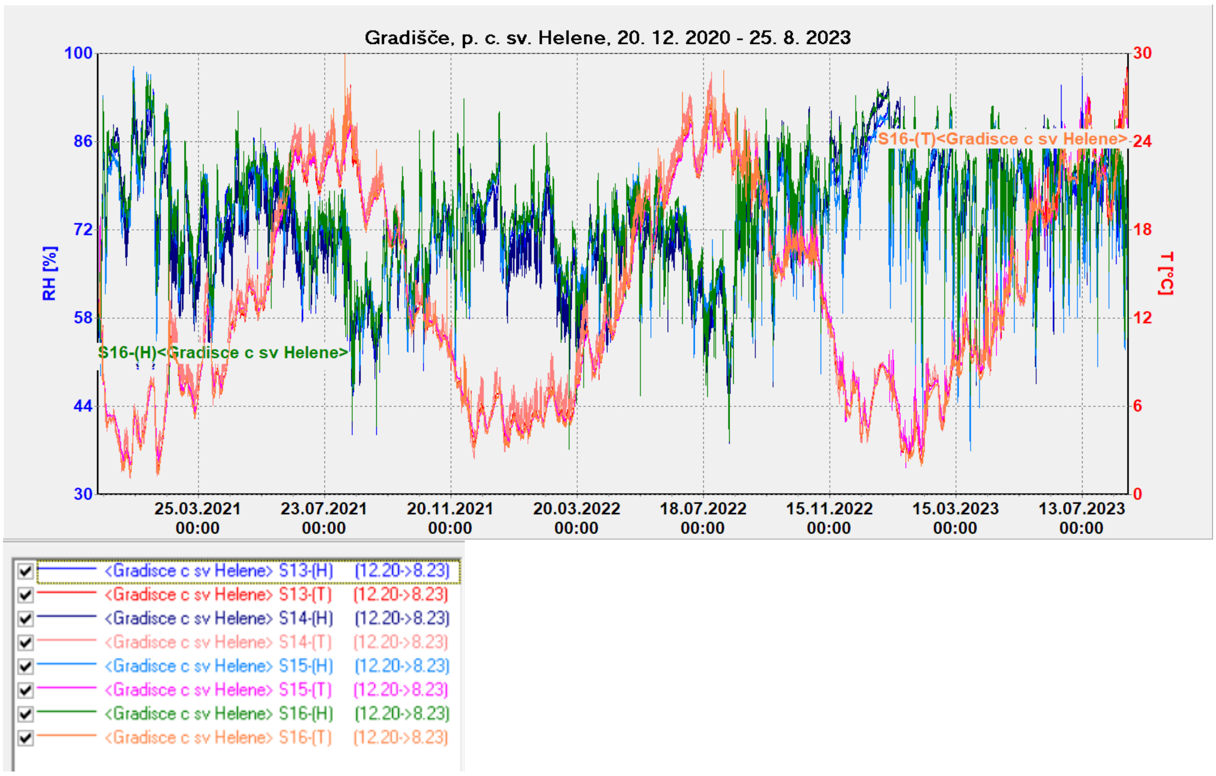
North (16)

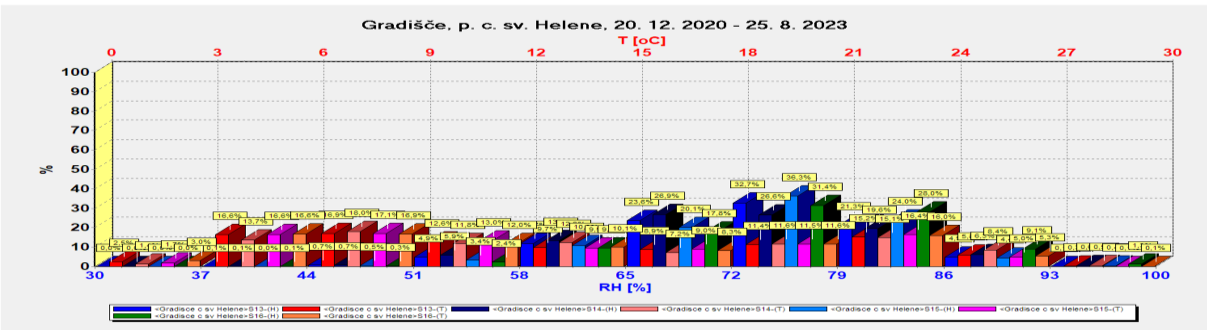
East (15)

South (14)

LEGEND: T air, RH
All sensors

Relative humidity levels distribution



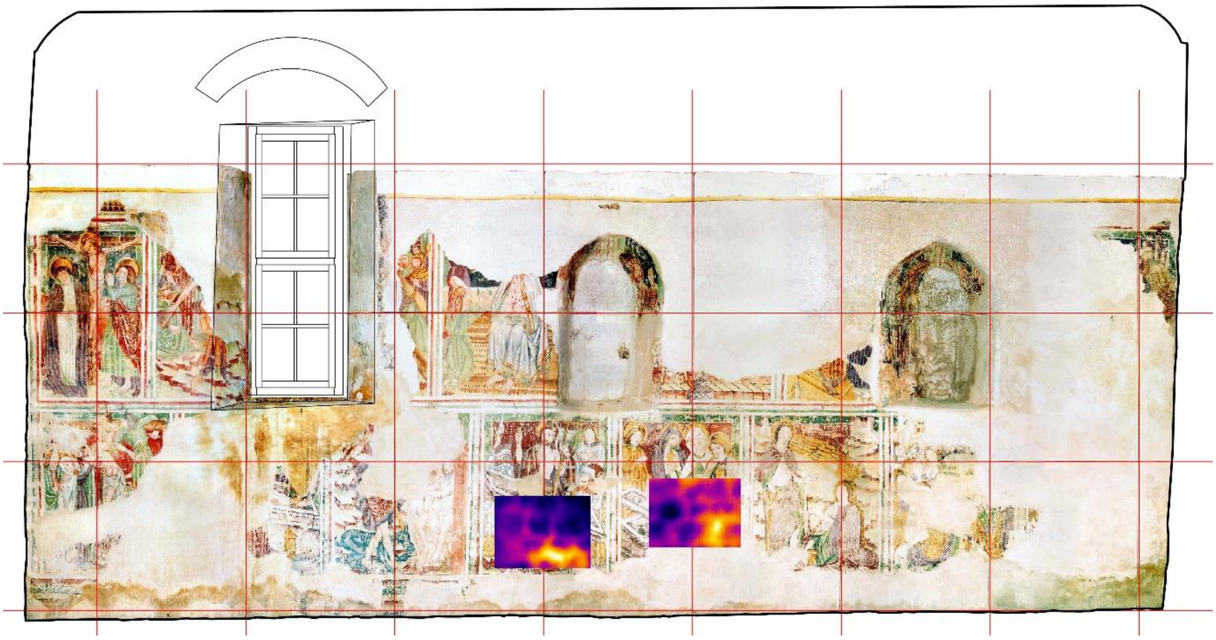



## 5. INFRARED THERMOGRAPHY

### *a) Northern wall*

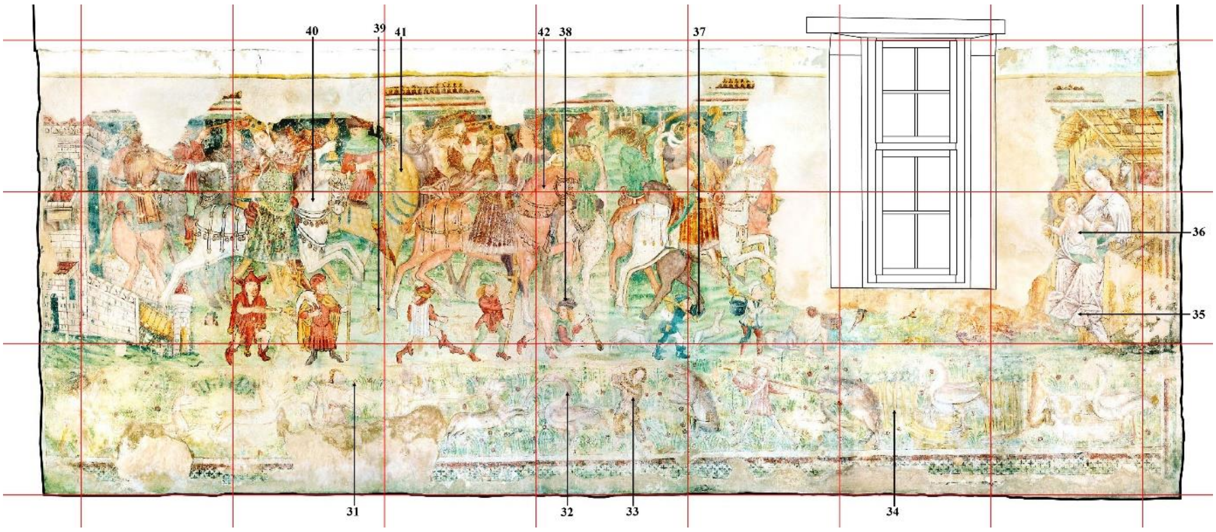
### *b) Southern wall*

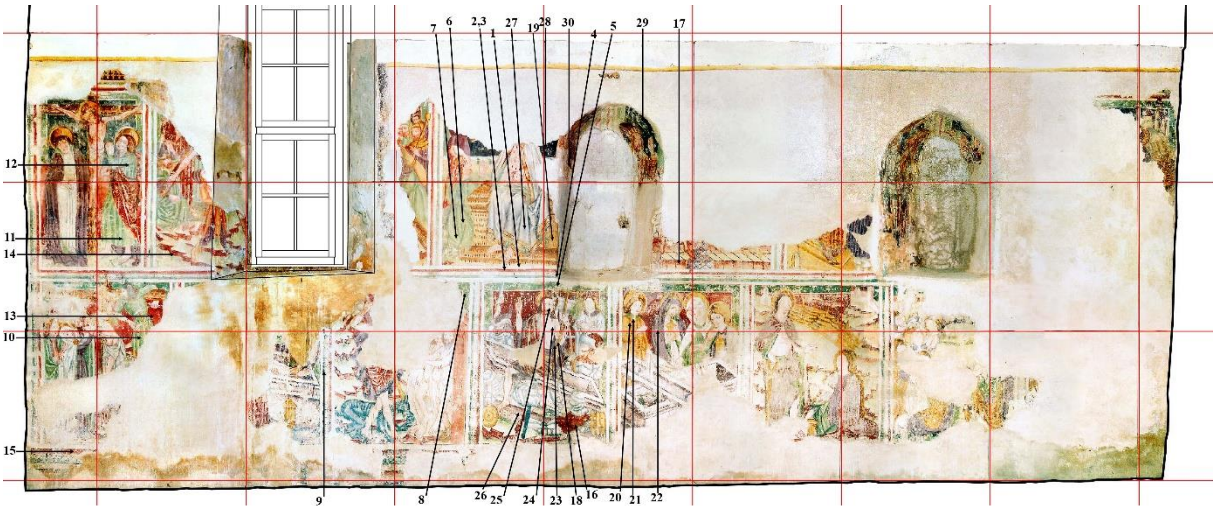


## 6. MATERIAL ANALYSES RESULTS

### 6.1 *In situ* Raman and XRF analyses

### *a) Raman analyses, June 2021*




| Location | Colour | Materials | Gypsum /calcite ratio* |
|---|---|---|---|
| ***Southern wall*** | | | |
| 1 | white | calcite | |
| 2 | red | calcite, haematite | |
| 3 | red | calcite | |
| 4 | green | calcite, gypsum, maybe green earth | 600/3912 =0,153 |
| 5 | green | calcite, maybe gypsum, aluminium salts | maybe 190/806=0,236 |
| 6 | green | calcite, gypsum, maybe green earth | 3790/3870=0,979 |
| 7 | green | calcite, gypsum | 1537/2925=0,525 |
| 8 | green | calcite | |
| 9 | green | calcite | |
| 10 | green | calcite, gypsum, quartz, green earth | 560/7880=0,071 |
| 11 | green | calcite, gypsum | 630/3000=0,210 |

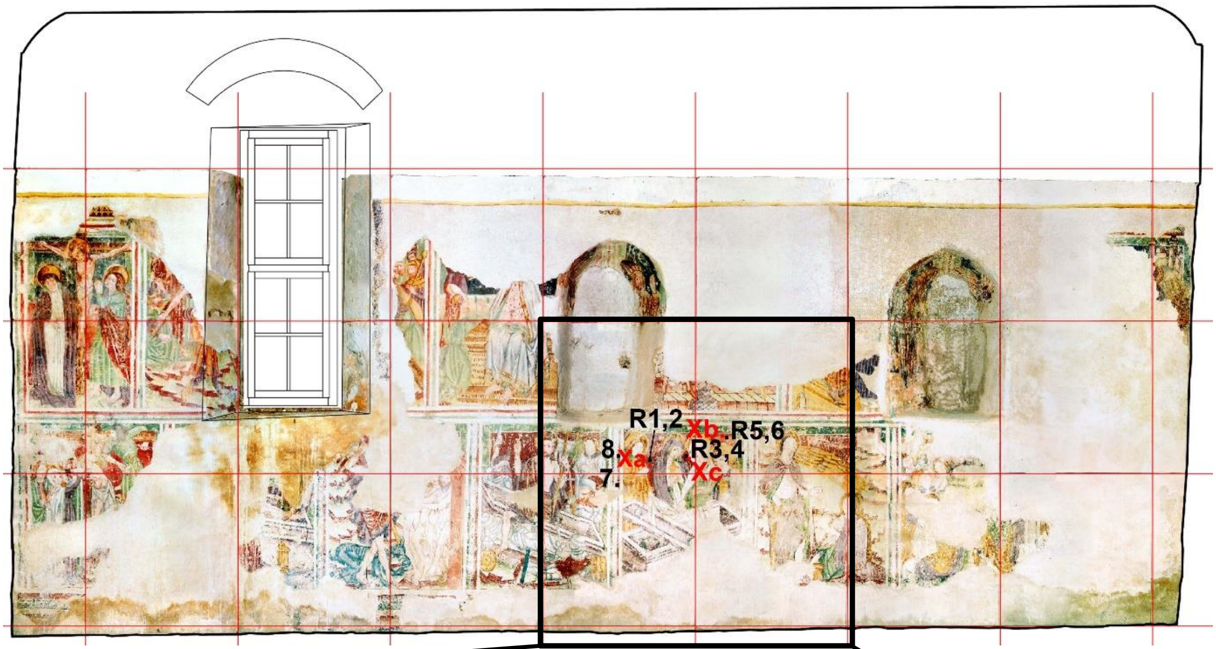
 

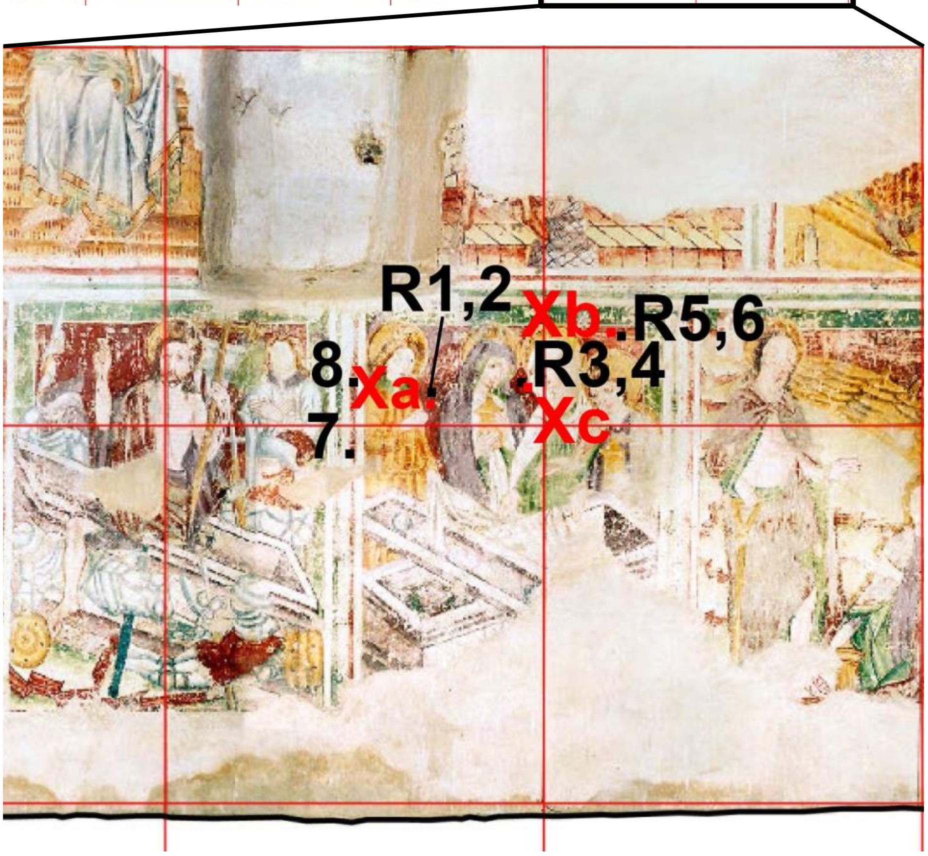
| | | | |
|---|---|---|---|
| 12 | green | calcite, gypsum | 604/2790=0,216 |
| 13 | red | calcite, gypsum, quartz, haematite | 345/2870=0,120 |
| 14 | red | calcite, gypsum, haematite | 824/3490=0,236 |
| 15 | red | calcite, haematite | |
| 16 | red | calcite, quartz, haematite | |
| 17 | red | calcite, gypsum, quartz, haematite | 1150/5200=0,221 |
| 18 | ochre | calcite, goethite | |
| 19 | ochre | calcite, gypsum, maybe goethite | 225/4410=0,051 |
| 20 | yellow | calcite, gypsum | 760/3200=0,238 |
| 21 | ochre | calcite, goethite | |
| 22 | violet | calcite, gypsum, haematite (presumably caput mortuum) | 1680/2500=0,672 |
| 23 | violet | calcite, haematite (presumably caput mortuum) | |
| 24 | carnation | calcite, gypsum | 210/4415=0,048 |
| 25 | carnation | calcite, gypsum | 520/4680=0,111 |
| 26 | blue | calcite, gypsum, carbon black | 490/2570=0,191 |
| 27 | blue | calcite, gypsum, carbon black, quartz | 333/2835=0,117 |
| 28 | blue | calcite, gypsum, carbon black | 2210/2675=0,826 |
| 29 | blue | carbon black | |
| 30 | white | calcite, quartz | |
| ***Northern wall*** | | | |
| 31 | green | calcite, gypsum | 275/3200=0,086 |
| 32 | red | calcite, gypsum, quartz | 490/3530=0,139 |
| 33 | ochre | calcite, gypsum | 890/3520=0,253 |
| 34 | ochre | calcite, gypsum, quartz | 610/3560=0,171 |
| 35 | violet | calcite, gypsum, haematite (presumably caput mortuum) | 770/4470=0,172 |
| 36 | carnation | calcite | |
| 37 | blue | calcite, gypsum, carbon black, maybe haematite | 1475/2710=0,544 |
| 38 | violet | calcite, gypsum, haematite, nitrates (1050 $cm^{-1}$) | 590/2825=0,209 |
| 39 | green | calcite, gypsum | 355/2915=0,122 |
| 40 | white | calcite, gypsum | 405/4375=0,093 |
| 41 | ochre | calcite, goethite | |
| 42 | red | calcite, gypsum, haematite, nitrates (1049 $cm^{-1}$) | 105/4160=0,025 |

* In this column ratio between height of the gypsum band and calcite band are calculated. This is to approximate the amount of gypsum in the analysed area.

***b) Raman analyses, August 2021***

Southern wall



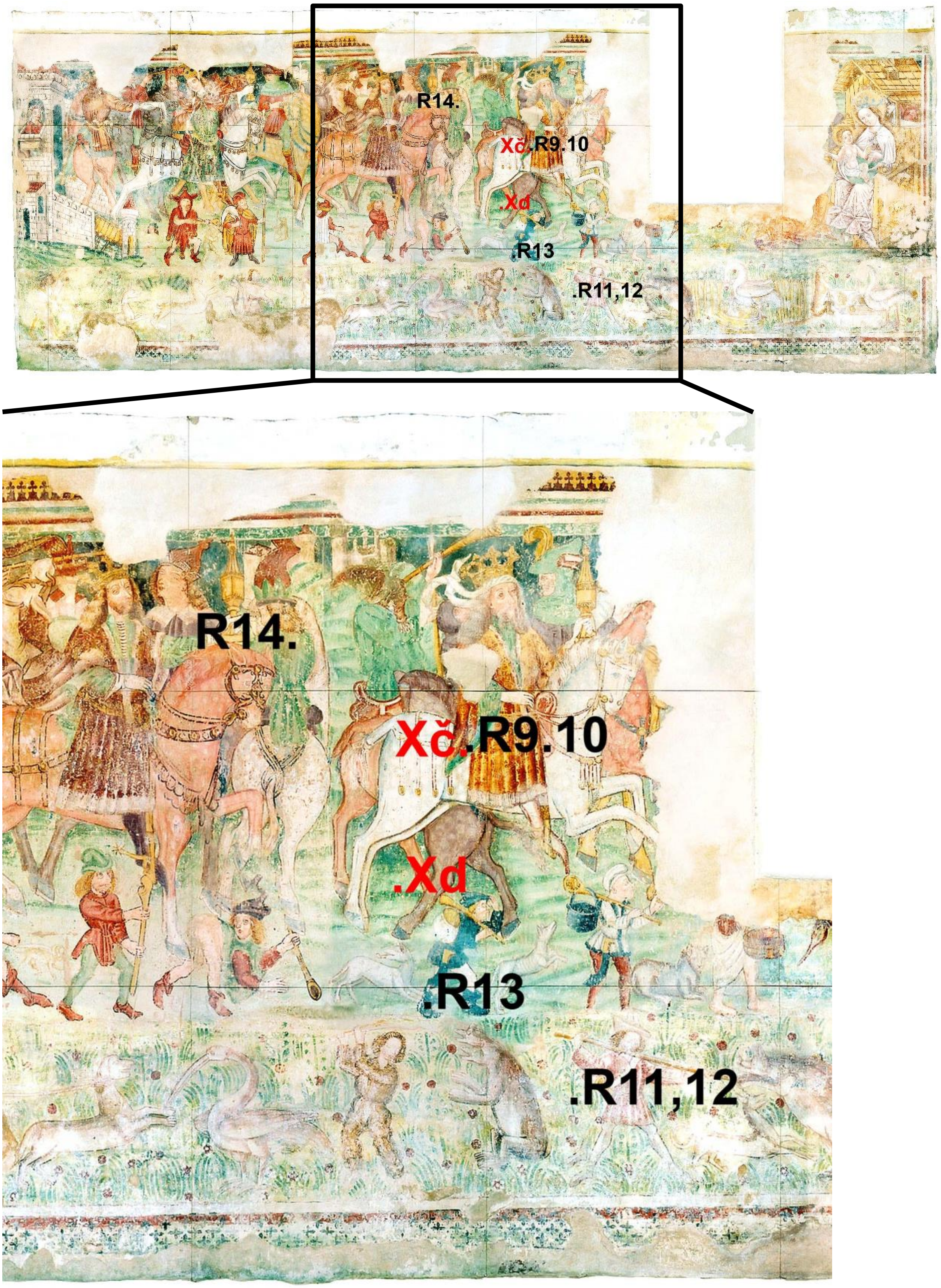




LEGEND:

**R = Raman**

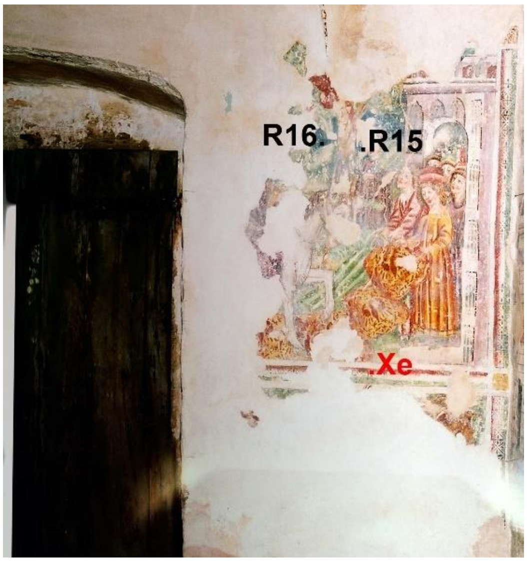
**X = XRF**

Northern wall

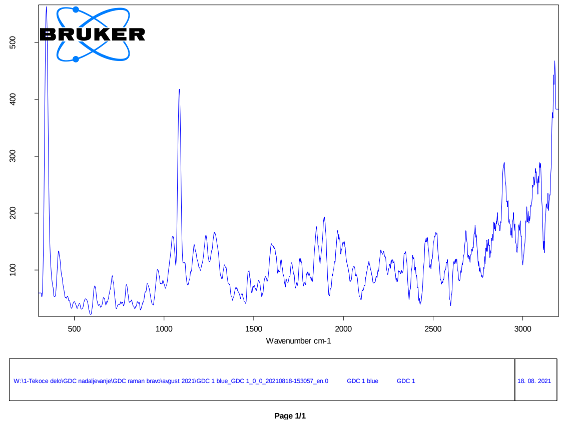


Western wall

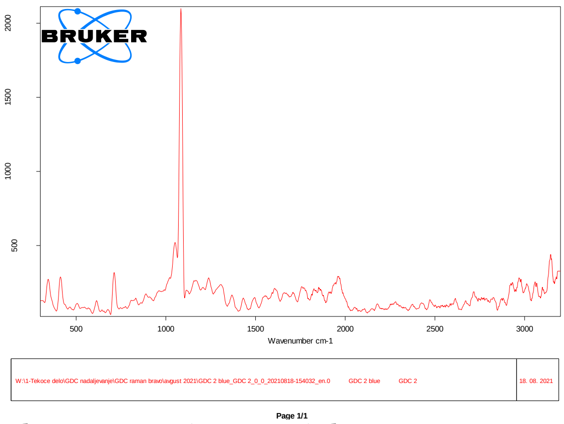



**R 1**



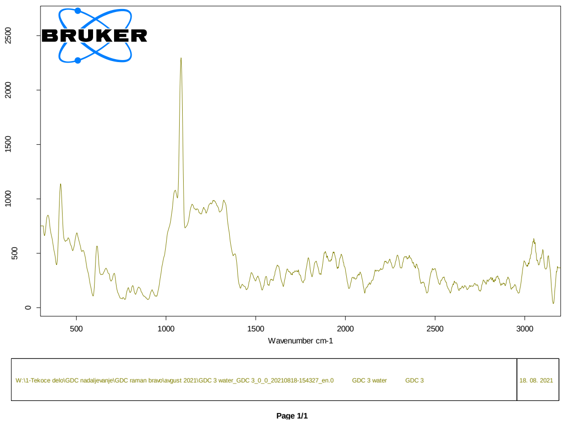

calcite, haematite, unidentified material (344 cm$^{-1}$), nitrates (1049 cm$^{-1}$), calcium oxalate (weddellite, 1472 cm$^{-1}$)

**R 2**



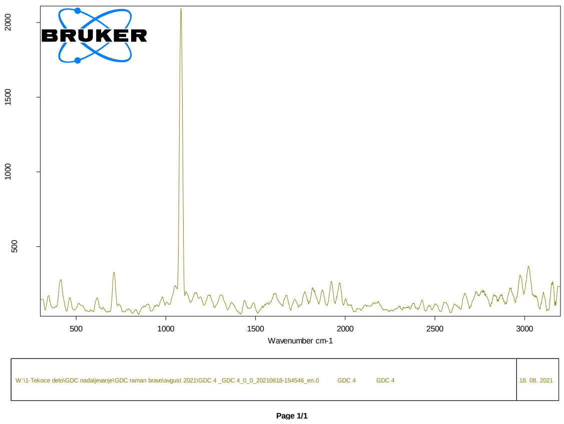

calcite, nitrates (1049 cm$^{-1}$), haematite, unidentified material (345 cm$^{-1}$)

**R 3**



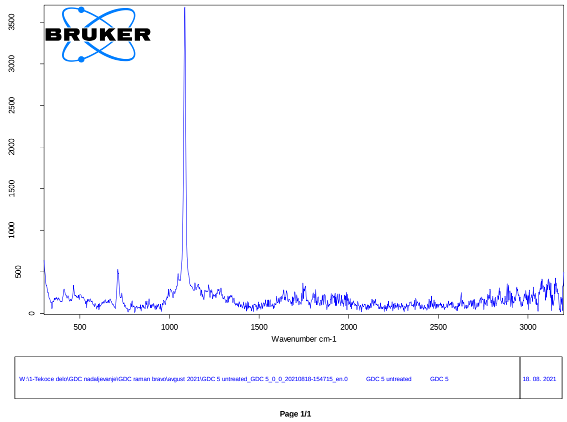

calcite, haematite, unidentified material (342 cm$^{-1}$, possibly chlorides (Alves et al., 2008; Rudolph et al, 2003)), nitrates, calcium oxalate (1321 cm$^{-1}$)

**R 4**



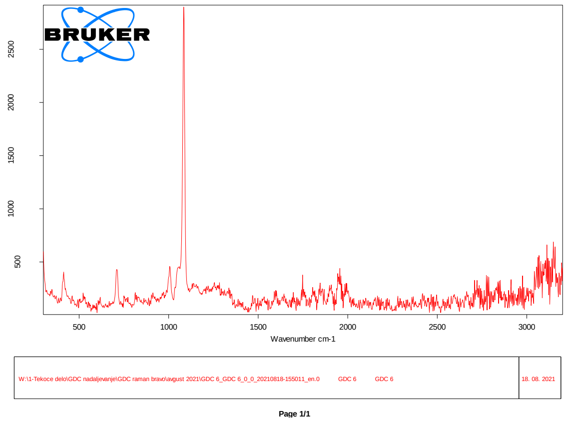

calcite, haematite

**R 5**



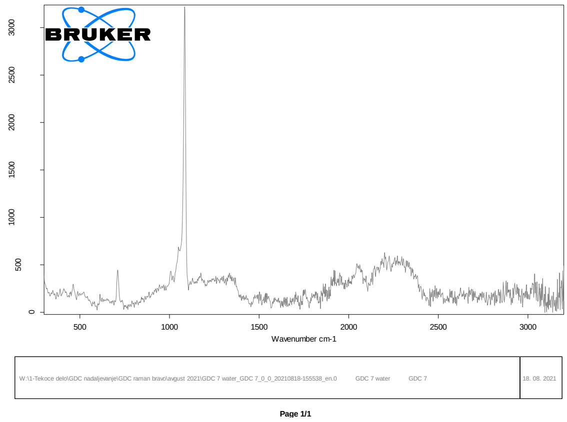

calcite, quartz, haematite, possibly some gypsum

**R 6**



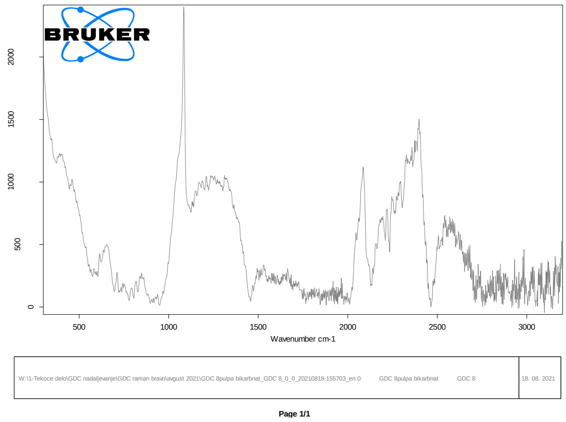

calcite, haematite, gypsum

**R 7**



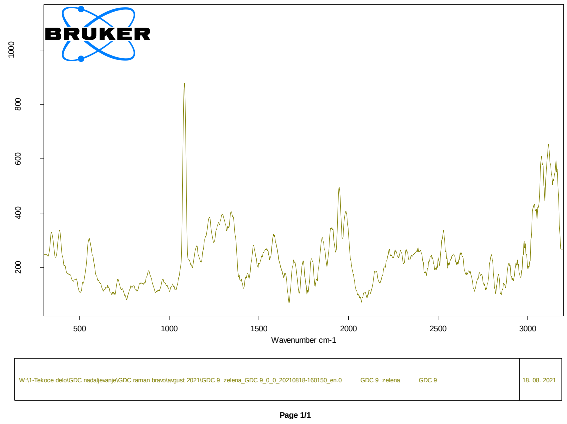

calcite, quartz, nitrates, gypsum

**R 8**



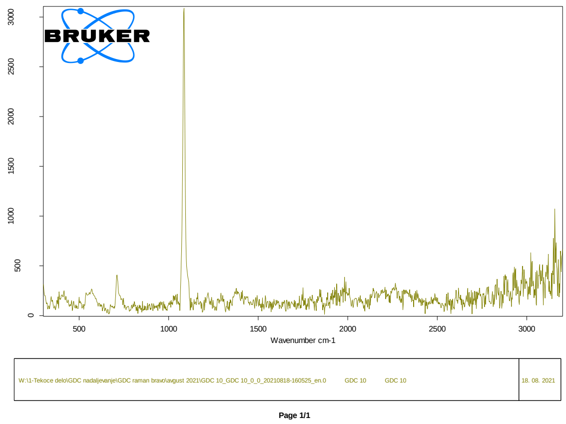

calcite

**R 9**




calcite, celadonite (green earth), unidentified material (341 cm-1; vermilion?)

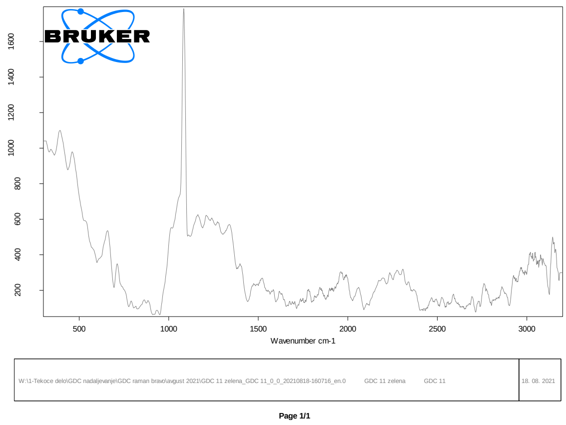
**R 10**




calcite

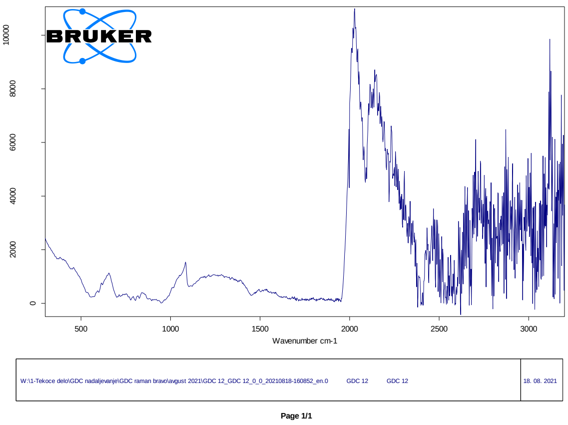
 

**R 11**



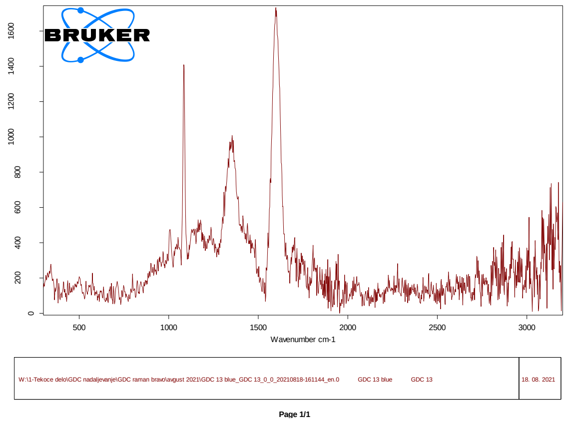

calcite, quartz, magnetite, possibly goethite

**R 12**



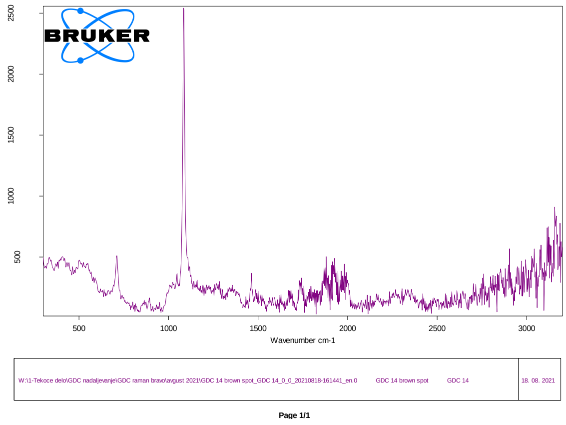

calcite, magnetite

**R 13**



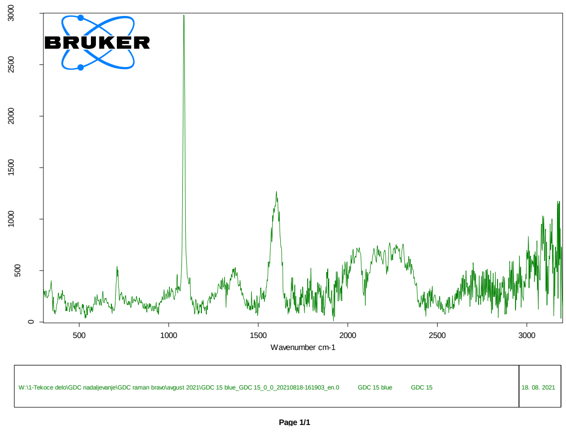

calcite, gypsum, carbon black, unidentified material (342 $cm^{-1}$)

**R 14**



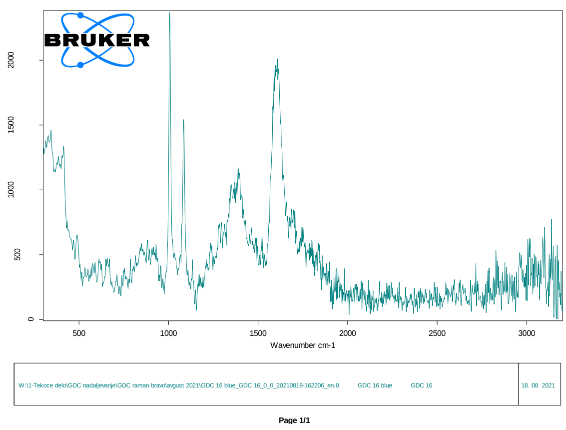

calcite, nitrates, calcium oxalate

**R 15**




calcite, carbon black

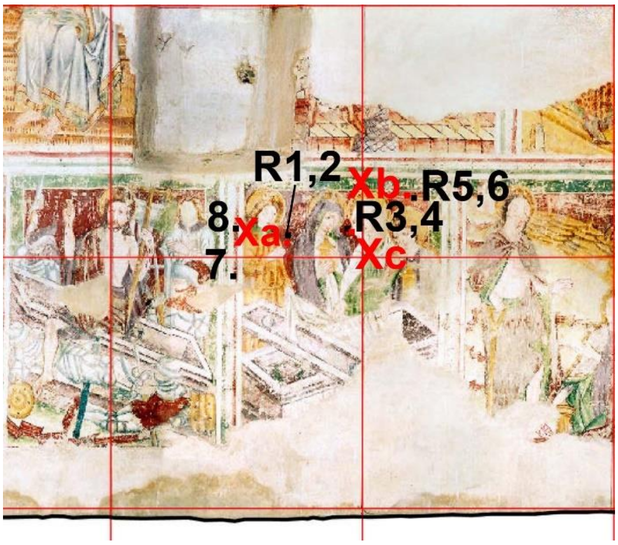
**R 16**

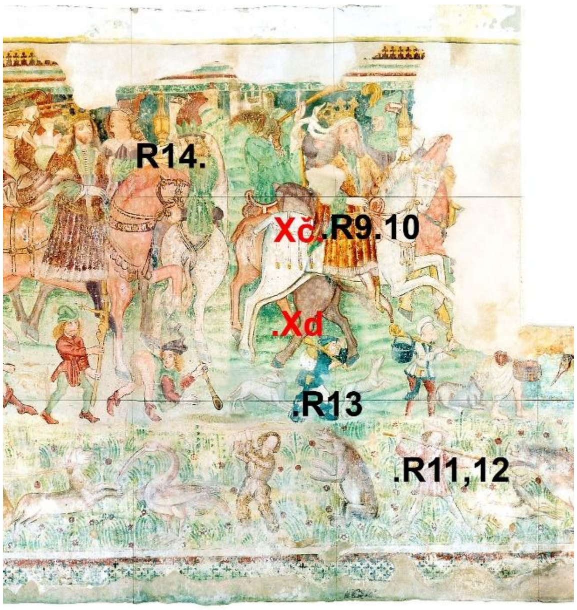



calcite, gypsum, carbon black, possibly haematite

### *c) XRF analyses, August 2021*




LEGEND: **R = Raman X = XRF**

| SAMPLING NUMBER | TABLE OF ELEMENTS | | RESULT |
|---|---|---|---|
| X a | Element | Concentration | clear presence of gypsum<br>chlorine |
| | Ca | 60,10 % | |
| | Si | 18,56% | |
| | Cl | 12,24 % | |
| | S | 6,47 % | |
| X b | Element | Concentration | possible presence of gypsum, however due to large error (5,46 %) doubtful |
| | Ca | 91,45 % | |
| | S | 3,06 % | |
| | Fe | 2,69 % | |
| X c | Element | Concentration | large amount of gypsum |
| | Ca | 82,31 % | |
| | S | 14,92 % | |
| X č | Element | Concentration | iron oxide pigment<br>possible presence of copper pigment, however due to relatively large error (0,90 %) questionable |
| | Si | 48,74 % | |
| | Ca | 43,75 % | |
| | Fe | 5,52 % | |
| | Cu | 0,98 % | |
| X d | Element | Concentration | possible presence of gypsum, however due to large error (4,20 %) doubtful |
| | Ca | 73,93 % | |
| | Si | 23,75 % | |
| | S | 1,65 % | |
| X e | Element | Concentration | possible presence of gypsum, however due to large error (4,64 %) doubtful<br>unclear origin of argon |
| | Ca | 73,10 % | |
| | Si | 14,55 % | |
| | Ar | 5,91 % | |
| | S | 3,53 % | |

## 6.2 Microscopic and spectroscopic analyses on extracted samples

***Table 1**: List of extracted samples.*

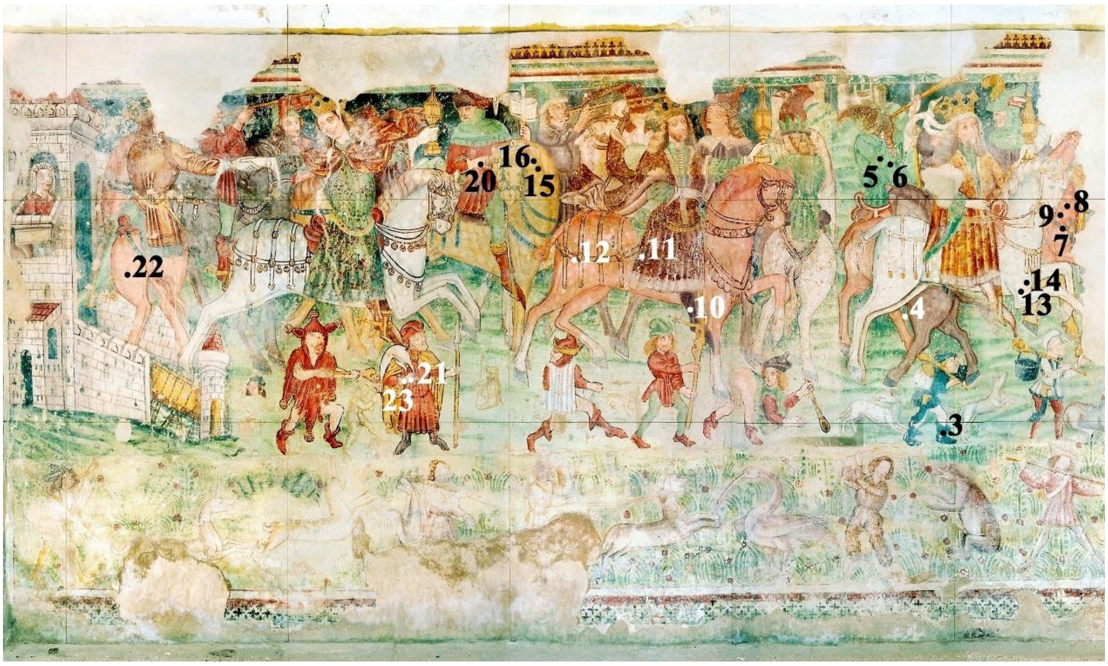
| WORKING CODE | SAMPLE TYPE | MICROLOCATION OF THE SAMPLE |
|---|---|---|
| GDC 1 | algae | N wall, corner beside triumphal arch, algae on plaster surface |
| GDC 2 | plaster, algae | N wall, beside triumphal arch, white border above paintings |
| GDC 3 | paint layer | N wall, man with bundle over shoulder, grey left boot |
| GDC 4 | paint layer | green background between horse legs |
| GDC 5 | paint layer | man with instrument, green drapery, brighter green |
| GDC 6 | paint layer | man with instrument, green drapery, darker green, fold, compare with GDC 5 |
| GDC 7 | paint layer | horse on right edge of painting, harness, grey area, over red ground? |
| GDC 8 | paint layer | horse on right edge of painting, circular pattern on neck, brighter red |
| GDC 9 | paint layer | horse on right edge of painting, circular pattern on neck, darker red |
| GDC 10 | paint layer | king on the reddish horse, king's right leg, violet |
| GDC 11 | paint layer | king on the reddish horse, dark red drapery, on left edge, dark red over ochre? |
| GDC 12 | paint layer | king on the reddish horse, dark red harness, belt, dark red edge |
| GDC 13 | paint layer | white horse on right side of the painting, right front leg, white background |
| GDC 14 | paint layer | white horse on right side of the painting, right front leg, white decorative point |
| GDC 15 | paint layer | bright brown horse, circular pattern on the neck, dark ochre |
| GDC 16 | paint layer | bright brown horse, circular pattern on the neck, bright ochre |
| GDC 17 | paint layer | S wall, W corner, 30cm above ground, surface plaster for salts |
| GDC 18 | paint layer | W wall, S corner, 30cm above ground, under visible humidity level, very hard surface (sinter?), for salts |
| GDC 19 | paint layer | presbytery, N wall, under window, 40cm above ground, mould, carnation, detached plaster, traces of water leaking, for salts |
| GDC 20 | paint layer | N wall, rider on yellow horse, right hand, carnation, retouching or *secco*, thin layer on plaster, detached |
| GDC 21 | paint layer | hunter with catch over shoulder, right hand, carnation |
| GDC 22 | paint layer | back right leg of horse, pink, probably fresco, binder analysis |
| GDC 23 | paint layer | hunter with catch over shoulder, right hand, carnation, binder analysis |
| GDC 24 | plaster | plaster, N wall, ornament above the floor, between lines |
| GDC 25 | mortar | mortar, outer N wall, between stone bricks |

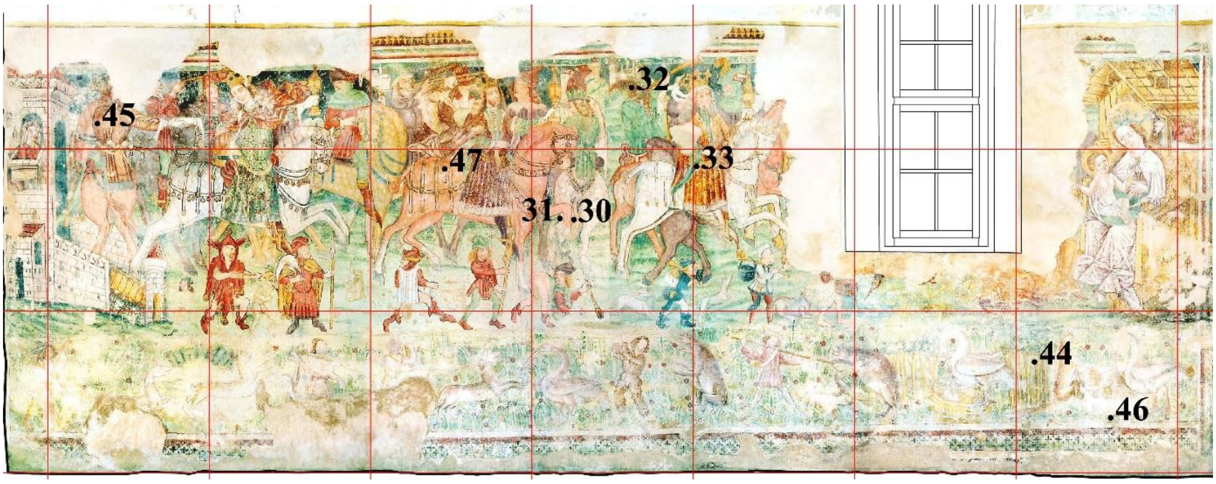
 

| | | |
|---|---|---|
| GDC 28 | coating layer | coating layer, N wall, left from the window, man with a flute, nose, just coating, sampled with diamond stick |
| GDC 29 | coating layer | coating layer, N wall, brown horse in front, back left leg, probably wax stain |
| GDC 30 | paint layer | white, N wall, white horse, left from the tail, BaOH |
| GDC 31 | paint layer | white, N wall, white horse, left leg, under knee of brown horse, BaOH, ammonium bicarbonate, Japanese paper |
| GDC 32 | paint layer | dark white, N wall, left from the window, man with a flute, hat, coating layer |
| GDC 33 | paint layer | dark green, N wall, left from the window, king, sleeve |
| GDC 34 | paint layer | black with orange fluorescence, right of the door, window, ornament bottom right |
| GDC 35 | paint layer | light violet, S wall, grave, anionic resins |
| GDC 36 | paint layer | white, S wall, right of the window, under 1st niche, frame, cleaned with water |
| GDC 37 | paint layer | white, S wall, right of the window, under 1st niche, frame, under GDC 36, BaOH |
| GDC 38 | paint layer | white, S wall, right of the window, under 1st niche, frame, under GDC 37, BaOH and ammonium bicarbonate, poultice |
| GDC 39 | paint layer | red, S wall, right from the window, under 1st niche, right scene, background between figures, blue pigment?, ammonium bicarbonate with poultice |
| GDC 40 | paint layer | white, S wall, right of the window, under 1st niche, frame, left from yellow drapery |
| GDC 41 | algae | algae, presbytery façade |
| GDC 42 | algae | algae, presbytery façade |
| GDC 43 | algae | algae, presbytery façade |
| GDC 44 | incrustation | white material, N wall, between trees, left from fox; white haze appears after cleaning with ammonium carbonate |
| GDC 45 | paint layer | red, N wall, man on left, his back, sinter on surface of paint layer |
| GDC 46 | paint layer | green, N wall, grass under bottle, while cleaning with ammonium bicarbonate salts appear on surface |
| GDC 47 | paint layer | red, N wall, red horse of the king, his back, coating |

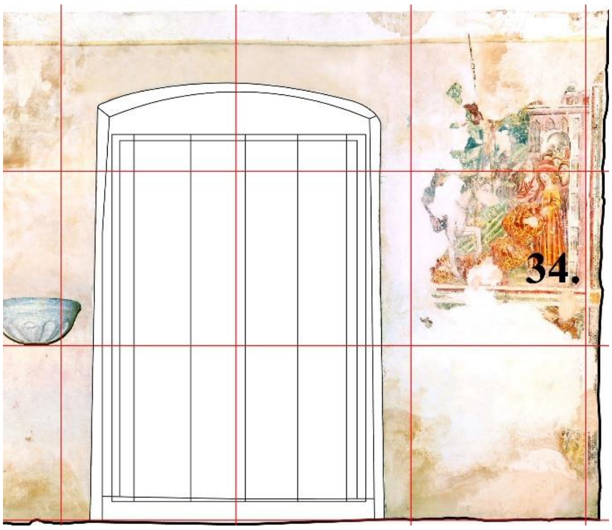
 

Northern wall




Western wall



Southern wall


| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 1** | N wall, corner beside triumphal arch, algae on plaster surface |

REMARK: Samples that were analysed before and were not relevant for present study are only listed in this report and no results are shown.

| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 2** | N wall, beside triumphal arch, white border above paintings |

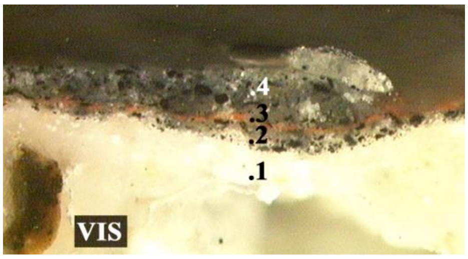
| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 3** | N wall, man with bundle over shoulder, grey left boot |

**STRATIGRAPHY**

5- transparent layer
4- black
3- red
2- black
1- plaster

**VIS PHOTOGRAPHY**

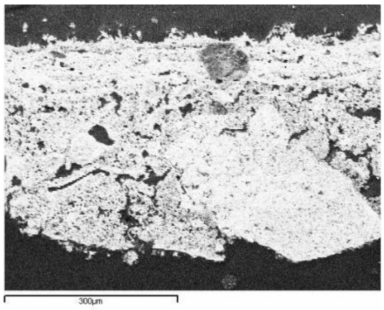



**UVF PHOTOGRAPHY**

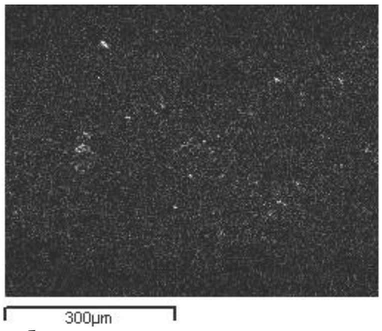

## *FTIR spectroscopy*

Results
- calcite
- hydrated alumosilicates
- gypsum

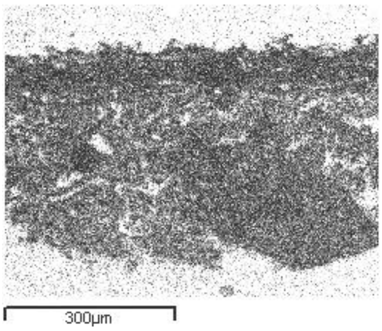
## *SEM EDS*



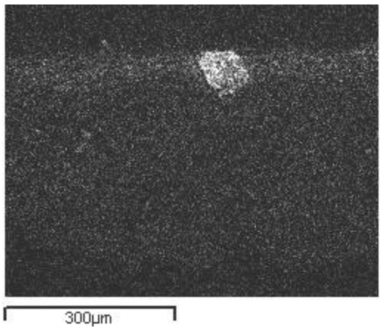
**mapping image**



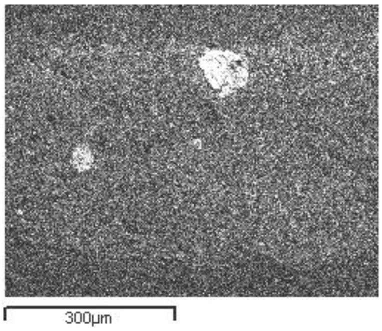

**Al**



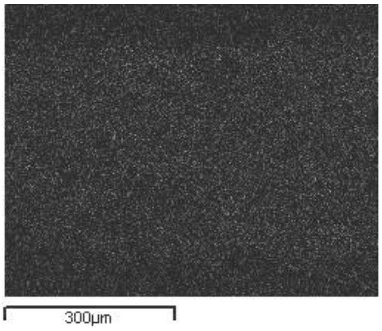

**C**



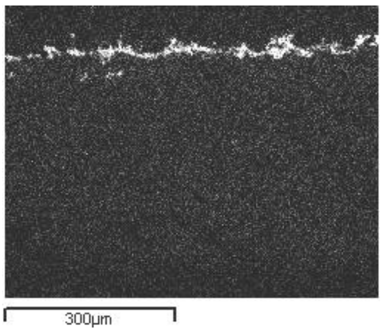

**Mg**



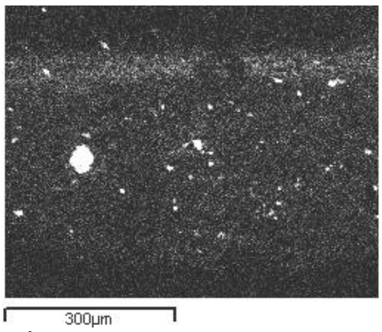

**O**



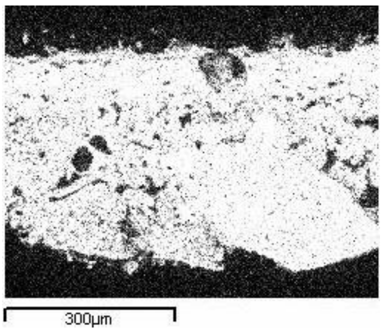

**P**




**S**



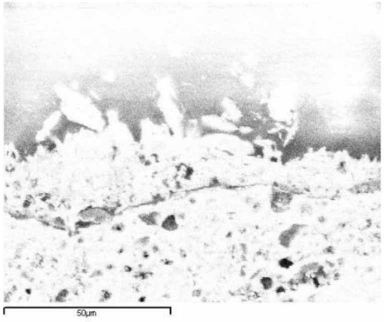

**Si**



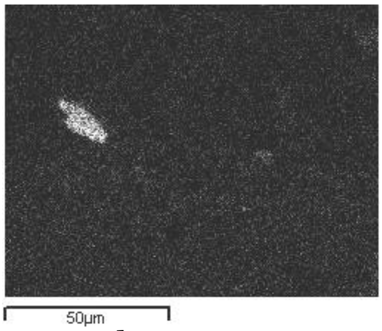

**Ca**

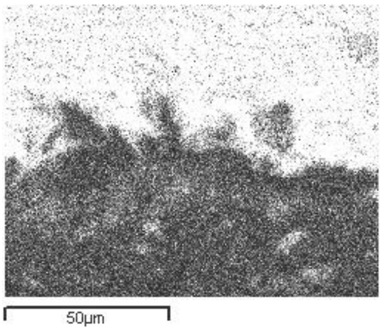
Detail:



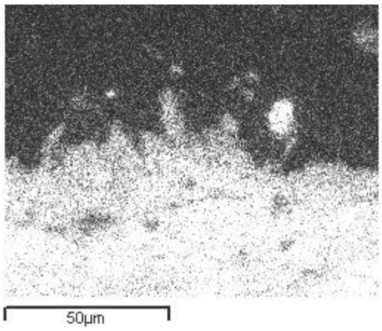
**mapping image**



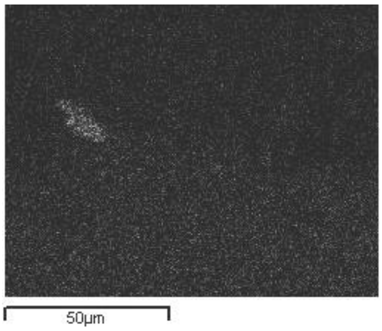

**Al**



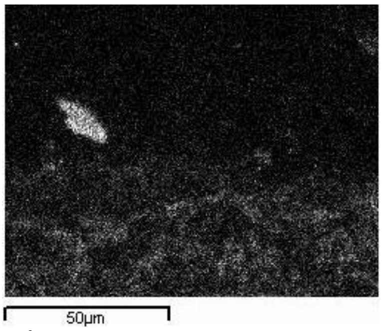

**C**



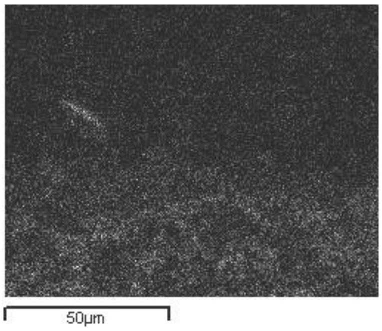

**Ca**



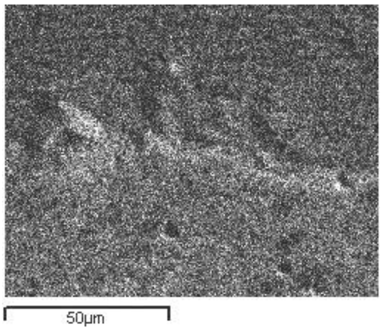

**K**



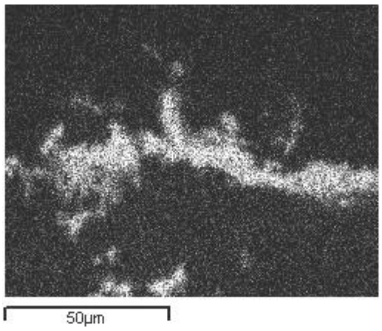

**Si**




**Mg**

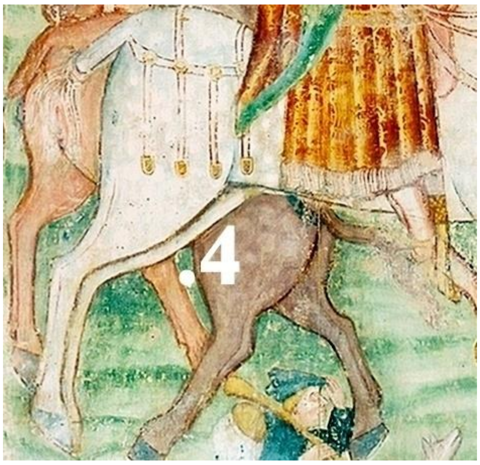



**O**




**S**

| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| GDC 4 | green background between horse legs |



**STRATIGRAPHY**

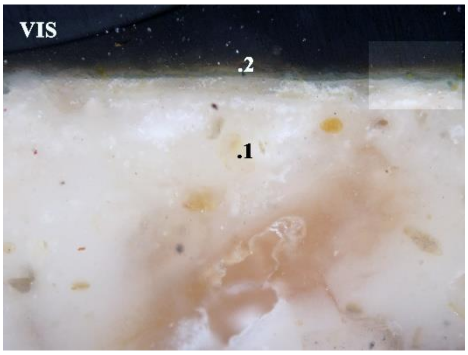
4- transparent layer

3- green

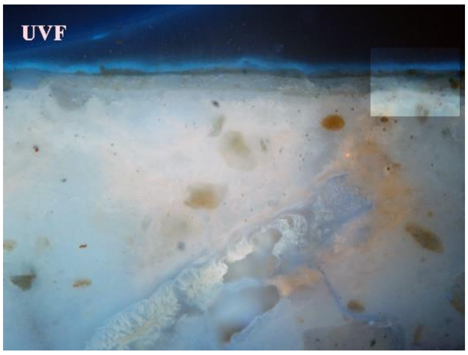
2- whitewash

1- plaster

**VIS PHOTOGRAPHY**




**UVF PHOTOGRAPHY**

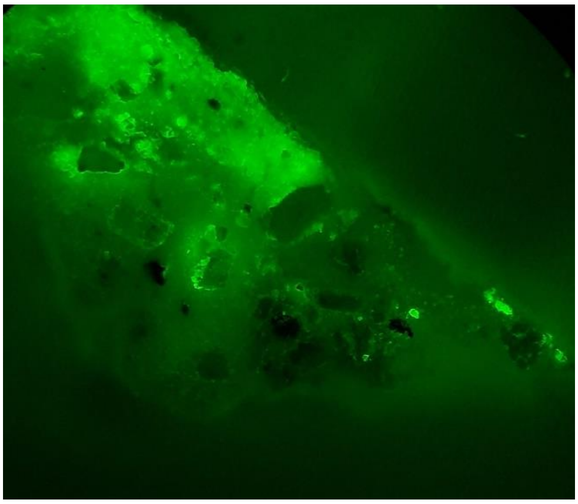


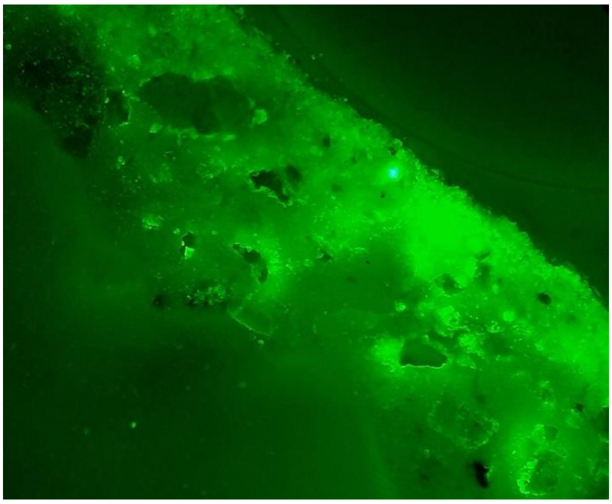

## *FTIR spectroscopy*

Results

- calcite
- green earths
- gypsum

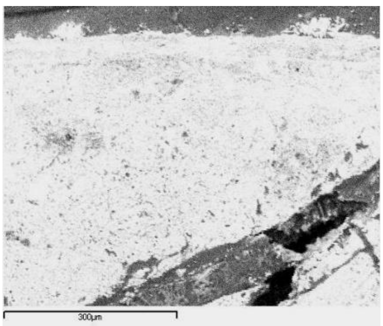
## *IFM*



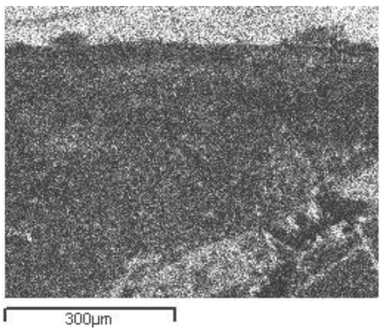


(photograph: J. Kosel)

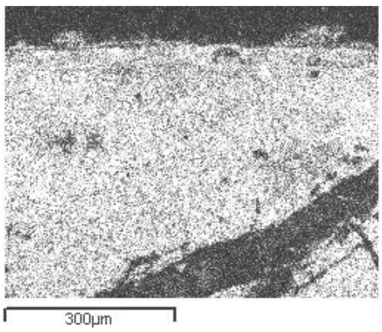
## *SEM EDS*




**mapping image**

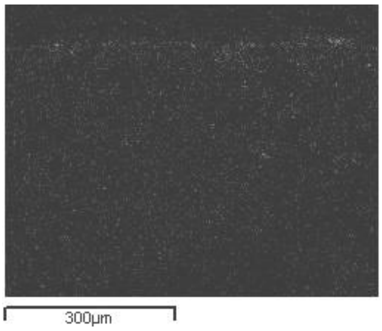



**C**

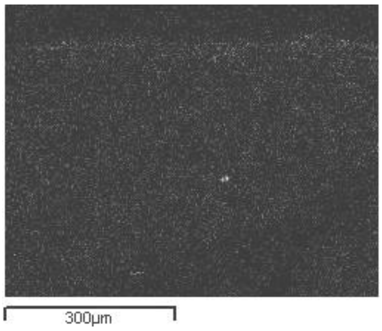



**Ca**

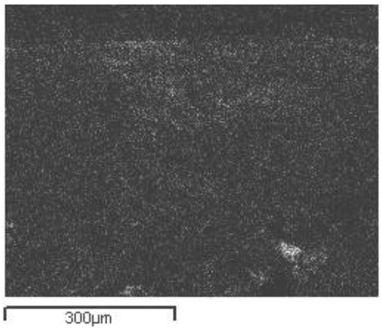
 



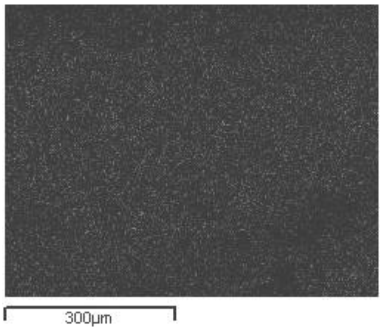

**Fe**



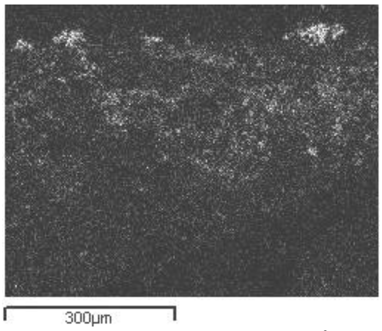

**K**



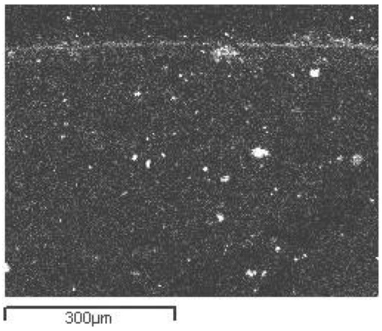

**Mg**




**P**




**S**



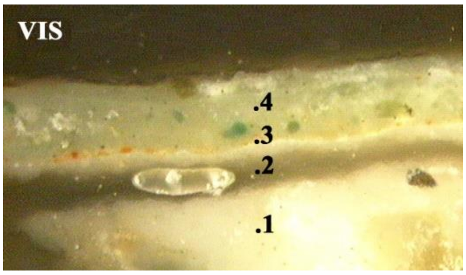

**Si**

| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 5** | green background between horse legs |

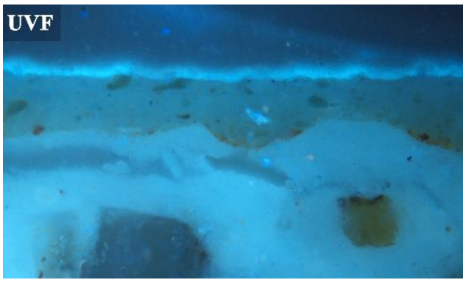

**STRATIGRAPHY**

5- transparent layer
4- green
3- red
2- whitewash
1- plaster

**VIS PHOTOGRAPHY**




**UVF PHOTOGRAPHY**

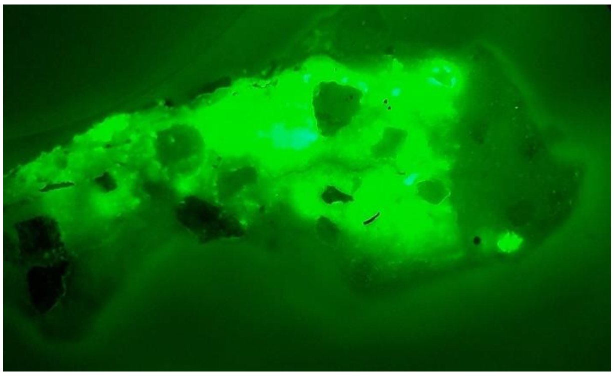


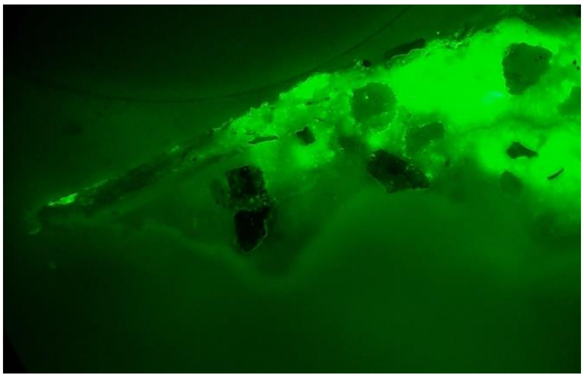

 

### *FTIR spectroscopy*

Results
- calcite
- green earths
- silicates

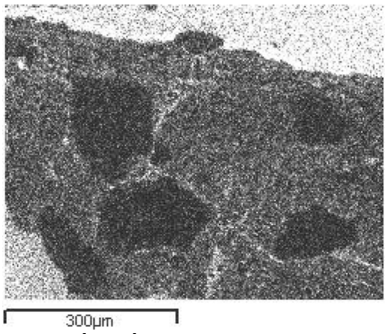
### *IFM*



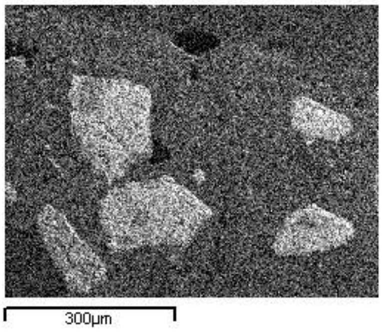


(photograph: J. Kosel)

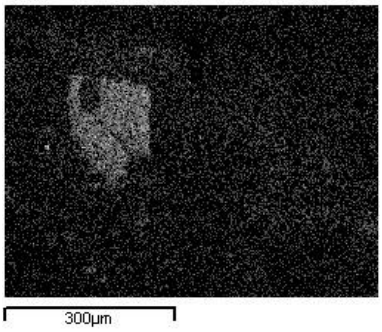
### *SEM EDS*



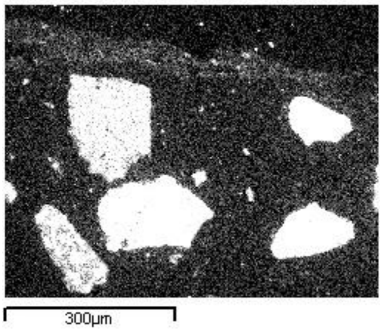

**mapping image**



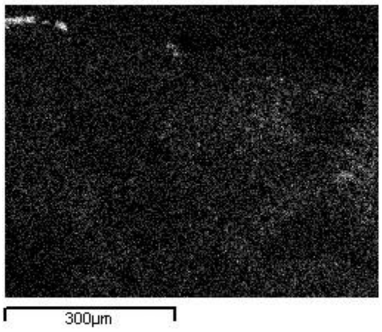

**O**



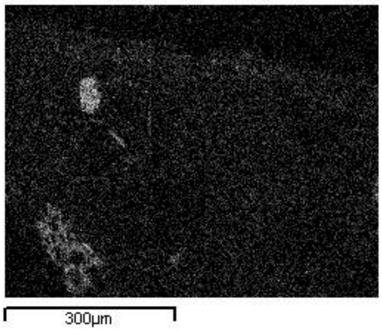

**Na**



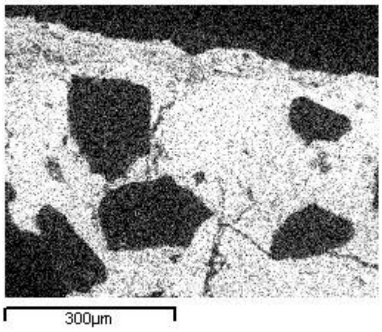

**Si**

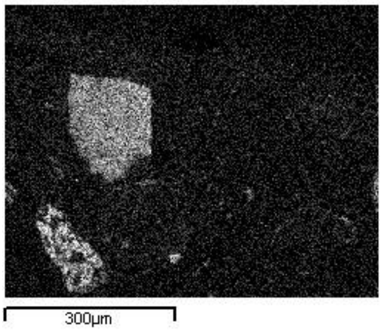


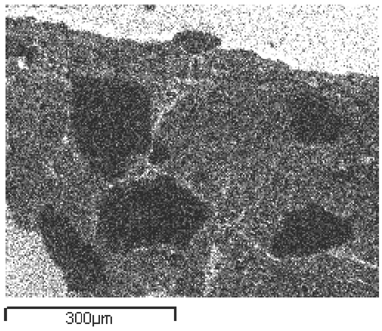

**S**




K




**Ca** **Al** **C**

| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 6** | man with instrument, green drappery, darker green, fold, compare with GDC 5 |


**STRATIGRAPHY**

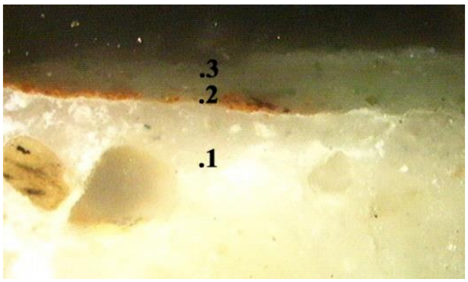
4- transparent layer

3- green

2- red

1- plaster

**VIS PHOTOGRAPHY**



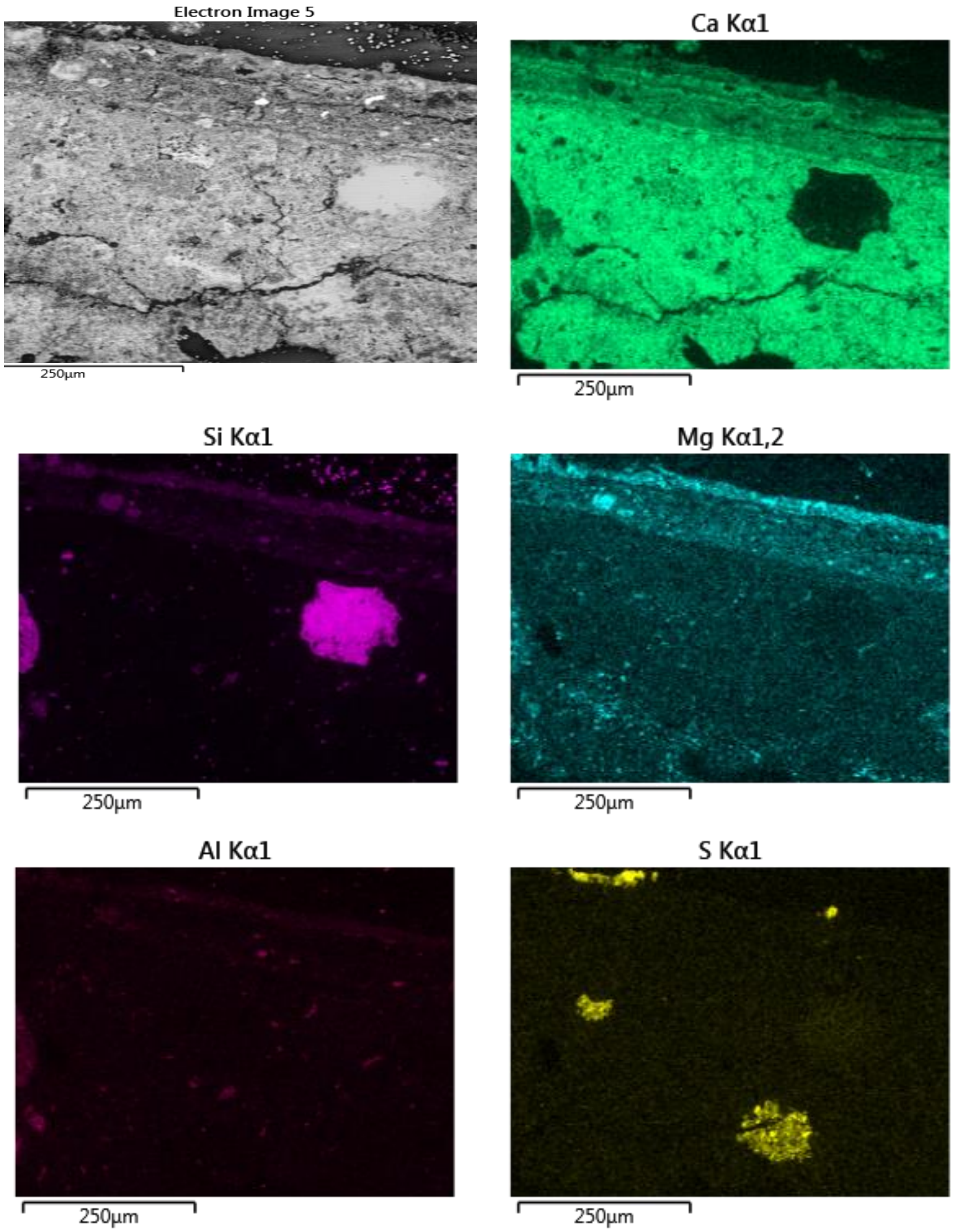

**UVF PHOTOGRAPHY**

### *FTIR spectroscopy*

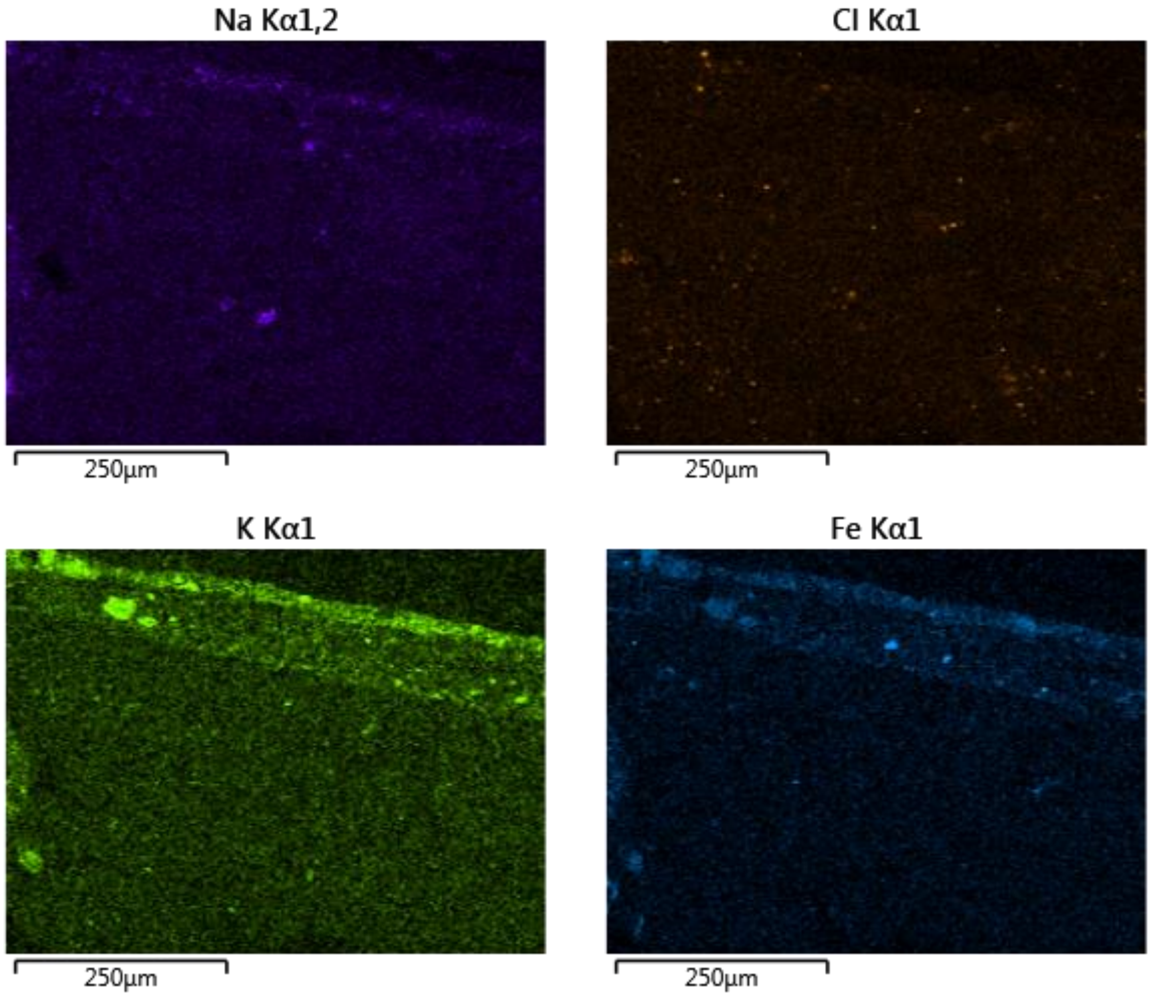
Results

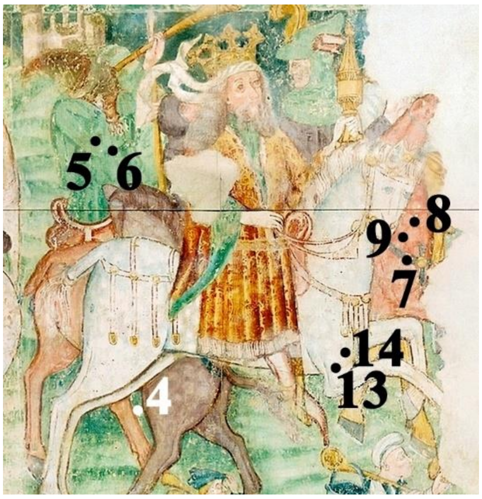
- calcite
- green earths
- gypsum
- oxalates

***SEM EDS***


Electron Image 5
250µm
Ca Kα1
250µm
Si Kα1
250µm
Mg Kα1,2
250µm
Al Kα1
250µm
S Kα1
250µm




| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 7** | horse on right edge of painting, harness, grey area, over red ground?  |

**STRATIGRAPHY**

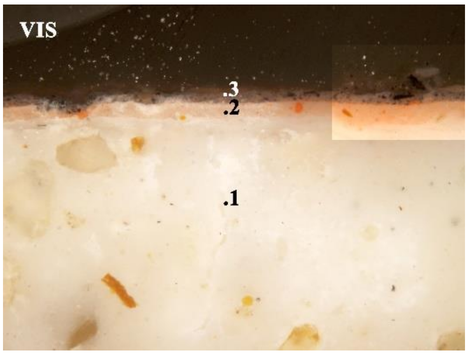
4- transparent layer

3- grey

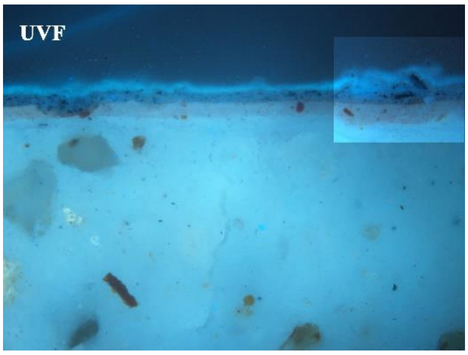
2- red

1- plaster

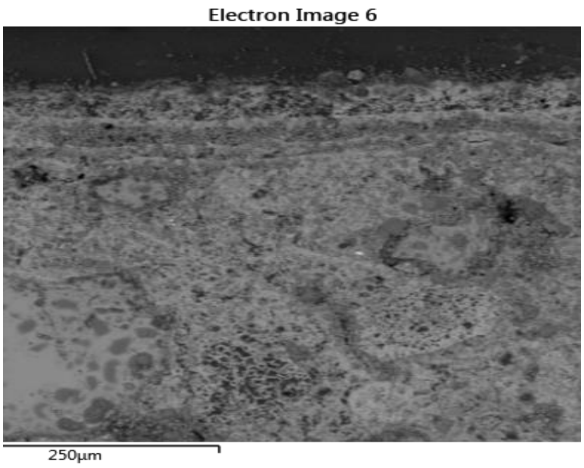
**VIS PHOTOGRAPHY**

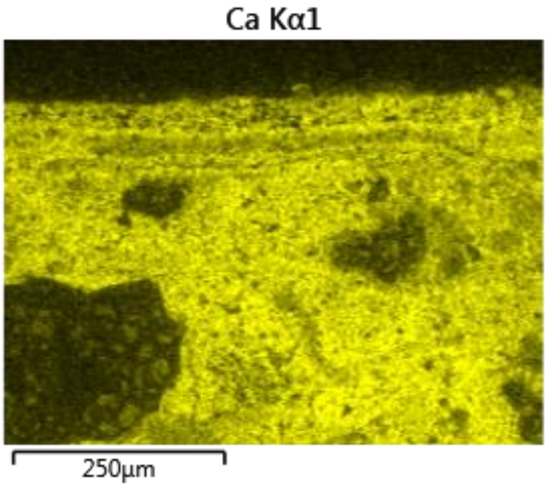


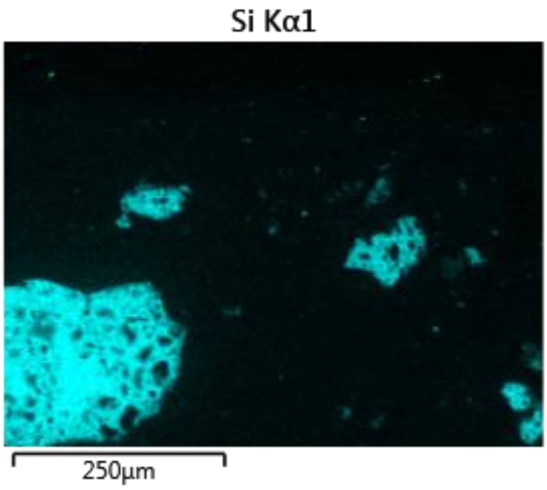

**UVF PHOTOGRAPHY**

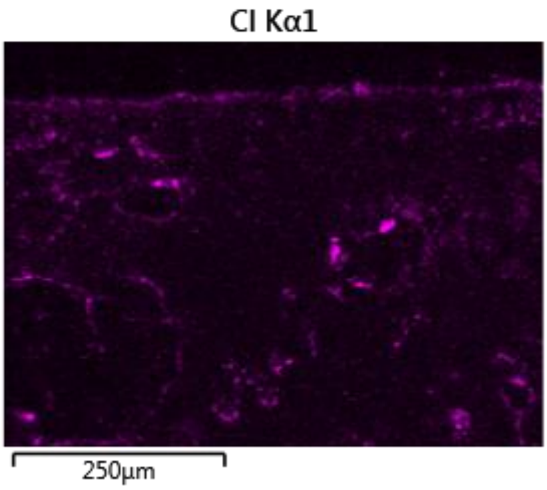



## *SEM EDS*

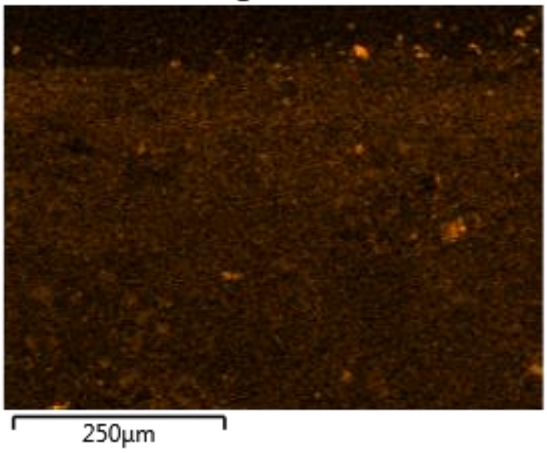


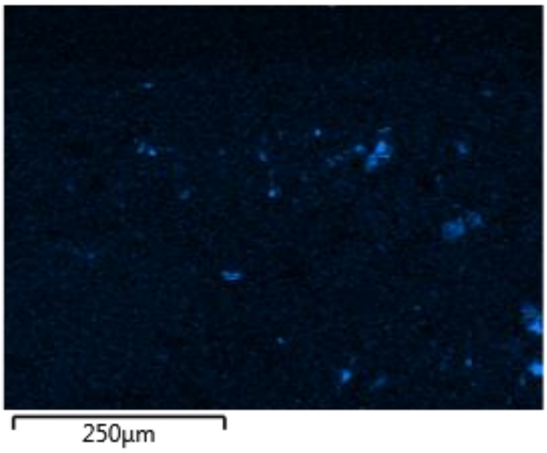



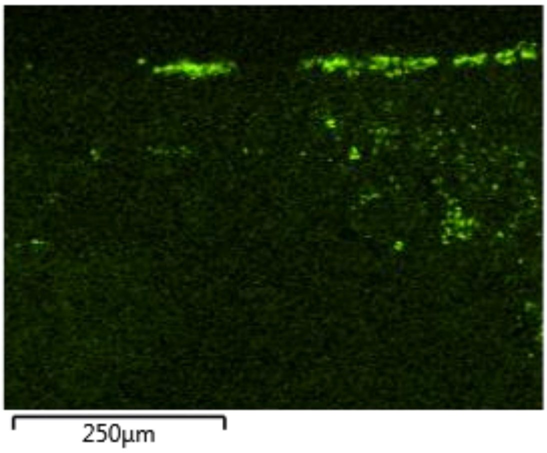
Mg Kα1,2



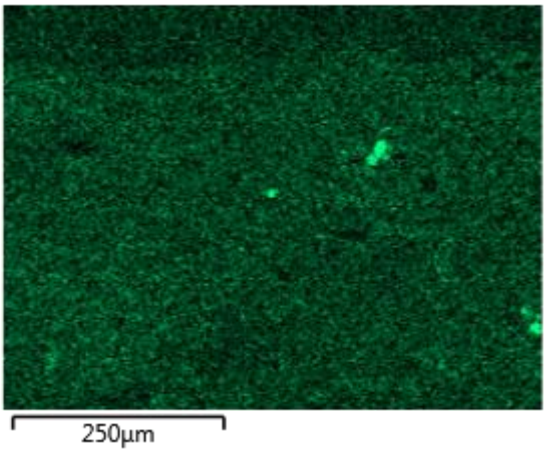

Br Lα1,2



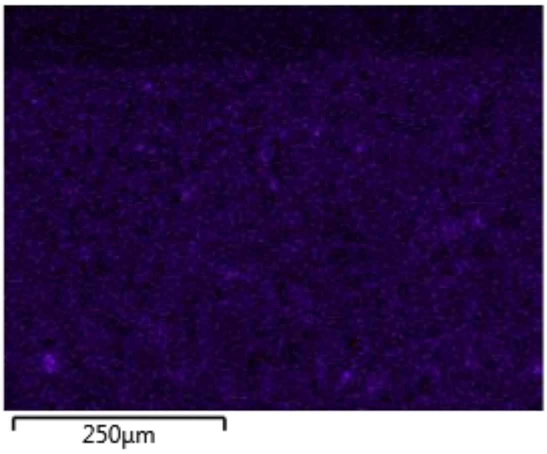

S Kα1



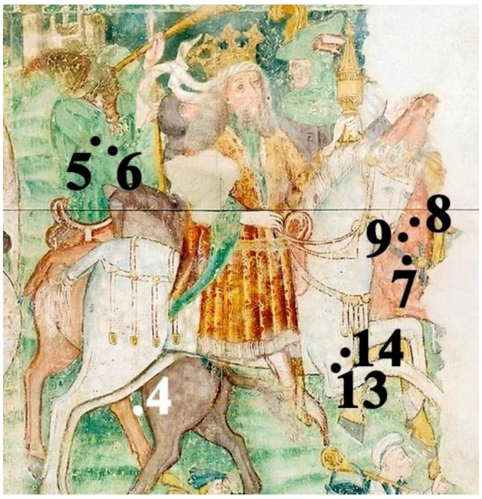

Na Kα1,2

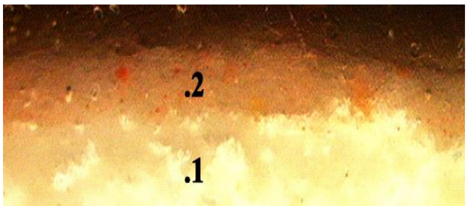
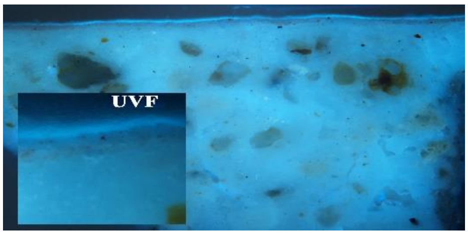



K Kα1




| SAMPLE CODE | SAMPLE MICROLOCATION |
| --- | --- |
| **GDC 8** | horse on right edge of painting, circular pattern on neck, brighter red |



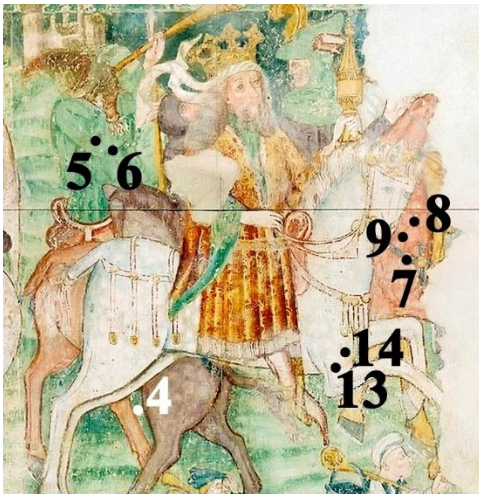

| STRATIGRAPHY | VIS PHOTOGRAPHY | UVF PHOTOGRAPHY |
|---|---|---|
| 3- transparent layer<br>2- red<br>1- plaster |  |  |





### *FTIR spectroscopy*

Results
- calcite
- silicates

| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| GDC 9 | horse on right edge of painting, circular pattern on neck, darker red<br> |

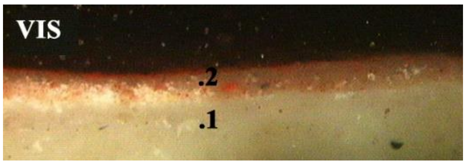


**STRATIGRAPHY**

3- transparent layer
2- red
1- plaster

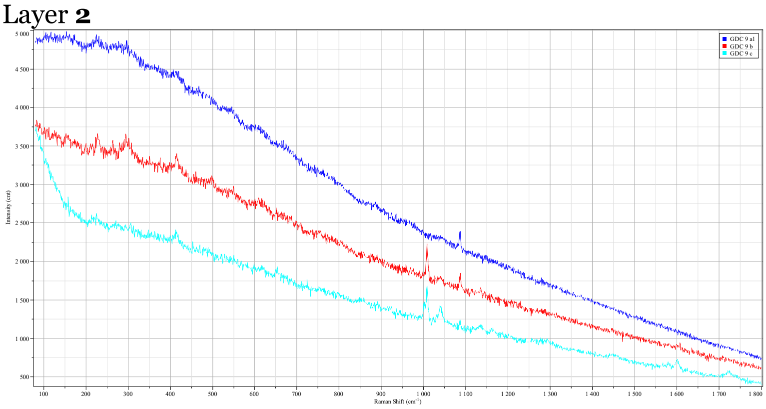
**VIS PHOTOGRAPHY**




**UVF PHOTOGRAPHY**


***Raman spectroscopy***

Layer **2**



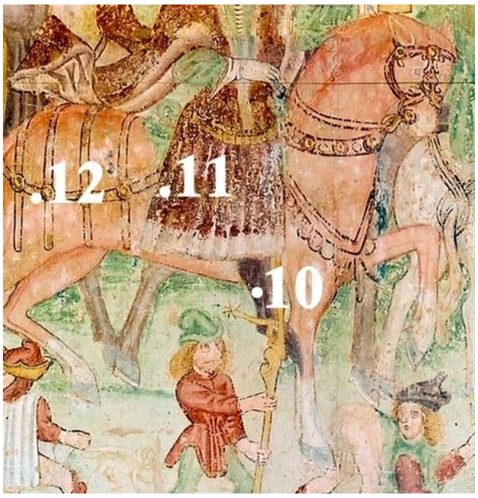
Results
- calcite
- haematite
- gypsum

**SAMPLE CODE**

**GDC 10**

**SAMPLE MICROLOCATION**

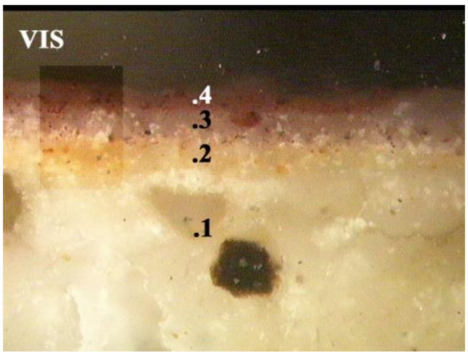
horse on right edge of painting, harness, grey area, over red ground?



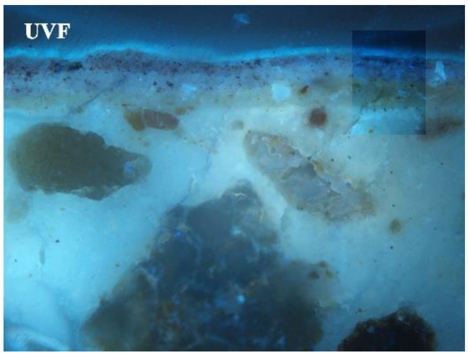

**STRATIGRAPHY**

5- transparent layer
4- dark red
3- bright red
2- bright ochre
1- plaster

**VIS PHOTOGRAPHY**

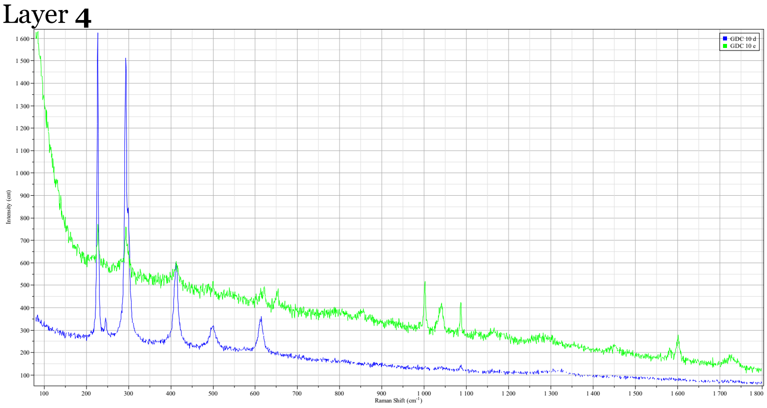



**UVF PHOTOGRAPHY**



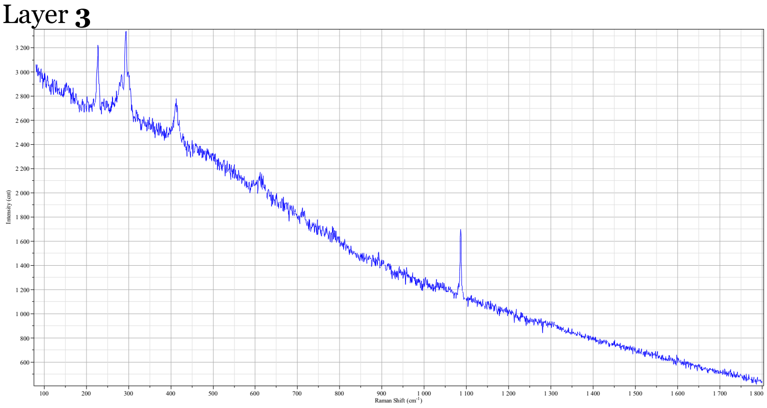
## *Raman spectroscopy*

Layer **4**



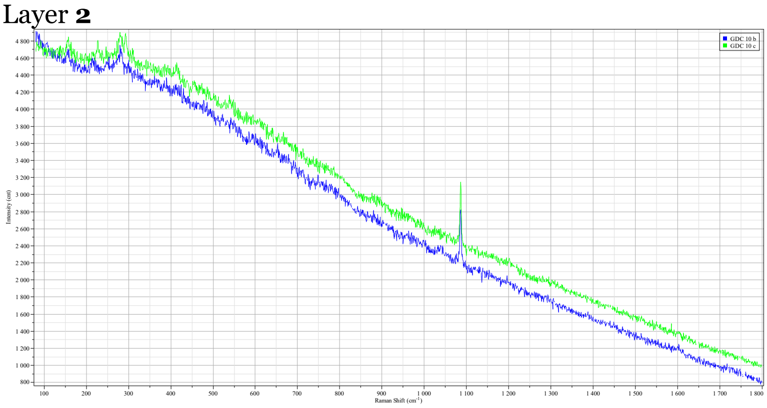
Results
- calcite
- haematite (possibly synthetic)

Layer **3**



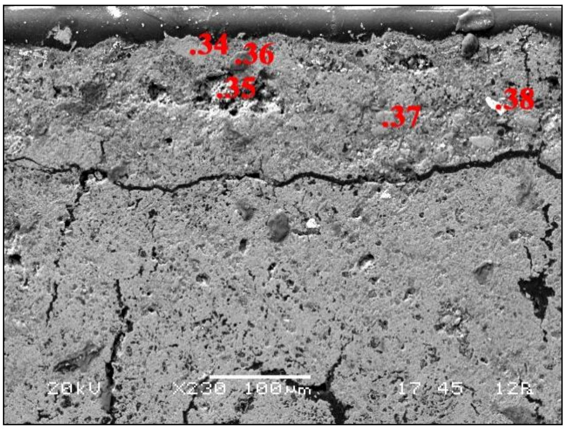
Results
- calcite
- haematite

Layer **2**



Results
- calcite
- haematite

## *SEM EDS*




**GDC 10 spectrum 34**

| Element | App Conc. | Intensity Corrn. | Weight% | Weight% Sigma | Atomic% |
|---|---|---|---|---|---|
| C K | 39.97 | 0.5588 | 23.05 | 2.02 | 32.96 |
| O K | 64.31 | 0.4008 | 51.71 | 2.00 | 55.50 |
| Si K | 0.58 | 0.8614 | 0.22 | 0.17 | 0.13 |
| S K | 19.38 | 0.9618 | 6.49 | 0.43 | 3.48 |
| Ca K | 56.83 | 0.9887 | 18.52 | 0.91 | 7.94 |

**GDC 10 spectrum 35**

| Element | App Conc. | Intensity Corrn. | Weight% | Weight% Sigma | Atomic% |
|---|---|---|---|---|---|
| C K | 43.05 | 0.7968 | 18.41 | 1.75 | 27.43 |
| O K | 58.44 | 0.3772 | 52.78 | 2.05 | 59.06 |
| Na K | 1.14 | 0.6137 | 0.63 | 0.35 | 0.49 |
| Mg K | 1.67 | 0.6058 | 0.94 | 0.28 | 0.69 |
| Si K | 1.21 | 0.8323 | 0.50 | 0.21 | 0.32 |
| Cl K | 2.17 | 0.8471 | 0.87 | 0.23 | 0.44 |
| K K | 1.80 | 1.1422 | 0.54 | 0.23 | 0.25 |
| Ca K | 75.15 | 1.0107 | 25.33 | 1.21 | 11.31 |

**GDC 10 spectrum 36**

| Element | App Conc. | Intensity Corrn. | Weight% | Weight% Sigma | Atomic% |
|---|---|---|---|---|---|
| C K | 83.99 | 0.7871 | 38.53 | 1.97 | 49.68 |
| O K | 47.74 | 0.3866 | 44.58 | 2.13 | 43.16 |
| Na K | 1.41 | 0.6780 | 0.75 | 0.33 | 0.50 |
| Mg K | 2.09 | 0.6544 | 1.15 | 0.27 | 0.74 |
| S K | 0.93 | 0.9562 | 0.35 | 0.17 | 0.17 |
| Cl K | 4.55 | 0.8360 | 1.96 | 0.27 | 0.86 |
| K K | 1.75 | 1.0845 | 0.58 | 0.21 | 0.23 |
| Ca K | 33.07 | 0.9876 | 12.09 | 0.69 | 4.67 |

**GDC 10 spectrum 37**

| Element | App Conc. | Intensity Corrn. | Weight% | Weight% Sigma | Atomic% |
|---|---|---|---|---|---|
| C K | 19.89 | 0.3251 | 15.72 | 3.97 | 22.72 |
| O K | 150.54 | 0.7280 | 53.12 | 2.94 | 57.63 |
| Na K | 15.53 | 0.7566 | 5.27 | 0.67 | 3.98 |
| Al K | 16.98 | 0.7796 | 5.59 | 0.61 | 3.60 |
| Si K | 55.18 | 0.8022 | 17.67 | 1.20 | 10.92 |
| Cl K | 0.61 | 0.7147 | 0.22 | 0.23 | 0.11 |
| Ca K | 8.91 | 0.9507 | 2.41 | 0.41 | 1.04 |

**GDC 10 spectrum 38**

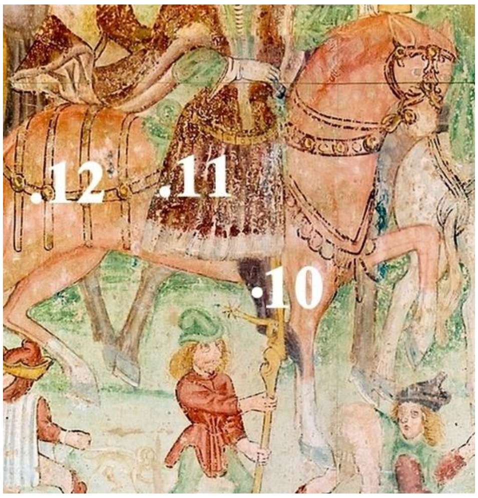
| Element | App Conc. | Intensity Corrn. | Weight% | Weight% Sigma | Atomic% |
|---|---|---|---|---|---|
| C K | 25.28 | 0.5655 | 13.23 | 1.73 | 22.41 |
| O K | 160.53 | 0.9621 | 49.40 | 1.53 | 62.80 |
| Mg K | 1.07 | 0.4645 | 0.69 | 0.25 | 0.57 |
| Si K | 2.09 | 0.7099 | 0.87 | 0.20 | 0.63 |
| P K | 0.68 | 1.1090 | 0.18 | 0.17 | 0.12 |
| Cl K | 0.66 | 0.7939 | 0.24 | 0.17 | 0.14 |
| Ca K | 10.69 | 1.0431 | 3.03 | 0.29 | 1.54 |
| Fe K | 93.58 | 0.8564 | 32.35 | 1.26 | 11.78 |

**SAMPLE CODE**

**GDC 11**

**SAMPLE MICROLOCATION**

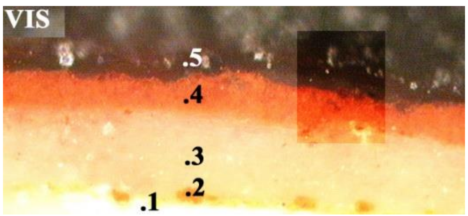
king on the reddish horse, dark red drapery, on left edge, dark red over ochre?



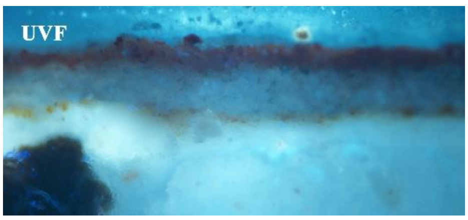

**STRATIGRAPHY**

5- transparent layer
4- red
3- bright red
2- ochre
1- plaster

**VIS PHOTOGRAPHY**



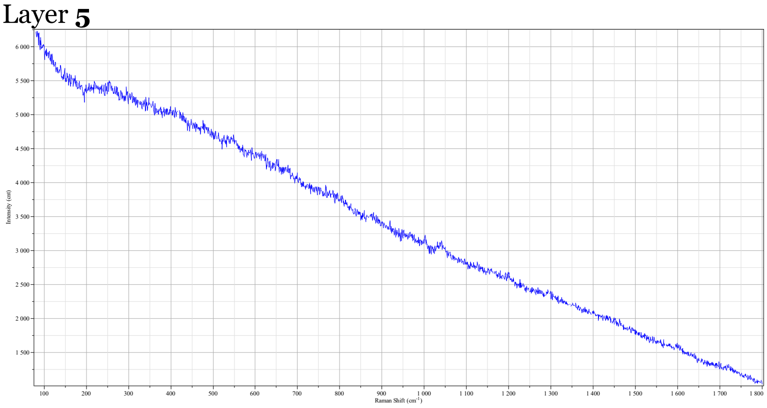

**UVF PHOTOGRAPHY**



## *Raman spectroscopy*

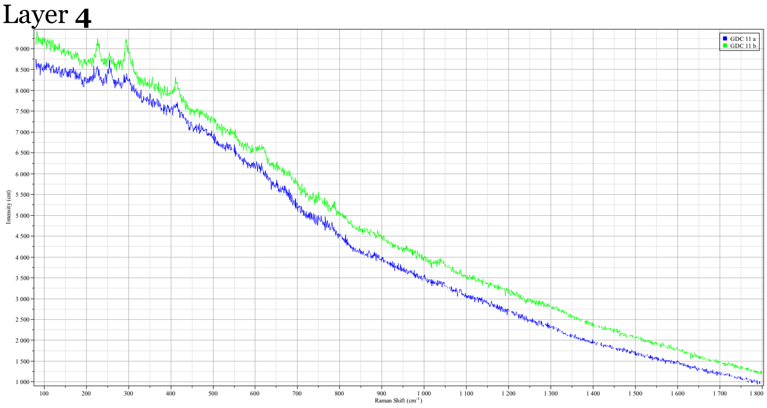
Layer 5



Results

- possibly vermilion
  Bad spectra, difficult to interpret.

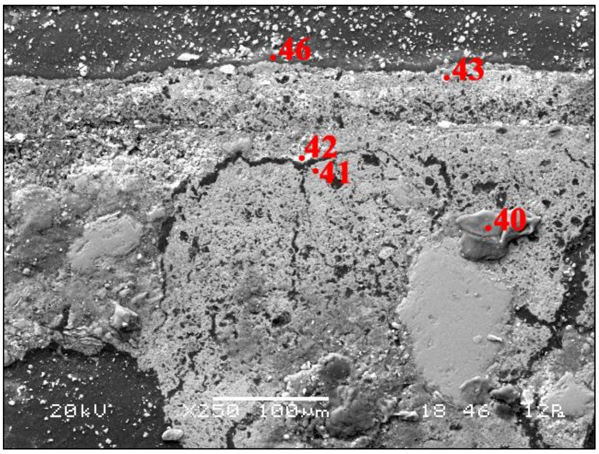
Layer 4



Results

- haematite
- vermilion
- calcite
- possibly nitrates

## *SEM EDS*




**GDC 11 spectrum 41**

| Element | App Conc. | Intensity Corrn. | Weight% | Weight% Sigma | Atomic% |
|---|---|---|---|---|---|
| C K | 66.10 | 0.7818 | 22.82 | 2.66 | 33.02 |
| O K | 69.87 | 0.3730 | 50.57 | 3.08 | 54.93 |
| Mg K | 1.13 | 0.6227 | 0.49 | 0.37 | 0.35 |
| Al K | 0.68 | 0.7419 | 0.25 | 0.32 | 0.16 |
| Si K | 4.18 | 0.8460 | 1.33 | 0.36 | 0.82 |
| S K | 1.32 | 0.9469 | 0.38 | 0.28 | 0.20 |
| Cl K | 2.12 | 0.8395 | 0.68 | 0.33 | 0.33 |
| K K | 1.95 | 1.1301 | 0.47 | 0.33 | 0.21 |
| Ca K | 85.72 | 1.0057 | 23.01 | 1.66 | 9.98 |

**GDC 11 spectrum 43**

| Element | App Conc. | Intensity Corrn. | Weight% | Weight% Sigma | Atomic% |
|---|---|---|---|---|---|
| C K | 56.60 | 0.5469 | 25.25 | 2.76 | 37.68 |
| O K | 114.42 | 0.6295 | 44.34 | 2.38 | 49.68 |
| Mg K | 4.05 | 0.5500 | 1.80 | 0.33 | 1.32 |
| Si K | 13.00 | 0.7738 | 4.10 | 0.37 | 2.62 |
| S K | 0.64 | 0.8764 | 0.18 | 0.18 | 0.10 |
| Cl K | 2.78 | 0.7905 | 0.86 | 0.22 | 0.43 |
| K K | 2.04 | 1.0635 | 0.47 | 0.20 | 0.21 |
| Ca K | 17.75 | 1.0088 | 4.29 | 0.40 | 1.92 |
| Ti K | 1.17 | 0.8438 | 0.34 | 0.23 | 0.13 |
| Fe K | 62.44 | 0.8283 | 18.39 | 1.27 | 5.90 |

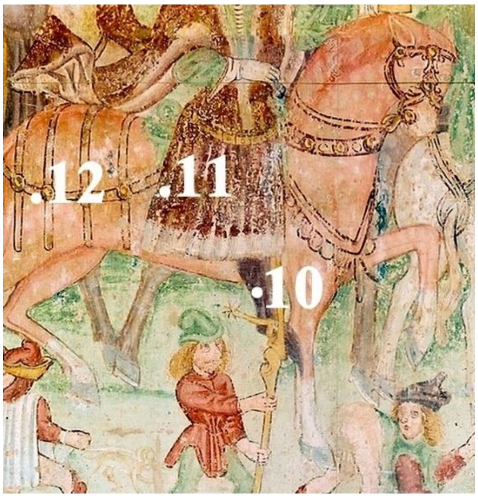
**GDC 11 SPECTRUM 40**

| Element | App Conc. | Intensity Corrn. | Weight% | Weight% Sigma | Atomic% |
|---|---|---|---|---|---|
| C K | 96.00 | 0.7365 | 43.33 | 2.09 | 53.68 |
| O K | 54.28 | 0.4125 | 43.74 | 2.17 | 40.68 |
| Na K | 1.57 | 0.7012 | 0.75 | 0.33 | 0.48 |
| Mg K | 1.72 | 0.6720 | 0.85 | 0.25 | 0.52 |
| Si K | 4.90 | 0.8721 | 1.87 | 0.25 | 0.99 |
| S K | 1.42 | 0.9385 | 0.50 | 0.19 | 0.23 |
| Cl K | 4.24 | 0.8188 | 1.72 | 0.28 | 0.72 |
| K K | 1.19 | 1.0574 | 0.37 | 0.20 | 0.14 |
| Ca K | 20.23 | 0.9784 | 6.87 | 0.51 | 2.55 |

**GDC 11 spectrum 46**

| Element | App Conc. | Intensity Corrn. | Weight% | Weight% Sigma | Atomic% |
|---|---|---|---|---|---|
| C K | 461.22 | 1.1933 | 70.10 | 2.48 | 76.73 |
| O K | 47.99 | 0.3270 | 26.62 | 2.56 | 21.87 |
| Si K | 11.70 | 0.9307 | 2.28 | 0.25 | 1.07 |
| Ca K | 5.39 | 0.9768 | 1.00 | 0.21 | 0.33 |

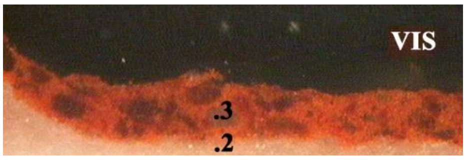
| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 12** | king on the reddish horse, dark red harness, belt, dark red edge |




**STRATIGRAPHY**

4- transparent layer
3- red
2- white
1- plaster

**VIS PHOTOGRAPHY**



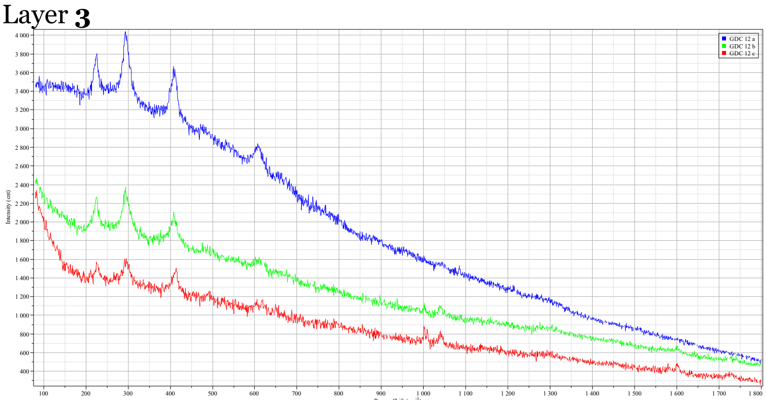

**UVF PHOTOGRAPHY**


## *FTIR spectroscopy*

Results
calcite
silicates

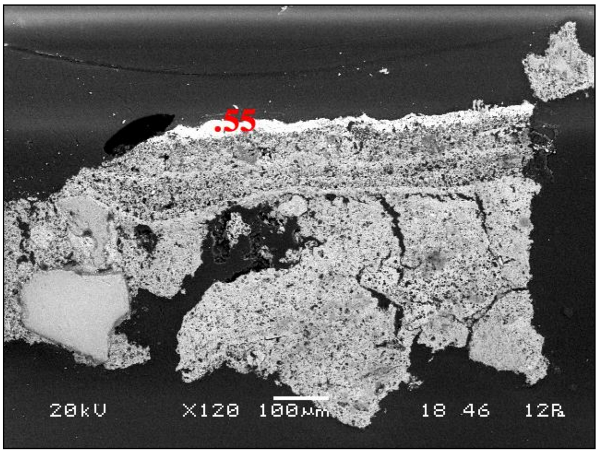
## *Raman spectroscopy*

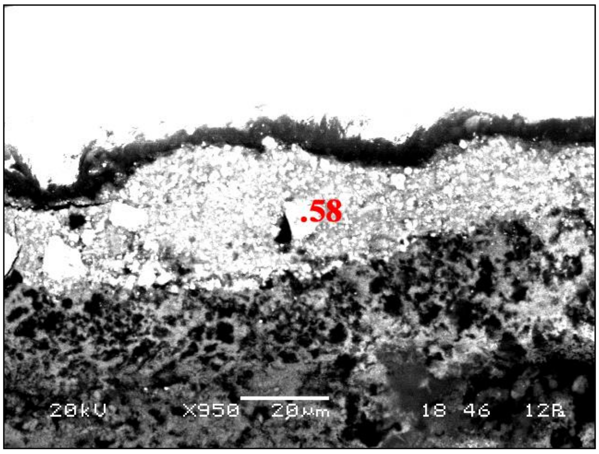
Layer 3



Results
- haematite
- calcite
- gypsum

## *SEM EDS*




**GDC 12 spectrum 55**

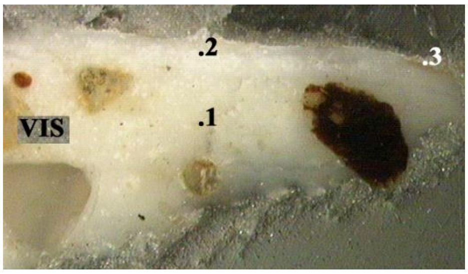
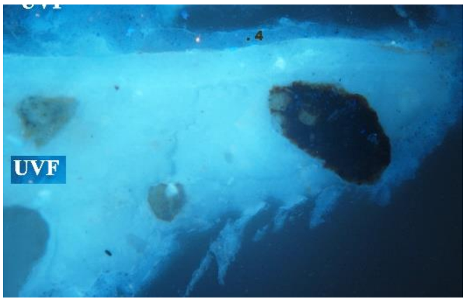
| Element | App Conc. | Intensity Corrn. | Weight% | Weight% Sigma | Atomic% |
|---|---|---|---|---|---|
| C K | 84.96 | 0.6942 | 28.73 | 1.68 | 41.77 |
| O K | 99.06 | 0.5314 | 43.76 | 1.85 | 47.76 |
| Mg K | 1.24 | 0.5530 | 0.53 | 0.24 | 0.38 |
| Al K | 1.07 | 0.6738 | 0.37 | 0.20 | 0.24 |
| Si K | 3.27 | 0.7844 | 0.98 | 0.21 | 0.61 |
| Cl K | 2.23 | 0.8153 | 0.64 | 0.20 | 0.32 |
| K K | 1.85 | 1.0895 | 0.40 | 0.19 | 0.18 |
| Ca K | 37.19 | 1.0168 | 8.59 | 0.53 | 3.74 |
| Fe K | 55.94 | 0.8206 | 16.00 | 1.11 | 5.00 |

**GDC 12 spectrum 58**

| Element | App Conc. | Intensity Corrn. | Weight% | Weight% Sigma | Atomic% |
|---|---|---|---|---|---|
| C K | 63.24 | 0.6158 | 25.93 | 2.71 | 41.52 |
| O K | 103.96 | 0.6993 | 37.54 | 2.68 | 45.12 |
| Si K | 2.15 | 0.7331 | 0.74 | 0.32 | 0.51 |
| Cl K | 1.33 | 0.8034 | 0.42 | 0.30 | 0.23 |
| K K | 1.73 | 1.0890 | 0.40 | 0.31 | 0.20 |
| Ca K | 11.81 | 1.0405 | 2.87 | 0.52 | 1.38 |
| Fe K | 108.18 | 0.8508 | 32.11 | 2.29 | 11.06 |

| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 13** | white horse on right side of the painting, right front leg, white background |

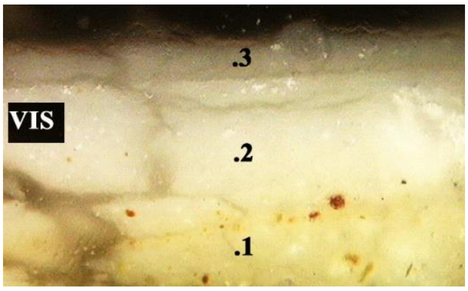
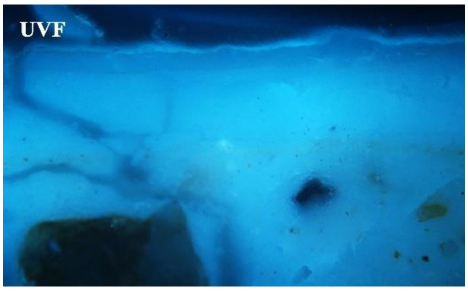

 

| STRATIGRAPHY | VIS PHOTOGRAPHY | UVF PHOTOGRAPHY |
|---|---|---|
| 4- transparent layer<br>3- bright pink (locally)<br>2- white<br>1- plaster |  |  |



| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 14** | white horse on right side of the painting, right front leg, white decorative point<br> |



| STRATIGRAPHY | VIS PHOTOGRAPHY | UVF PHOTOGRAPHY |
|---|---|---|
| 4- transparent layer<br>3- white<br>2- white<br>1- plaster |  |  |



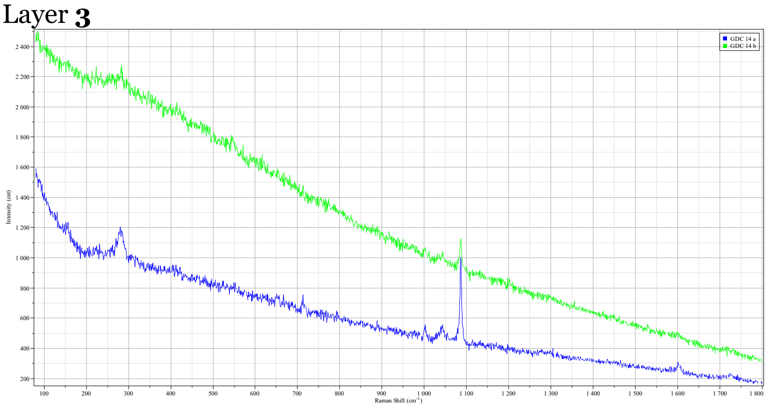
### *FTIR spectroscopy*

Results
- gypsum
- calcite

No organic materials, fluorescence probably origins from salts.

### *Raman spectroscopy*

Layer **3**



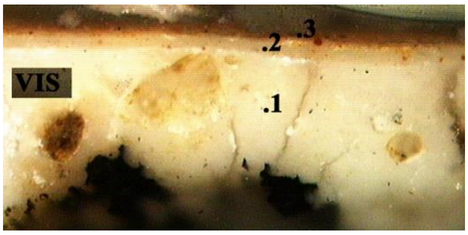
Results
- calcite
- gypsum

| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 15** | bright brown horse, circular pattern on the neck, dark ochre |

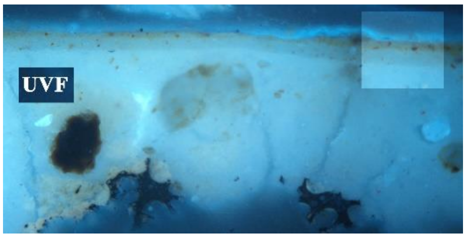

**STRATIGRAPHY**

4- transparent layer
3- ochre
2- bright ochre
1- plaster

**VIS PHOTOGRAPHY**

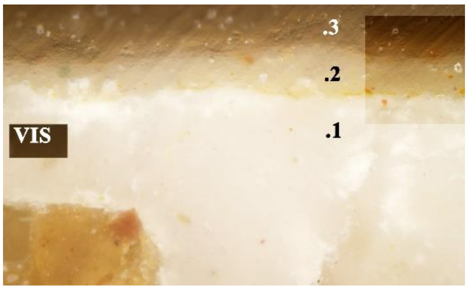
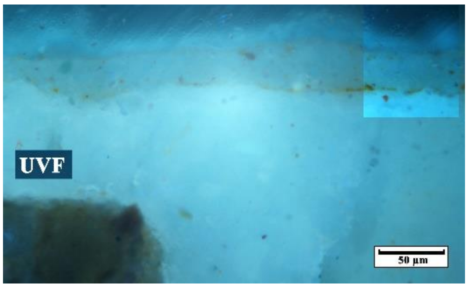



**UVF PHOTOGRAPHY**




| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 16** | bright brown horse, circular pattern on the neck, bright ochre |


| STRATIGRAPHY | VIS PHOTOGRAPHY | UVF PHOTOGRAPHY |
|---|---|---|
| 3- transparent<br>2- light brown<br>1- plaster |  |  |




### *FTIR spectroscopy*

Results
- calcite
- silicates
- gypsum

| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 17** | S wall, W corner, 30cm above ground, surface plaster for salts |

| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 18** | W wall, S corner, 30cm above ground, under visible humidity level, very hard surface (sinter?), for salts |

| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 19** | presbytery, N wall, under window, 40cm above ground, mould, carnation, detached plaster, traces of water leaking, for salts |

***Water soluble salts***

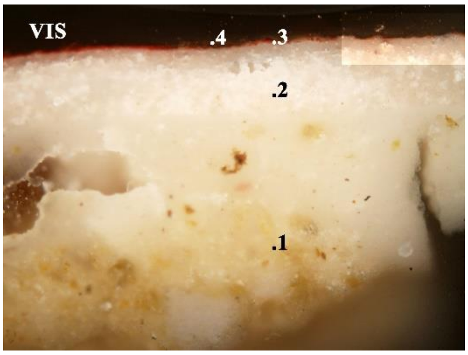
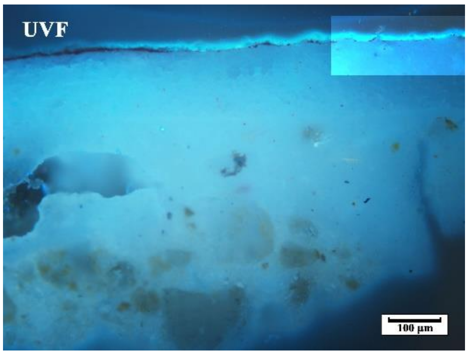
| | Test type | Aquamerck | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Specimen** | **pH** | **conductivity µS/cm** | **$Cl^-$** | **$SO4^{2-}$** | **$NO3^-$** | **$CO3^{2-}$ alkal.** | **$Ca^{2+}$** | **$Mg^{2+}$** | **$Na^+$** | **$K^+$** |
| | | | % | % | % | % | % | % | % | % |
| GDC 17 | 6 | 232,1 | 1,7 | 1,5 | 0,8 | 0,6 | 0,3 | 0,0 | 0,0 | 0,0 |
| GDC 18 | 7 | 149,8 | 0,6 | 1,1 | 0,0 | 0,6 | 0,1 | 0,0 | 0,0 | 0,0 |
| GDC 19 | 7 | 185,9 | 0,5 | 0,6 | 0,0 | 0,5 | 0,2 | 0,0 | 0,0 | 0,0 |

*Repeated test*

| | Test type | Aquamerck | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Specimen** | **pH** | **conductivity µS/cm** | **$Cl^-$** | **$SO4^{2-}$** | **$NO3^-$** | **$CO3^{2-}$ alkal.** | **$Ca^{2+}$** | **$Mg^{2+}$** | **$Na^+$** | **$K^+$** |
| | | | % | % | % | % | % | % | % | % |
| GDC 19 | 6 | 175,7 | 0,1 | 1,8 | 0,0 | 0,4 | 0,3 | 1,3 | err. | err. |

| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 20** | N wall, rider on yellow horse, right hand, carnation, retouching or secco, thin layer on plaster, detached |

| STRATIGRAPHY | VIS PHOTOGRAPHY | UVF PHOTOGRAPHY |
|---|---|---|
| 4- transparent layer<br>3- red<br>2- light pink<br>1- plaster |  |  |



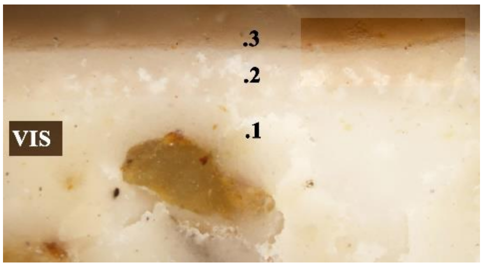
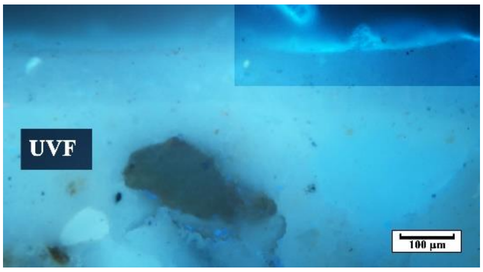


### *FTIR spectroscopy*

Results
- calcite
- gypsum
- silicates

| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 21** | hunter with catch over shoulder, right hand, carnation<br> |



| STRATIGRAPHY | VIS PHOTOGRAPHY | UVF PHOTOGRAPHY |
|---|---|---|
| 3- pink (locally)<br>2- light pink<br>1- plaster |  |  |





### *FTIR spectroscopy*

Results
- calcite
- gypsum
- silicates

| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 22** | back right leg of horse, pink, probably fresco, binder analysis |

| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 23** | hunter with catch over shoulder, right hand, carnation, binder analysis  |



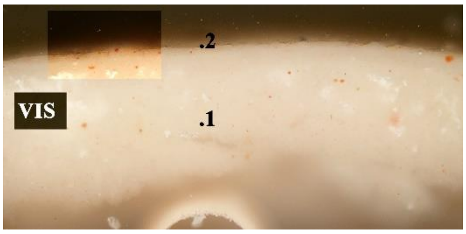
**STRATIGRAPHY**

3- transparent layer

2- ochre

1- plaster

**VIS PHOTOGRAPHY**





**UVF PHOTOGRAPHY**



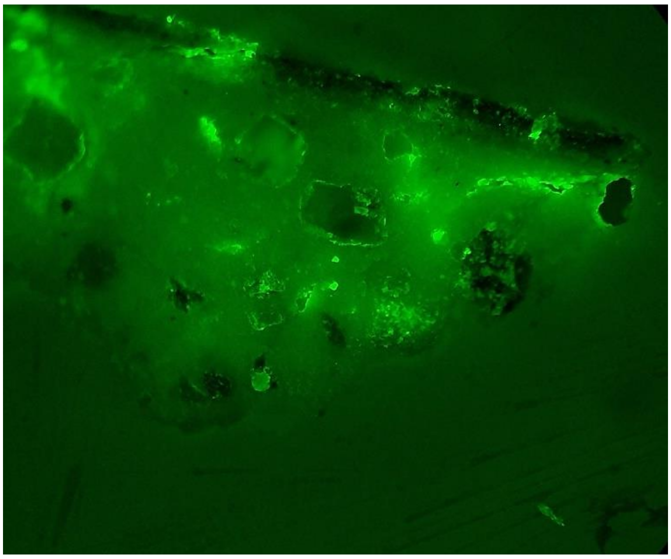
## *FTIR spectroscopy*

Results

- calcite
- gypsum

### *IFM*


(photograph: J. Kosel)

### *Amount of humidity in the samples*

(dried 3h / 50°C)

| Specimen | mass wet | mass dry | humidity |
|---|---|---|---|
| | g | g | % |
| GDC 21 | 0,2335 | 0,2267 | 2,91 |
| GDC 22 | 0,0126 | 0,0121 | 3,97 |
| GDC 23 | 0,015 | 0,0138 | 8,00 |

**SAMPLE CODE** **SAMPLE MICROLOCATION**

**GDC 24**

mortar, N wall, ornament above the floor, mortar between the lines

**MACROSCOPIC DESCRIPTION**

On the surface of the mortar, there is a layer of paint. This is followed by the mortar. Macroscopically, the plaster does not seem to consist of several layers. A very fine-grained aggregate is visible, mostly grey and rarely brownish. The binder is white, perhaps slightly brown.

**MICROSCOPIC DESCRIPTION**

*Upper layer*

Structure:
- sorting of aggregate: medium
- roundness of aggregate: semi-angular and angular
- size of aggregate: 0.05-0.65 mm, average 0.17 mm
- ratio aggregate/binder=predominant binder
- ratio silicate/carbonate aggregate= only silicate aggregate

Composition:
- quartz
- feldspar
- siltstones and mudstones

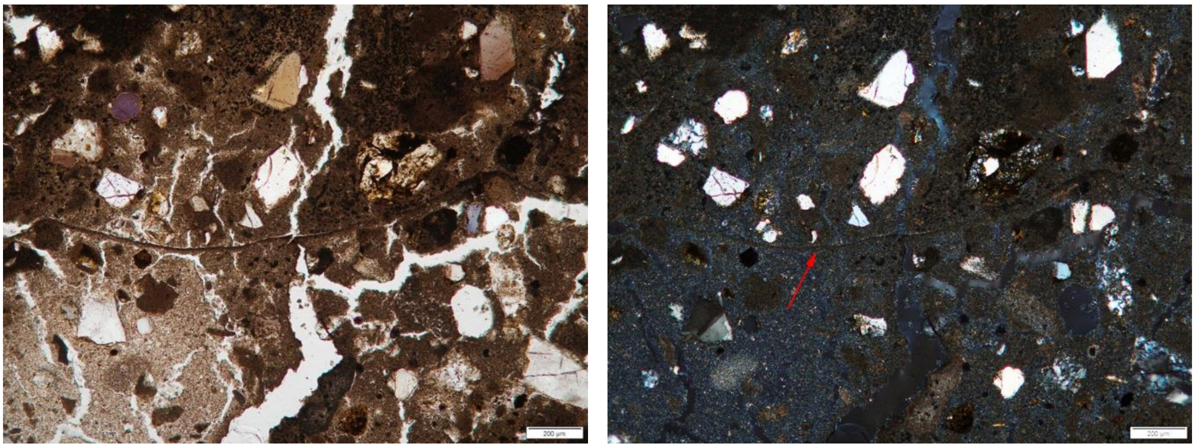
Binder:
- lime
- very cracked, porous
- recrystallized in some parts

*Lower layer*

Structure:
- sorting of aggregate: medium
- roundness of aggregate: semi-angular and angular
- size of aggregate: 0.05-0.56 mm, average 0.18 mm
- ratio aggregate/binder=predominant binder
- ratio silicate/carbonate aggregate= only silicate aggregate

Composition:
- quartz
- feldspar
- lithic grains of quartz sandstones, mudstones and siltstones

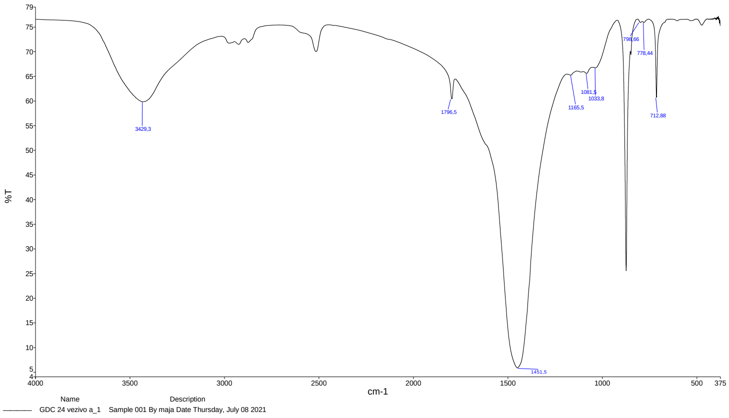
Binder:
- lime
- very cracked, porous



**Sample GDC 24.** An arrow marks the boundary between the upper and lower mortar layers**.** *Translucent light (left II polars, right + polars).*

## *FTIR spectroscopy*

Both mortar layers




Results

- calcite
- quartz

| SAMPLE CODE | SAMPLE MICROLOCATION |
| --- | --- |
| **GDC 25** | facade mortar, N wall, joint mortar between stones |

**MACROSCOPIC DESCRIPTION**

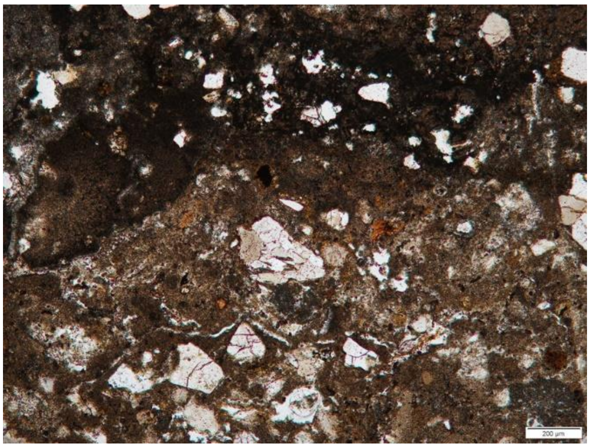
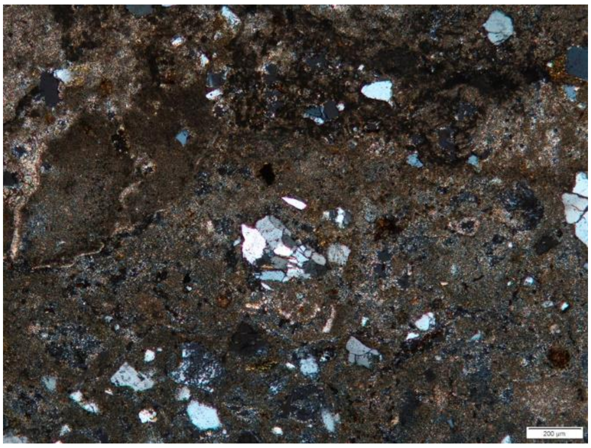
The sample is very similar to that of GDC 24. The aggregate is predominantly grey in colour and is very fine grained. The binder is white to light brown.

**MICROSCOPIC DESCRIPTION**

Structure:
- sorting of aggregate: medium
- roundness of aggregate: semi-angular and angular
- size of aggregate: 0.05 – 0.46 mm, average 0.16 mm
- ratio aggregate/binder = predominant binder
- ratio silicate/carbonate aggregate = only silicate aggregate

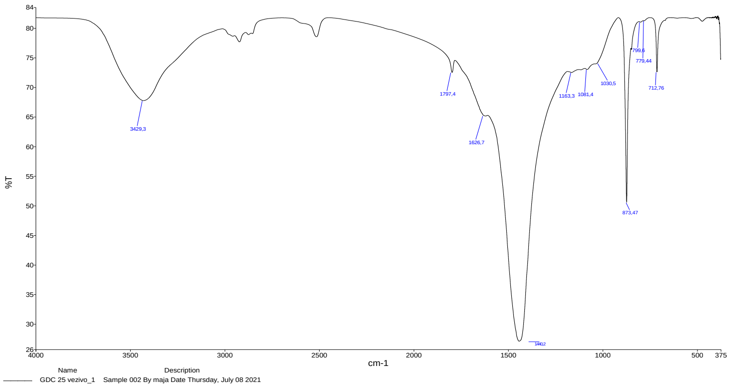
Composition:
- quartz
- feldspar
- quartz sandstones

Binder:
- lime
- very cracked, porous
- recrystallized in some parts

**Sample GDC 25.** *Translucent light (left II polars, right + polars).*

## *FTIR spectroscopy*



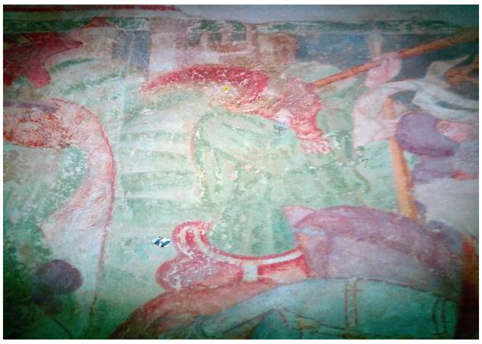

Results
- calcite
- quartz

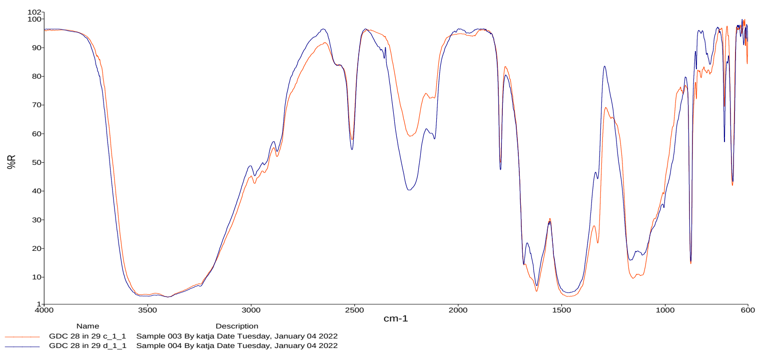
| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 26** | red, S wall, left from window, older painting, scene with Crucifixion, fragment right up<br><br>REMARK: sample was taken in frames of another project (Digital corpus of Slovene mediaeval wall painting) and results are not shown here |

| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 27** | blue, S wall, left from window, older painting, scene with Crucifixion, fragment right up<br><br>REMARK: sample was taken in frames of another project (Digital corpus of Slovene mediaeval wall painting) and results are not shown here |

| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 28** | coating layer, N wall, left from the window, man with a flute, nose, just coating, sampled with diamond stick |



***FTIR spectroscopy***



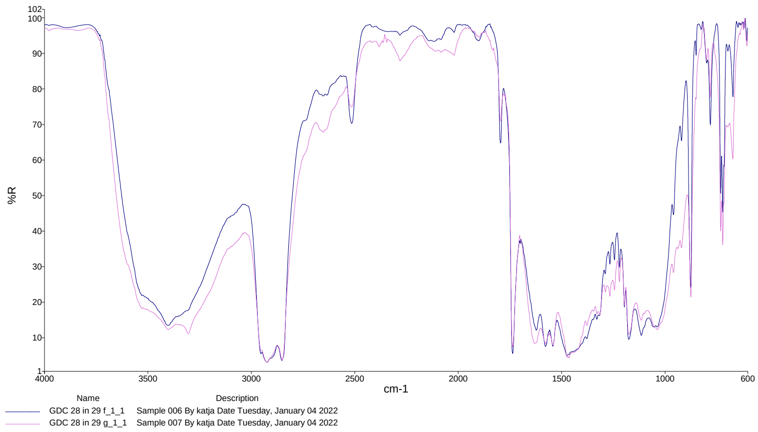

Results

- calcite
- gypsum
- calcium oxalate
- probably nitrates (825 $cm^{-1}$; Rey et al., 2005)
- probably carboxylates (1560 $cm^{-1}$)

| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 29** | coating layer, N wall, brown horse in front, back left leg, probably wax stain |

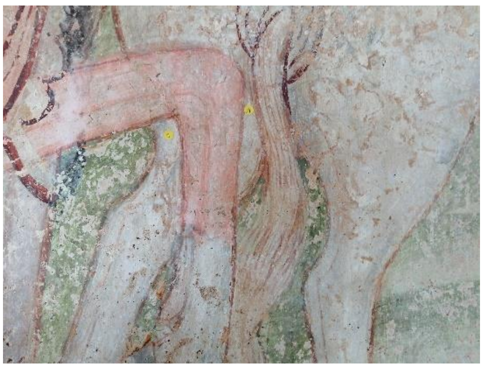
***FTIR spectroscopy***




Results

- wax
- calcite
- gypsum
- alumosilicates
- probably calcium oxalate
- calcium carboxylate

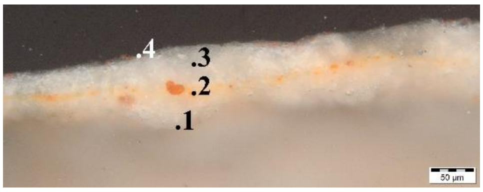
| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 30** | white, N wall, white horse, left from the tail, BaOH |

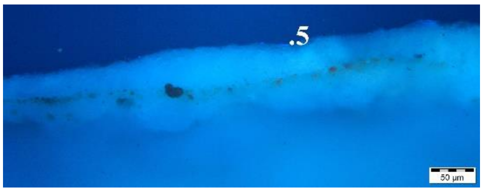


**STRATIGRAPHY** **VIS PHOTOGRAPHY** **UVF PHOTOGRAPHY**

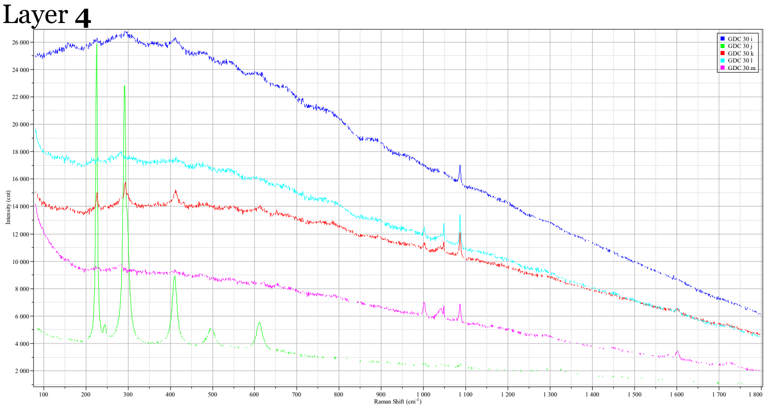
5- coating/ salts
4- red and black particles
3- white
2- ochre
1- plaster



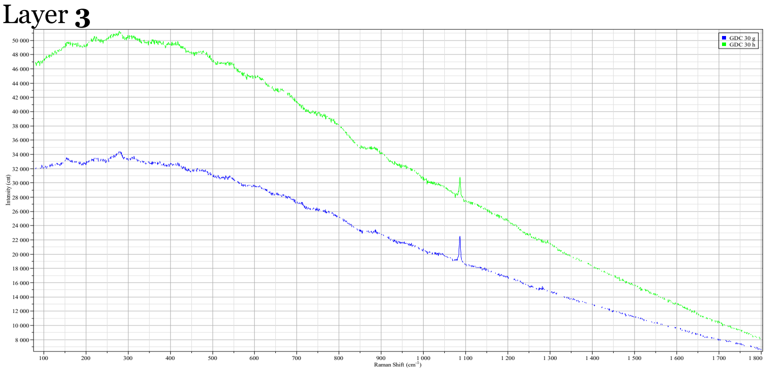

## *Raman spectroscopy*

Layer **4**



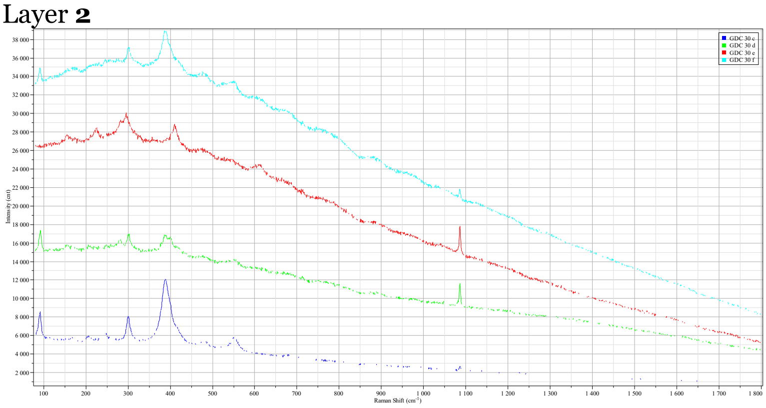
Results
- haematite
- calcite
- nitrates (1048 cm$^{-1}$; Tang et al., 2014)

Layer **3**



Results
- calcite

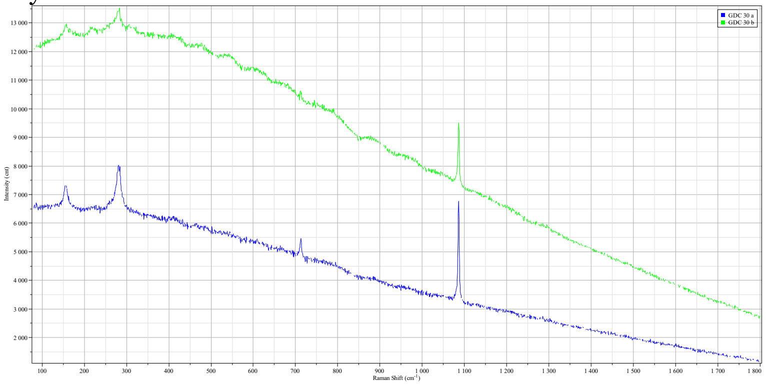
Layer **2**



Results
- calcite
- goethite
- haematite

Layer **1**




Results

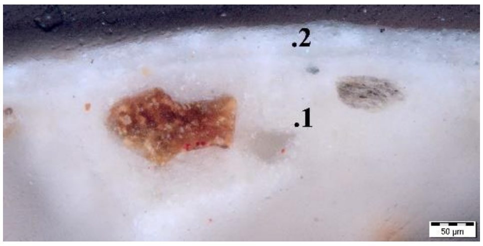
- calcite

| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 31** | white, N wall, white horse, left leg, under knee of brown horse, BaOH, ammonium bicarbonate, Japanese paper |

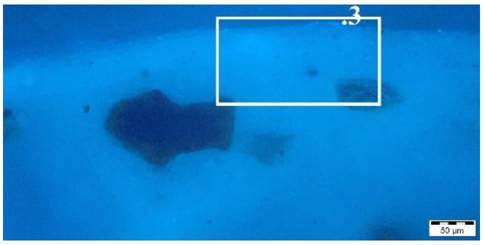
**STRATIGRAPHY**

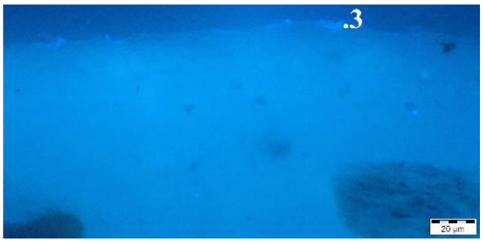
3- coating/ salts
2- white
1- plaster

**VIS PHOTOGRAPHY**




**UVF PHOTOGRAPHY**

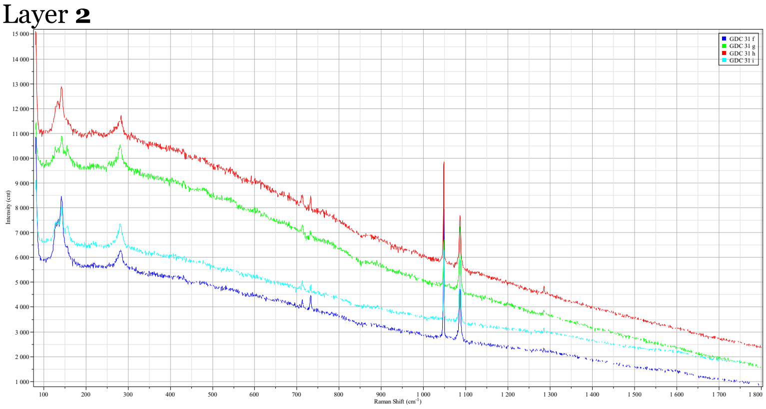


## *Raman spectroscopy*

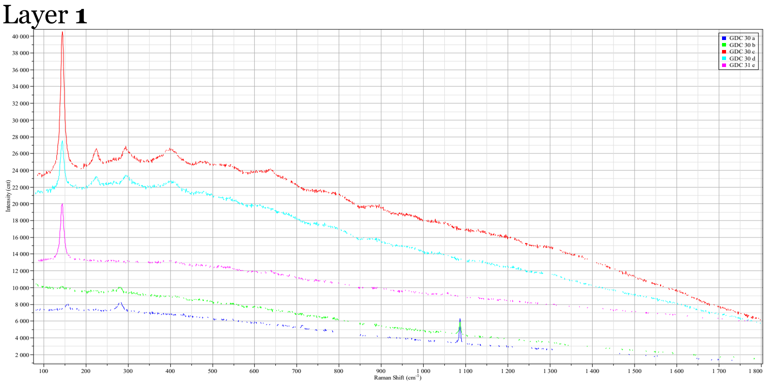
Layer **2**




Results

- calcite
- nitrates
- kaolinite

Layer **1**




Results

- calcite
- kaolinite

**SAMPLE CODE**

**GDC 32**

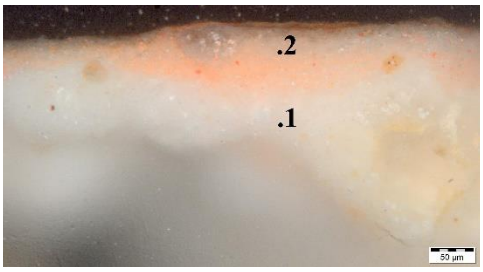
**SAMPLE MICROLOCATION**

dark white, N wall, left from the window, man with a flute, hat, coating layer

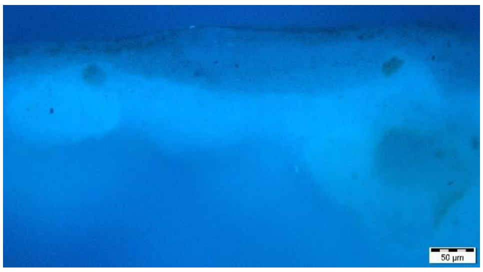
**STRATIGRAPHY**

2- red
1- plaster

**VIS PHOTOGRAPHY**



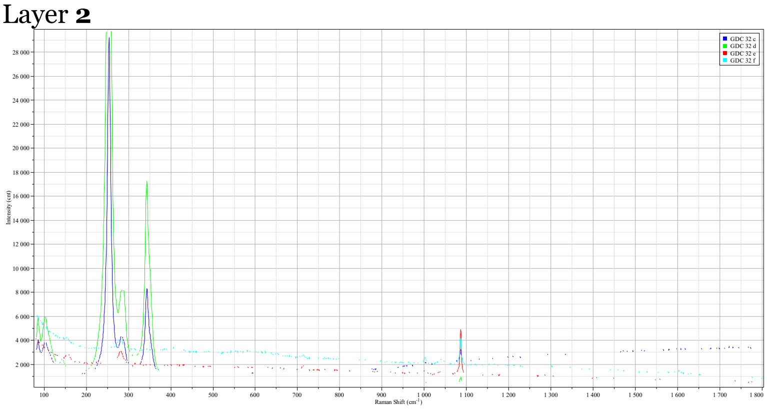

**UVF PHOTOGRAPHY**



## *Raman spectroscopy*

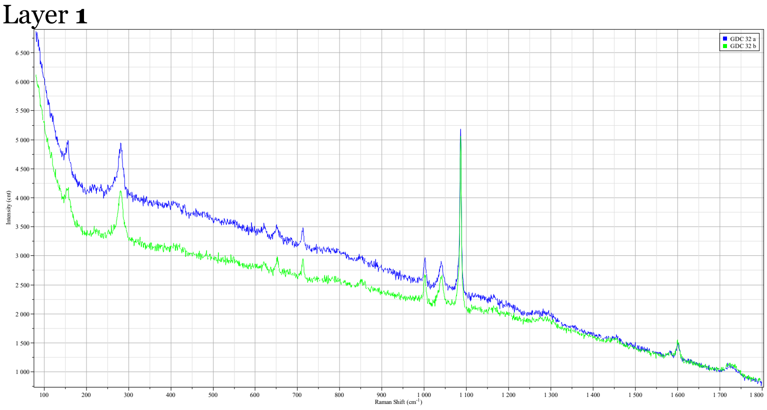
Layer **2**



Results

- vermilion
- calcite
- probably kaolinite

Layer **1**

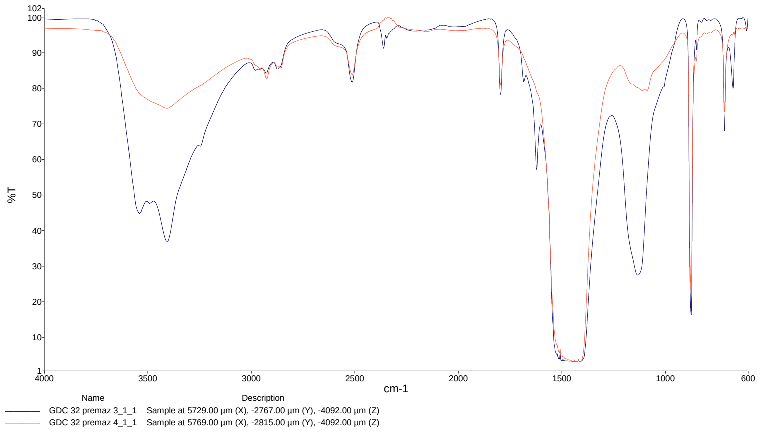


Results

- calcite

## *FTIR spectroscopy*

Layer **coating**

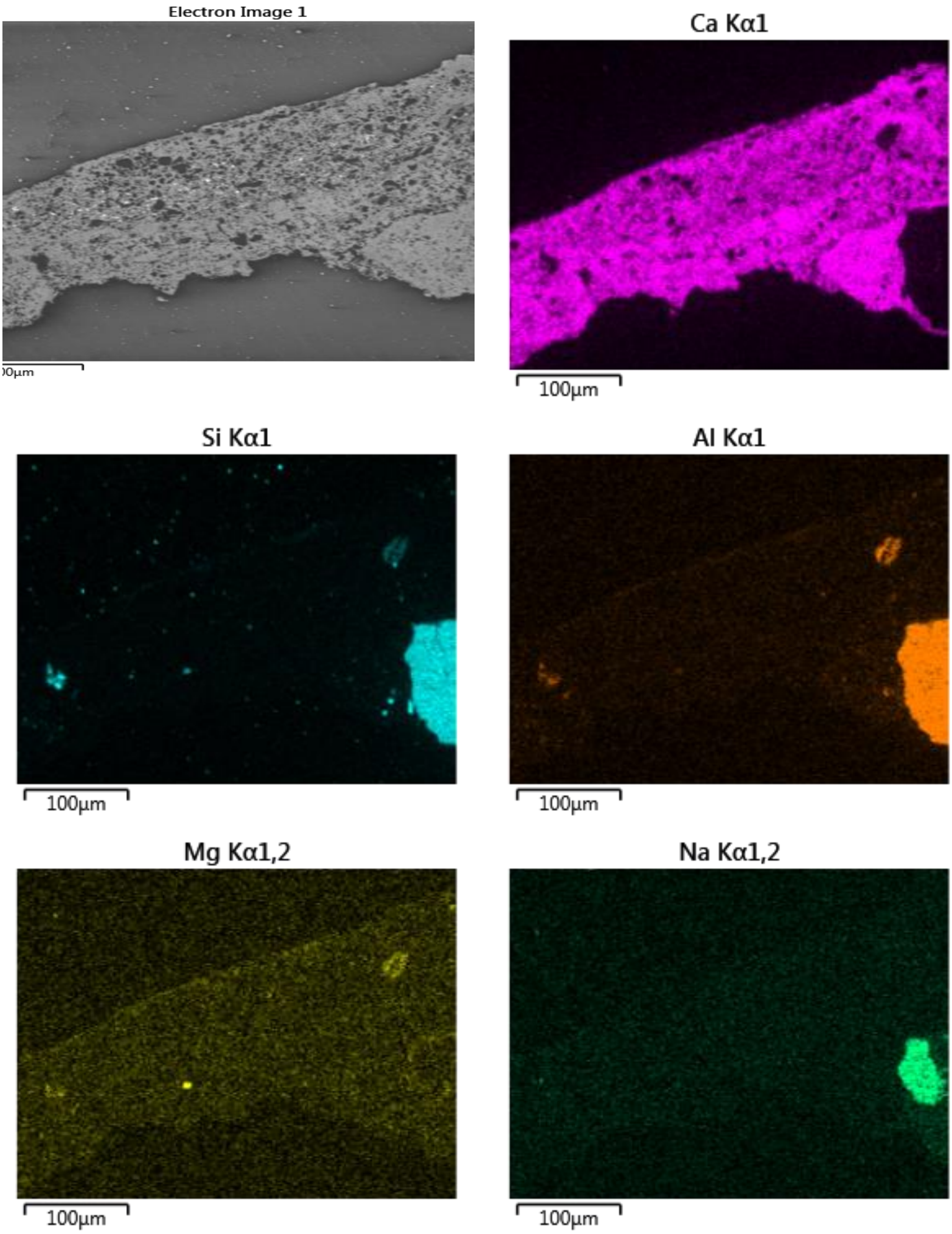



Results

- calcite
- gypsum

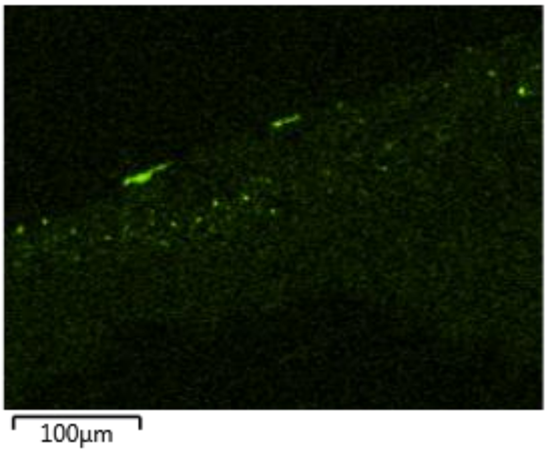
  No visible vibrations for organic materials. Probably just gypsum and impurities.

***SEM EDS***

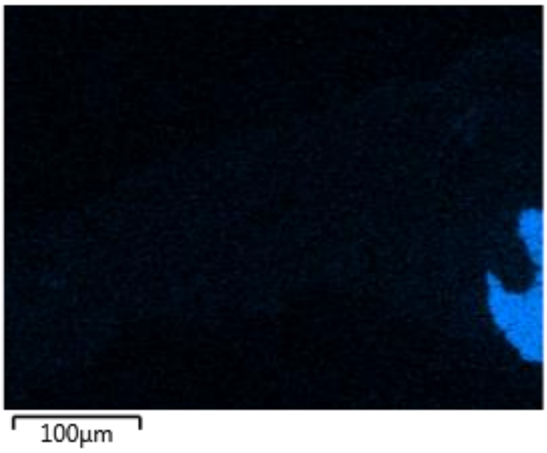

Electron Image 1
Ca Kα1
100µm
Si Kα1
100µm
Al Kα1
100µm
Mg Kα1,2
100µm
Na Kα1,2
100µm

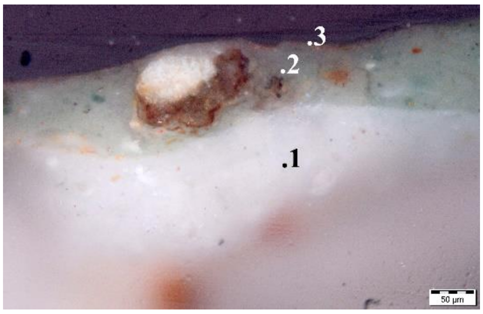
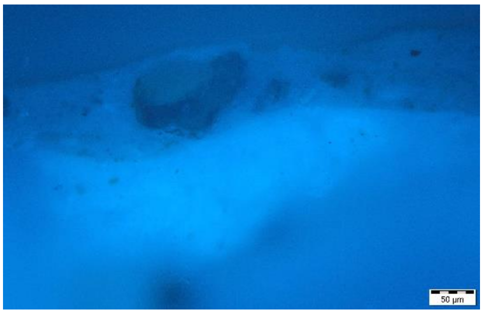
S Kα1




K Kα1



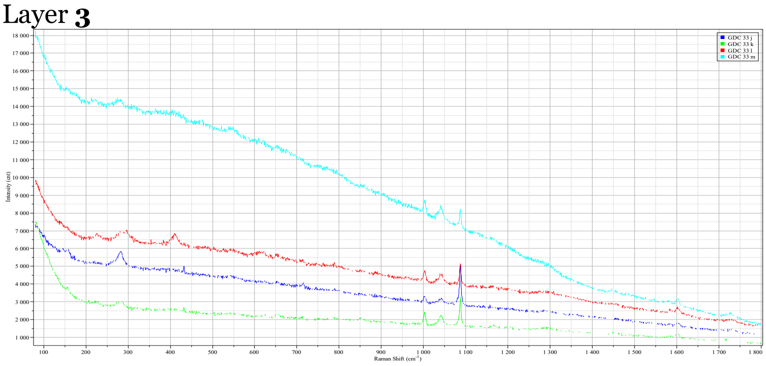

| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 33** | dark green, N wall, left from the window, king, sleeve  |

| STRATIGRAPHY | VIS PHOTOGRAPHY | UVF PHOTOGRAPHY |
|---|---|---|
| 3- red<br>2- green with red particles<br>1- plaster |  |  |

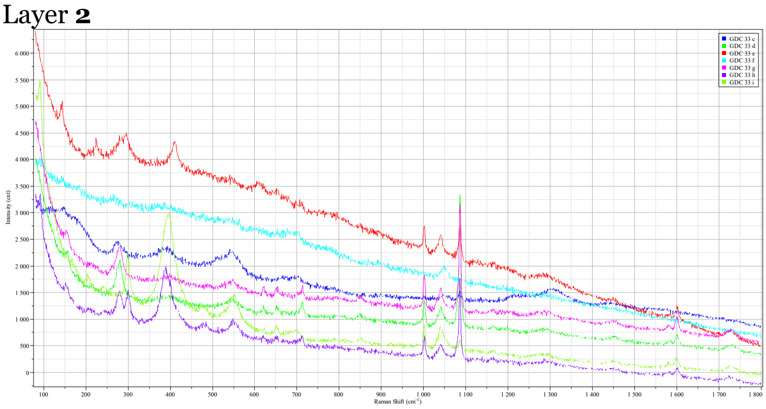
## *Raman spectroscopy*

Layer **3**



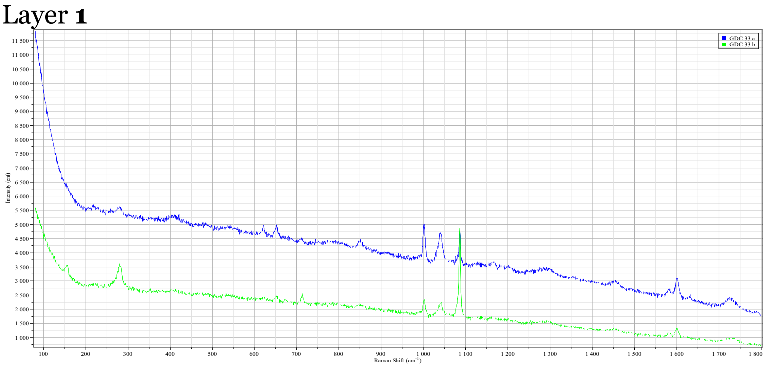
Results
- calcite
- haematite
- kaolinite

Layer **2**



Results
- calcite
- goethite
- probably green earth
- kaolinite

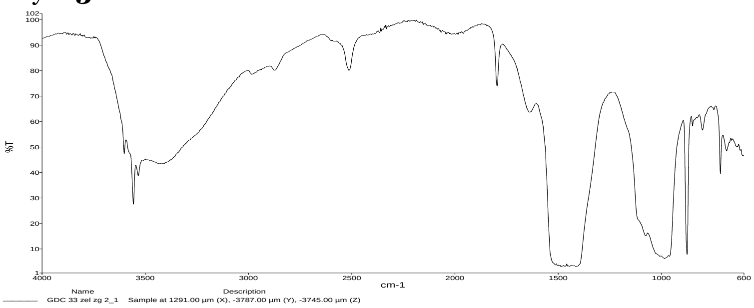
Layer **1**



Results
- calcite

## *FTIR spectroscopy*

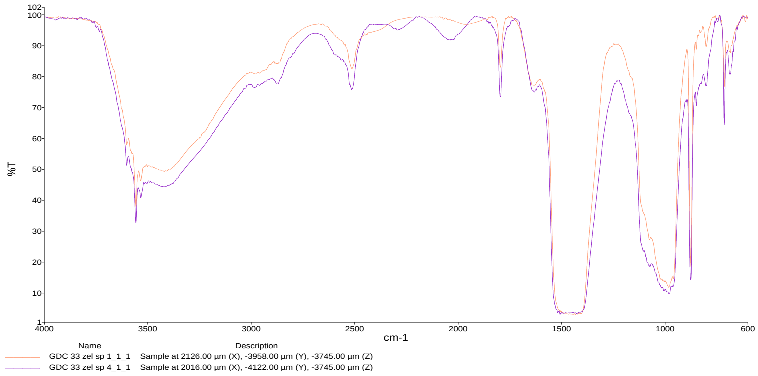
Layer **3**




Results
- calcite
- green earth
- calcium oxalate or proteins

Layer **2**




Results

- calcite
- green earth
- calcium oxalate or proteins

**SAMPLE CODE**

**GDC 34**

**SAMPLE MICROLOCATION**

black with orange fluorescence, right of the door, window, ornament bottom right

**STRATIGRAPHY**

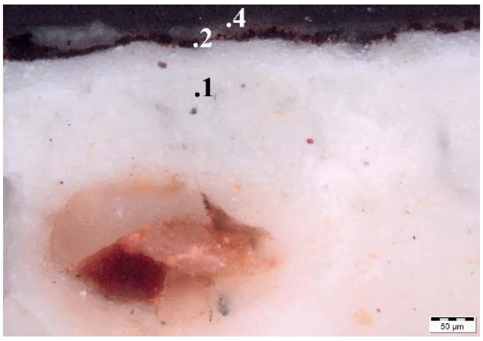
4- whitewash, the remnantt

3- coat layer, the remnant, orange fluorescence

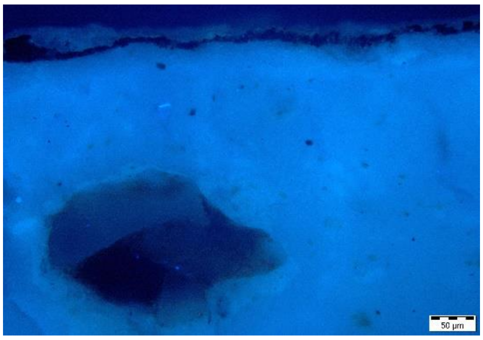
2- black

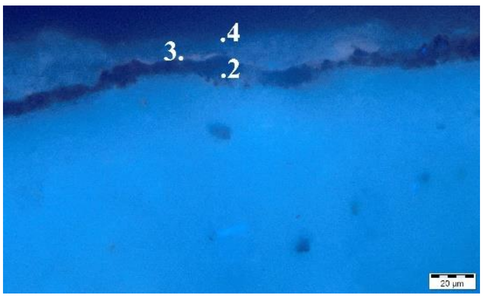
1- plaster

**VIS PHOTOGRAPHY**



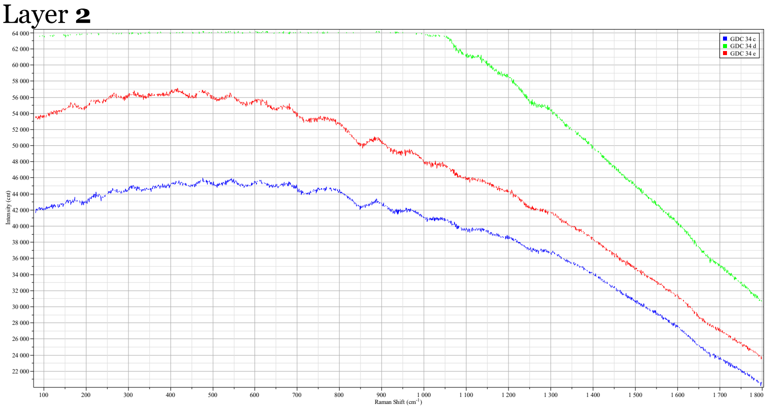

**UVF PHOTOGRAPHY**



## ***Raman spectroscopy***

Layer **2**

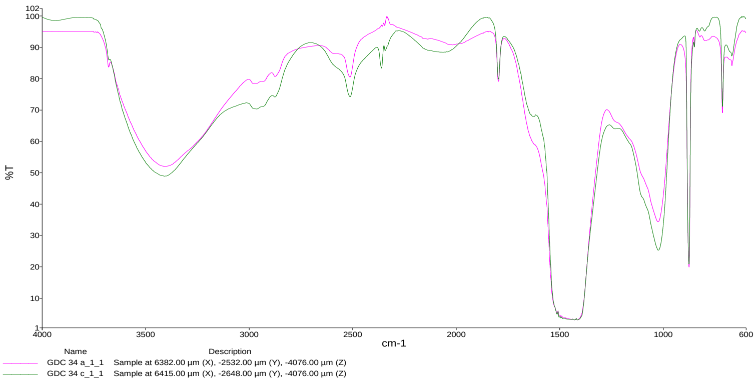


Results

- maybe carbon black

## ***FTIR spectroscopy***

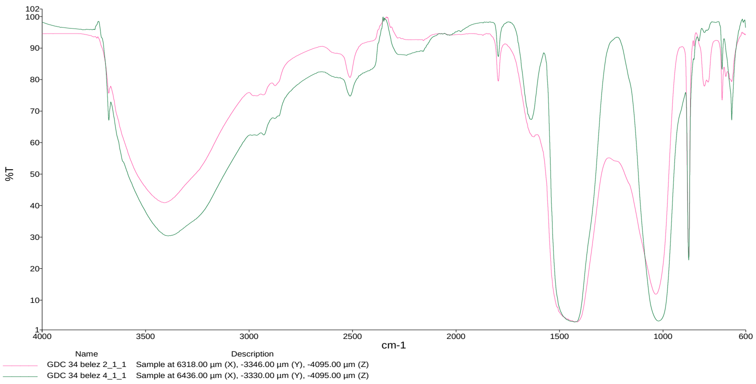
Layer **all**




Results

- calcite
- silicates (3680 cm-1), probably magnesium silicate (Kaste et al., 1998) or kaolin (Abazi, 2016)
- calcium oxalate or proteins

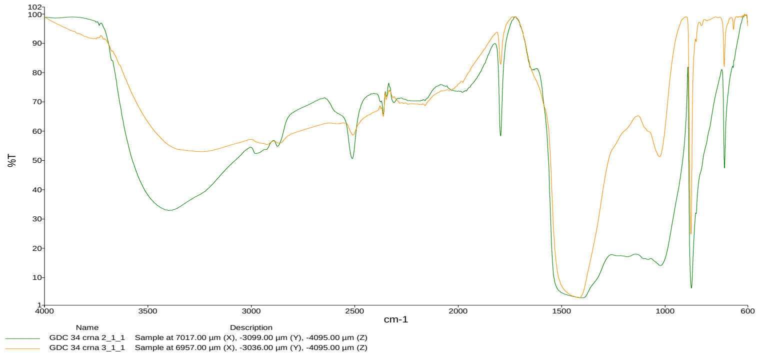
Layer **4 (maybe 3 as well)**




Results

- calcite
- kaolin
- proteins or calcium oxalate

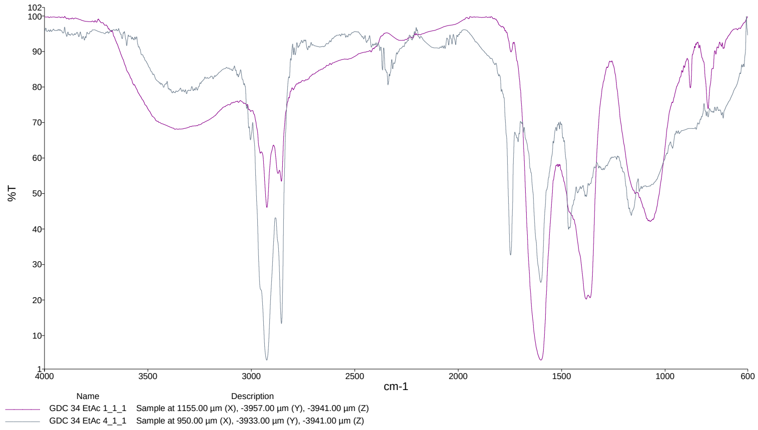
## Layer **3 (maybe also border layers)**




Results

- calcite
- silicates
- proteins or calcium oxalate

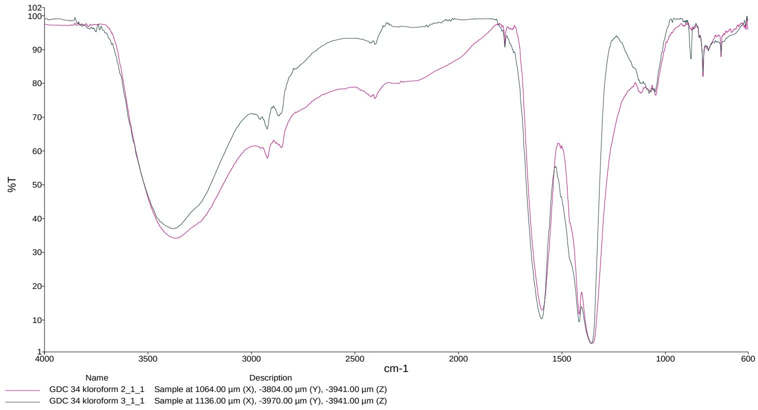
## Extraction with **ethyl acetate**




Results

- wax-like material
- probably carboxylates

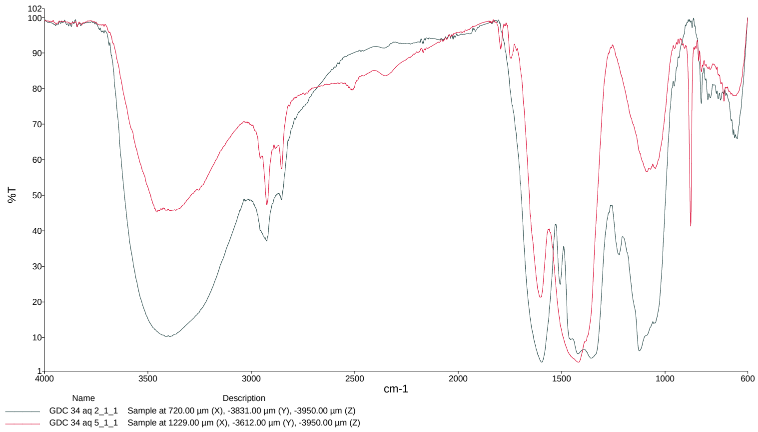
## Extraction with **chloroform**




Results

- calcite
- probably oxalates
- nitrates (probably calcium, potassium and sodium nitrate)

## Extraction with **hot distilled water**




Results

- calcite
- calcium oxalate
- unidentified material

**SAMPLE CODE**

**GDC 35**

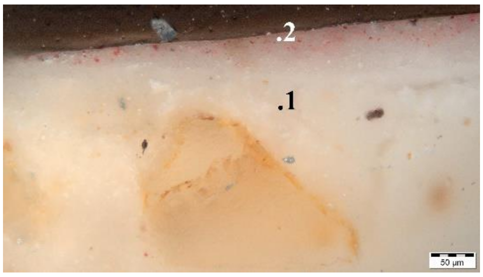
**SAMPLE MICROLOCATION**

light violet, S wall, grave, anionic resins

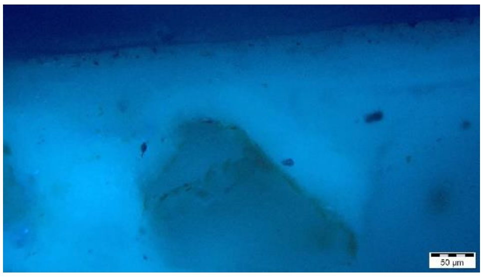
**STRATIGRAPHY**

2- red
1- plaster

**VIS PHOTOGRAPHY**

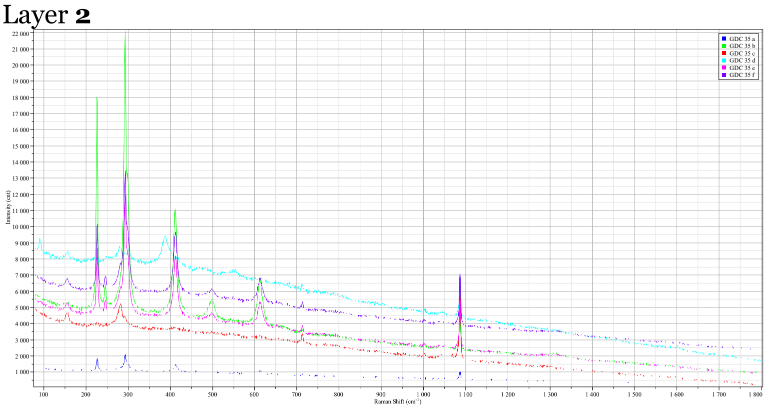



**UVF PHOTOGRAPHY**




### *Raman spectroscopy*

Layer **2**



Results

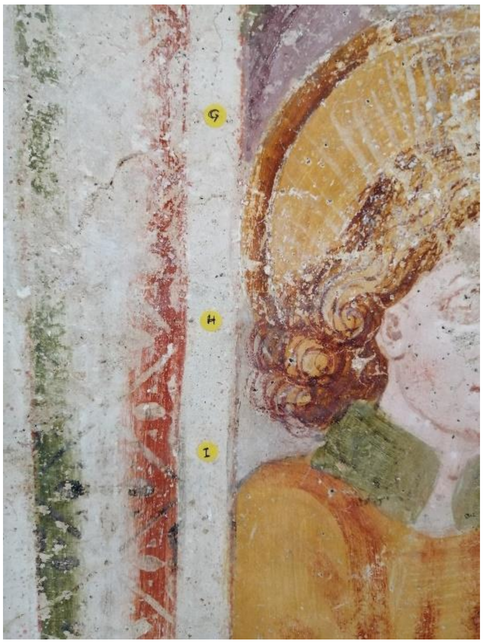
- haematite
- calcite
- probably sodium nitrate (1068 cm$^{-1}$; Vargas Jentzsch et al., 2013)

**SAMPLE CODE**

**GDC 36**
(label G)

**SAMPLE MICROLOCATION**

white, S wall, right of the window, under 1st niche, frame, cleaned with water

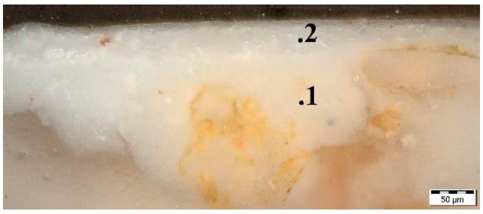


**STRATIGRAPHY**

2- white with red particles

1- plaster

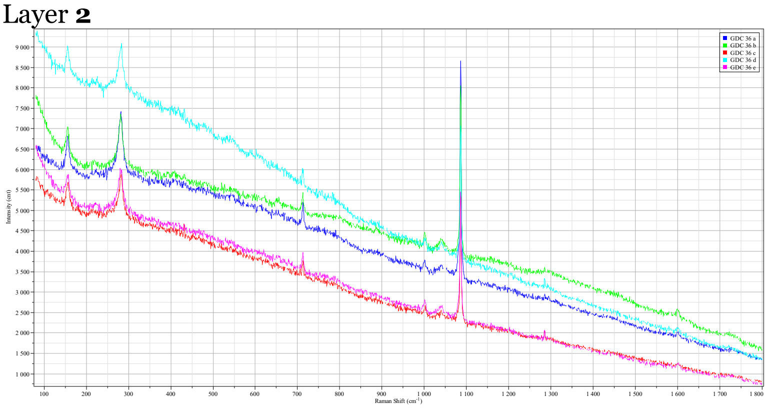
**VIS PHOTOGRAPHY**




**UVF PHOTOGRAPHY**


### *Raman spectroscopy*

Layer **2**



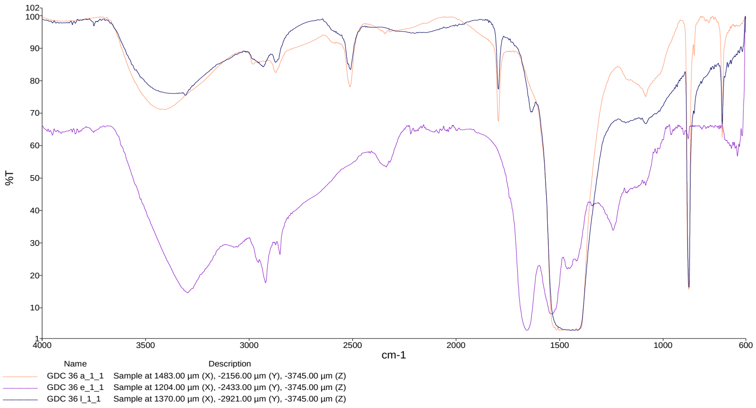
Results

- calcite
- maybe gypsum (sp. a)

## *FTIR spectroscopy*

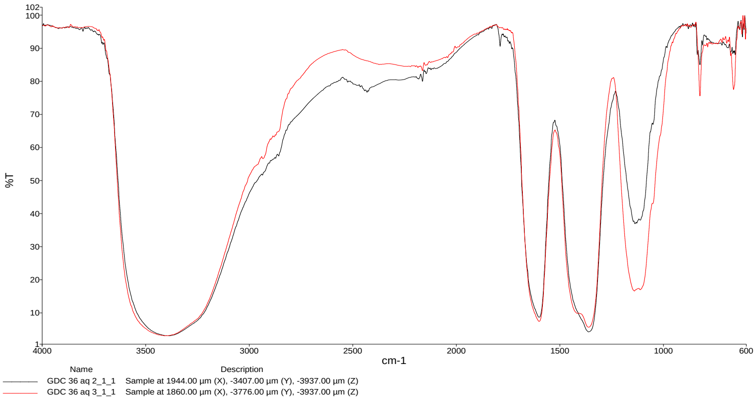
Layer **2**




Results

- calcite
- calcium oxalate
- proteins (visible in part of the sample as thin layer on surface)

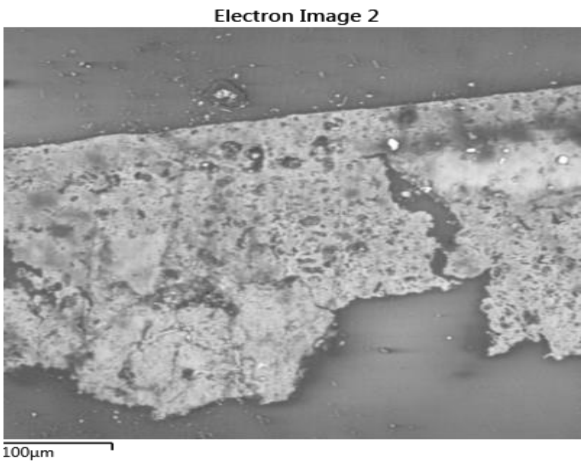
Extraction with **hot distilled water**

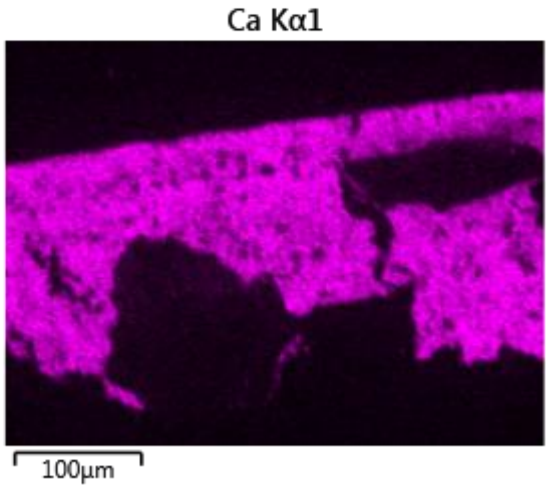



Results

- nitrates (probably calcium, potassium and sodium nitrate)

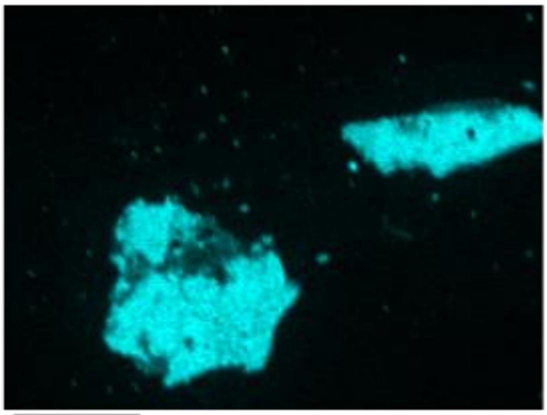
## *SEM EDS*



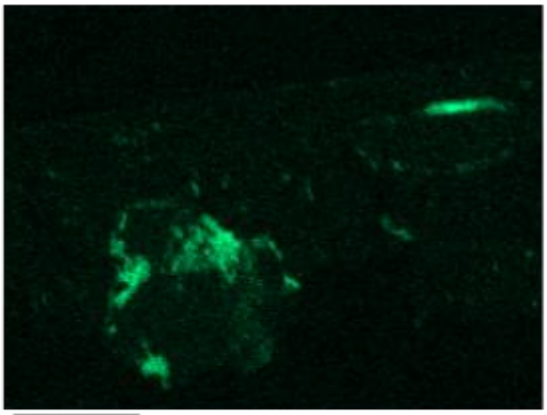

 

Si Kα1



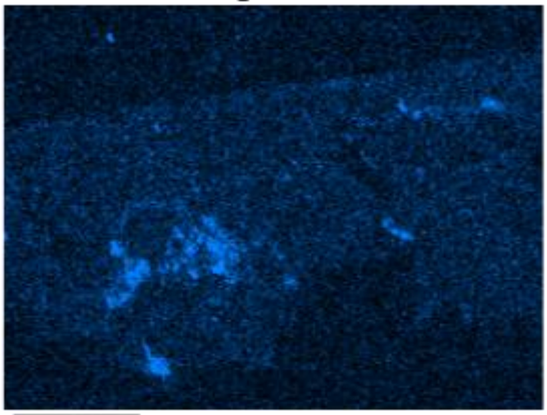
100μm

Al Kα1



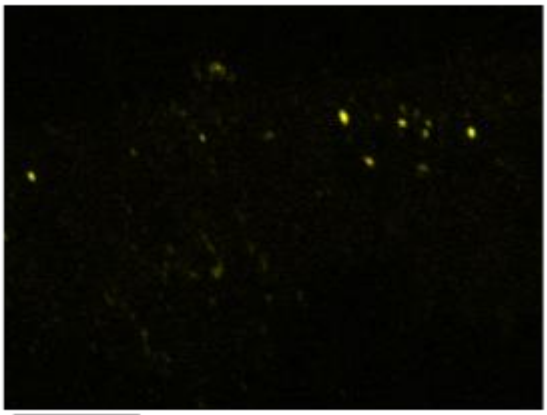
100μm

Mg Kα1,2



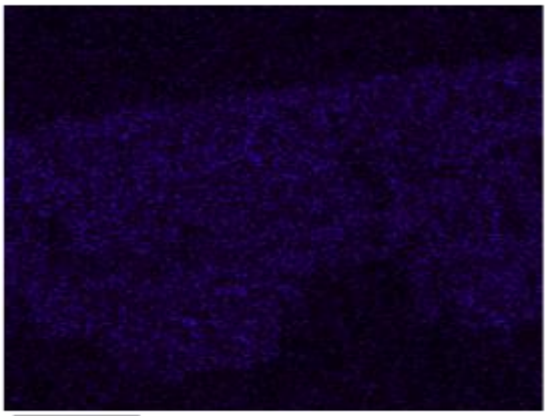
100μm

Cl Kα1



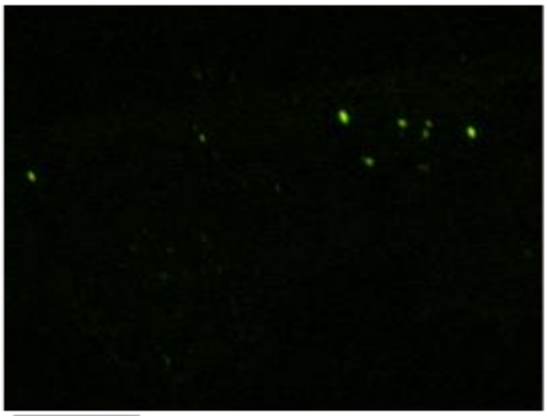
100μm

S Kα1



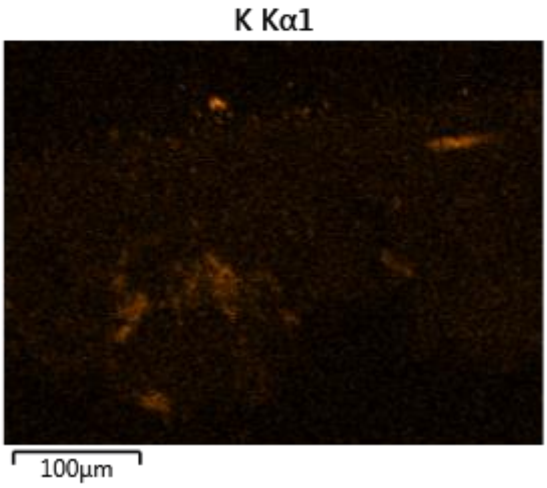
100μm

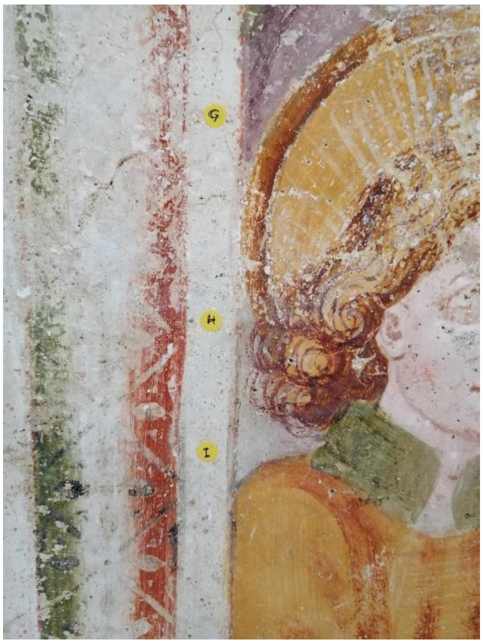
Na Kα1,2

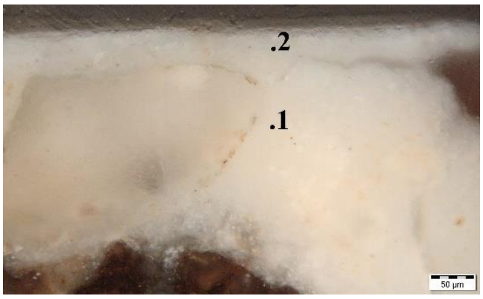
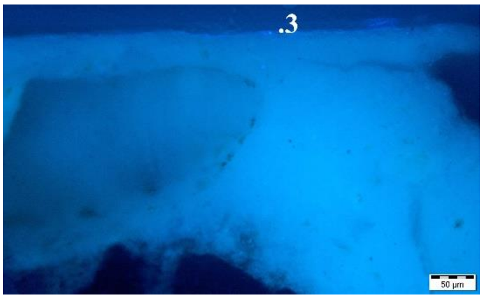


100μm




| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 37** (label H) | white, S wall, right of the window, under 1st niche, frame, under GDC 36, BaOH  |

| STRATIGRAPHY | VIS PHOTOGRAPHY | UVF PHOTOGRAPHY |
|---|---|---|
| 3- coating / salts<br>2- white with red particles<br>1- plaster |  |  |

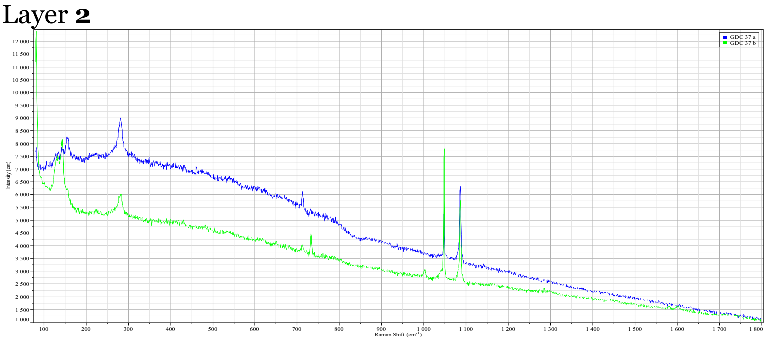




## *Raman spectroscopy*

Layer **2**



Results

- calcite
- nitrates

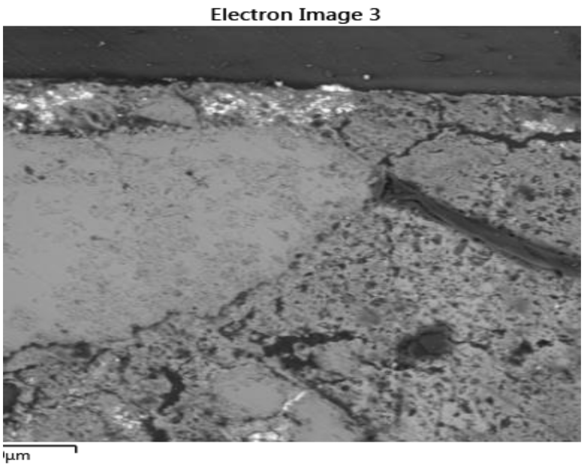
## *FTIR spectroscopy*

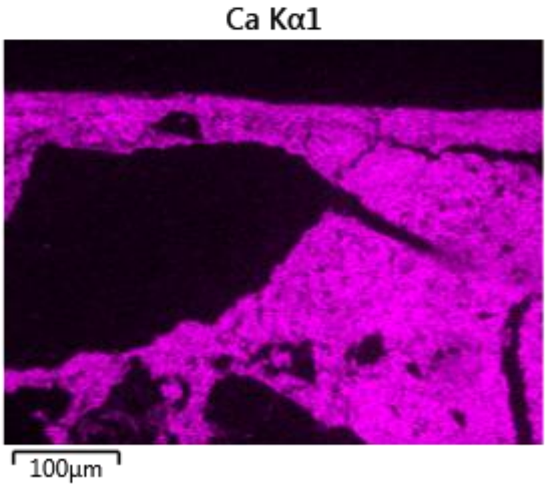
Extraction with **hot distilled water**


Results

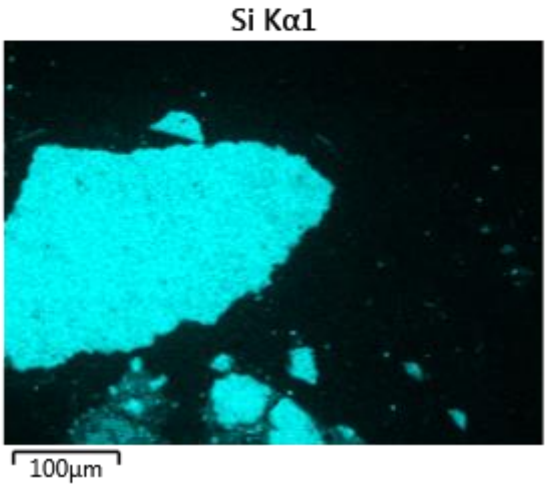
- nitrates (probably calcium, potassium and sodium nitrate)

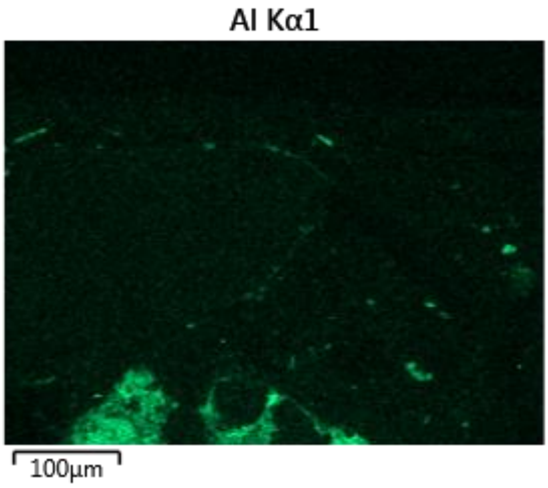
## *SEM EDS*

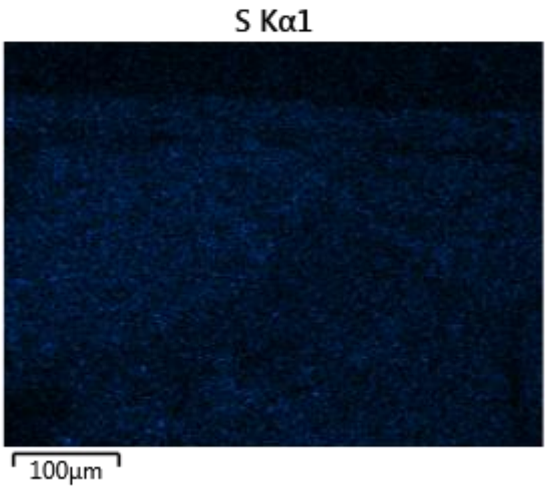


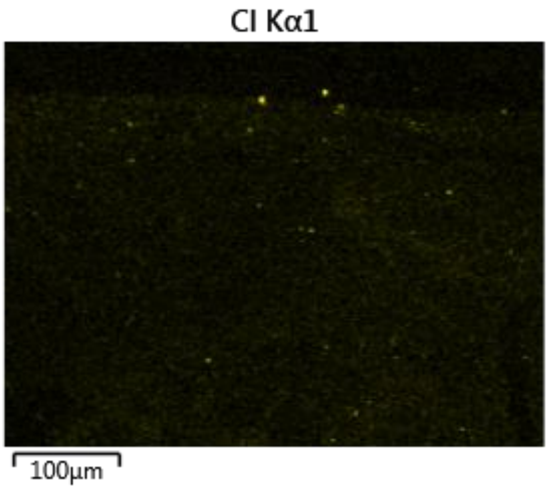



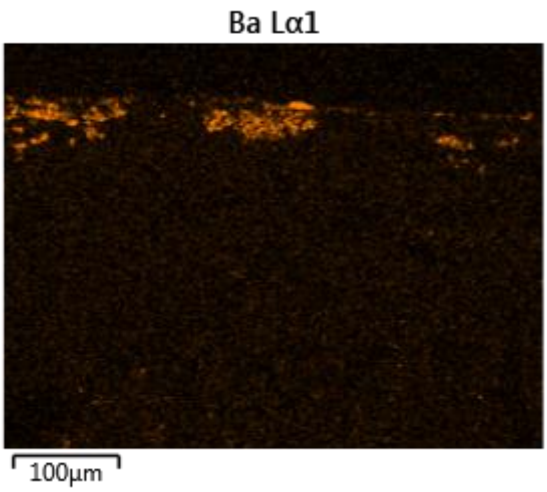

 


Si Kα1
100µm


Al Kα1
100µm


S Kα1
100µm

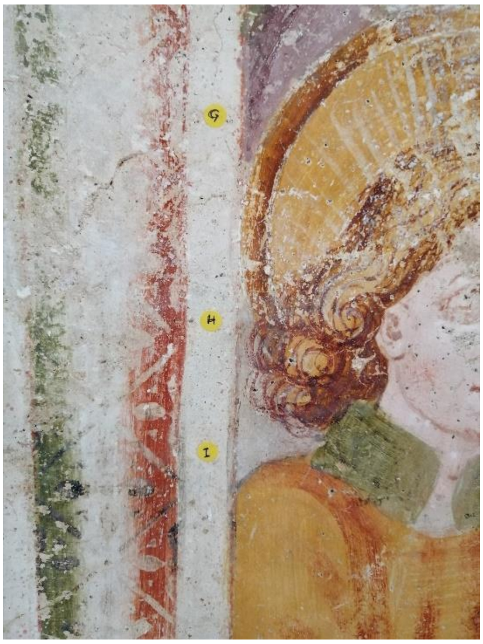

Cl Kα1
100µm


Ba Lα1
100µm

**SAMPLE CODE** **SAMPLE MICROLOCATION**

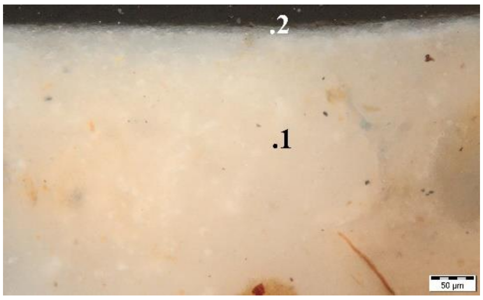
**GDC 38**
(label I)

white, S wall, right of the window, under 1st niche, frame, under GDC 37, BaOH and ammonium bicarbonate, poultice



**STRATIGRAPHY** **VIS PHOTOGRAPHY** **UVF PHOTOGRAPHY**

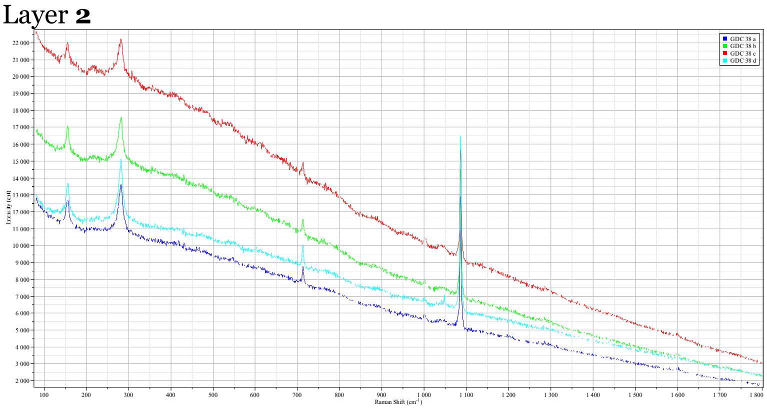
2- white
1- plaster





## *Raman spectroscopy*

Layer **2**

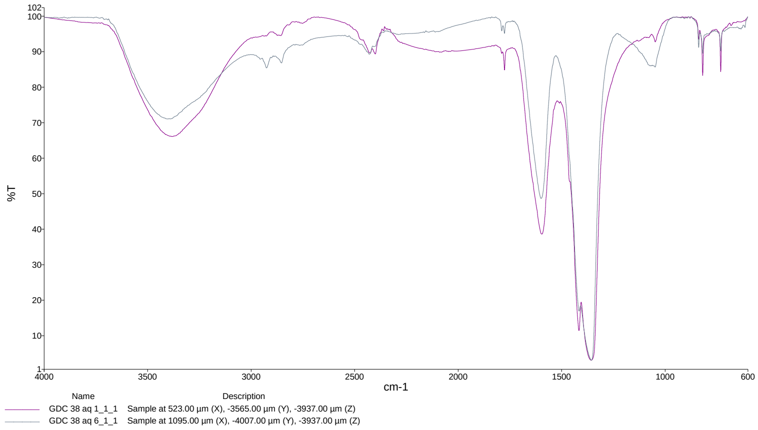


Results
- calcite
- nitrates

## *FTIR spectroscopy*

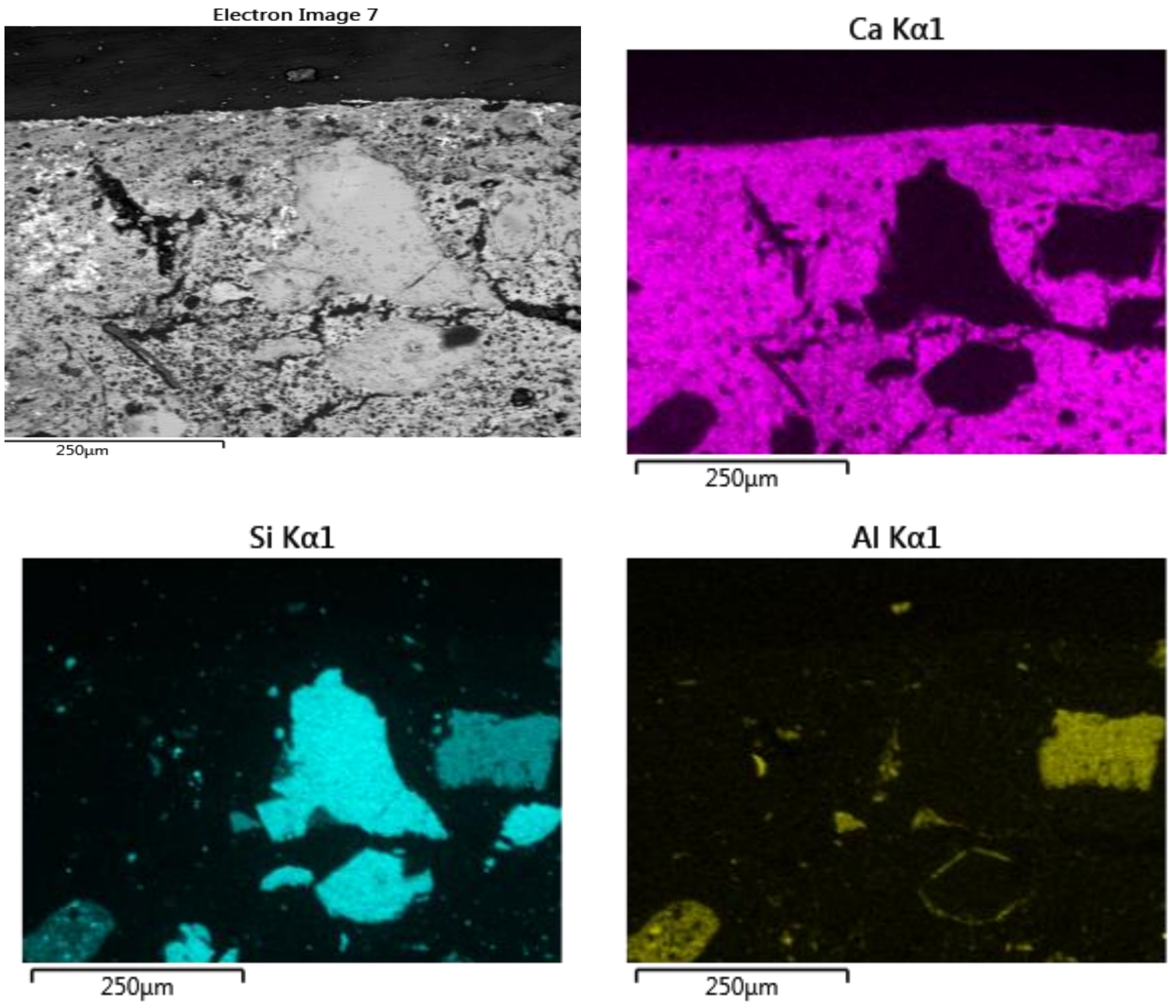
Extraction with **hot distilled water**



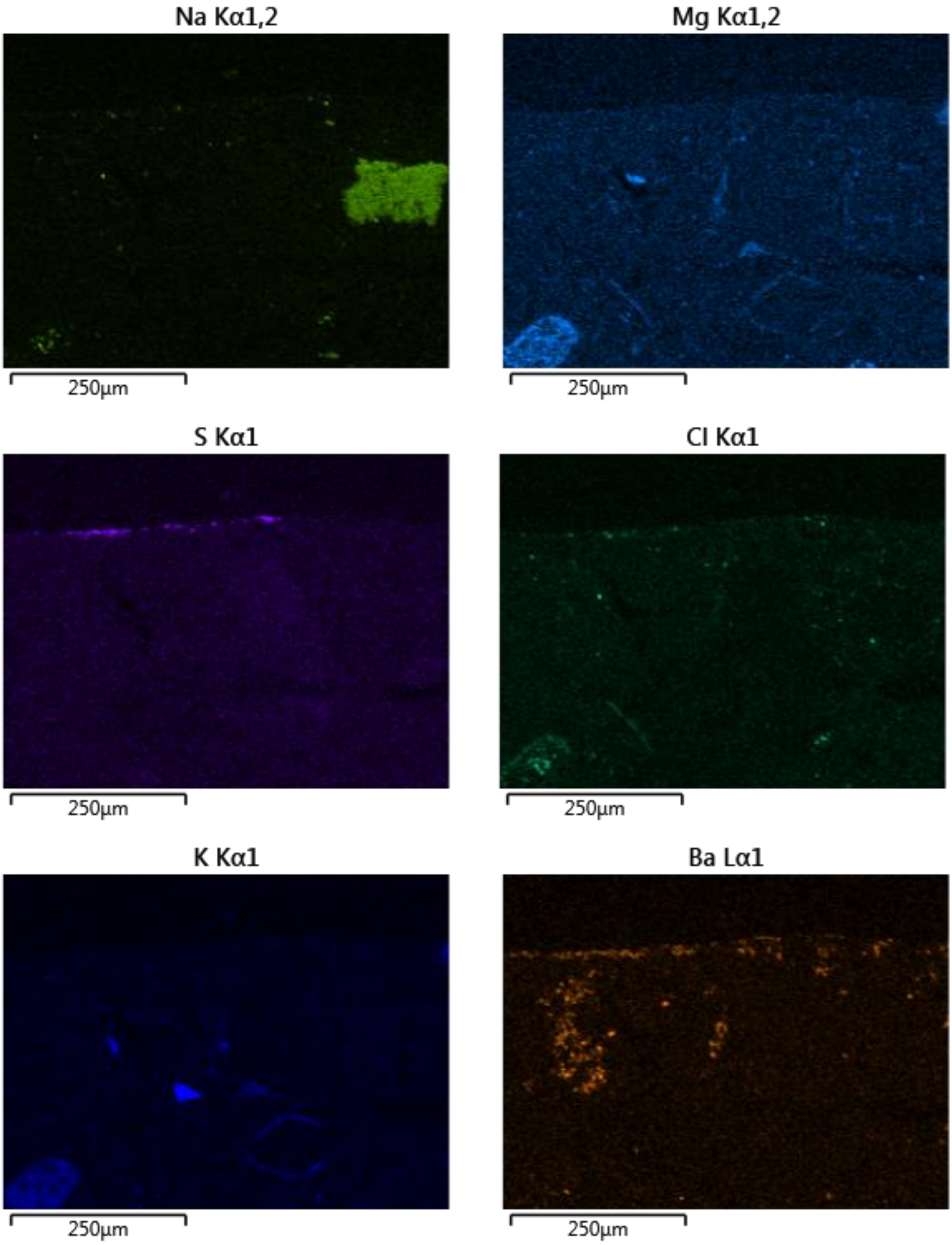

Results

- nitrates (probably calcium, potassium and sodium nitrate)

## *SEM EDS*



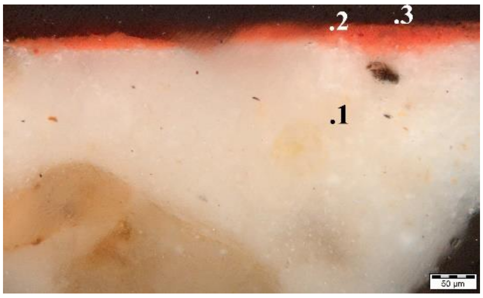

 


Na Kα1,2
250µm
Mg Kα1,2
250µm
S Kα1
250µm
Cl Kα1
250µm
K Kα1
250µm
Ba Lα1
250µm

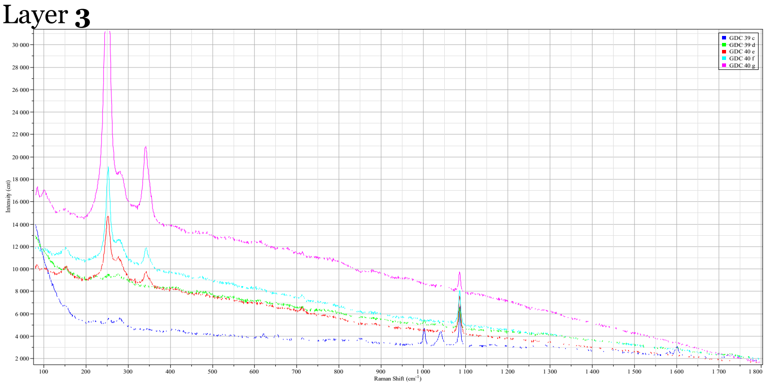
| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 39** | red, S wall, right from the window, under 1st niche, right scene, background between figures, blue pigment?, ammonium bicarbonate with poultice |

No visible blue particles.

| STRATIGRAPHY | VIS PHOTOGRAPHY | UVF PHOTOGRAPHY |
|---|---|---|
| 3- white, remains<br>2- red<br>1- plaster |  |  |

## *Raman spectroscopy*

Layer 3



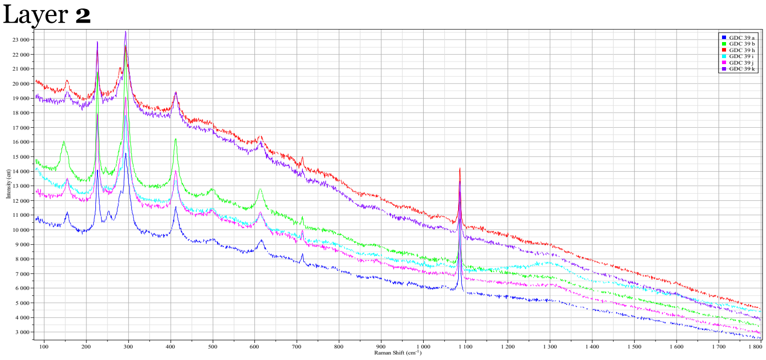
Results

- vermilion
- calcite
- haematite

REMARK:
Spectra e to g scanned on raw sample

Layer **2**

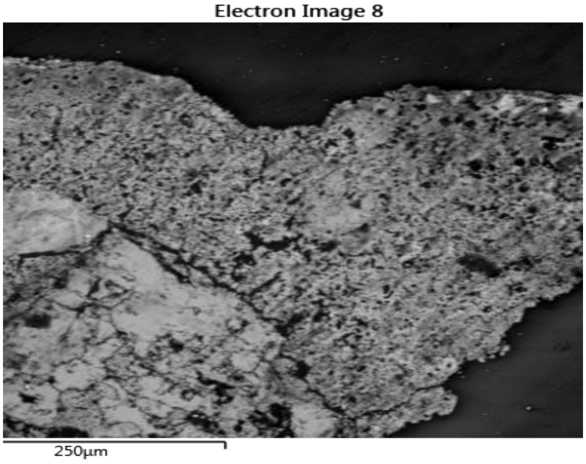


Results

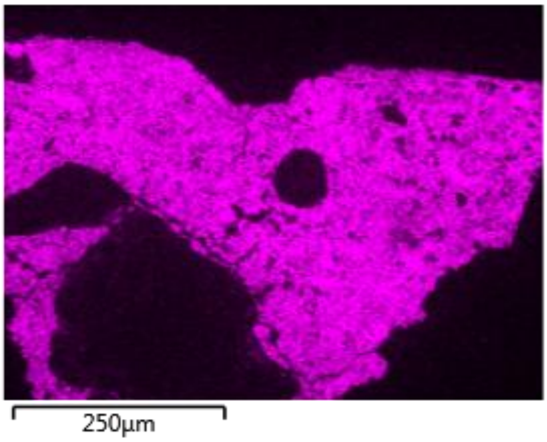
- calcite
- haematite
- vermilion
- maybe kaolinite

***SEM EDS***

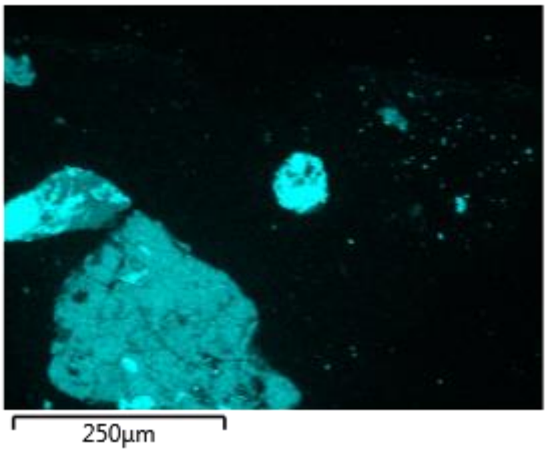
Electron Image 8



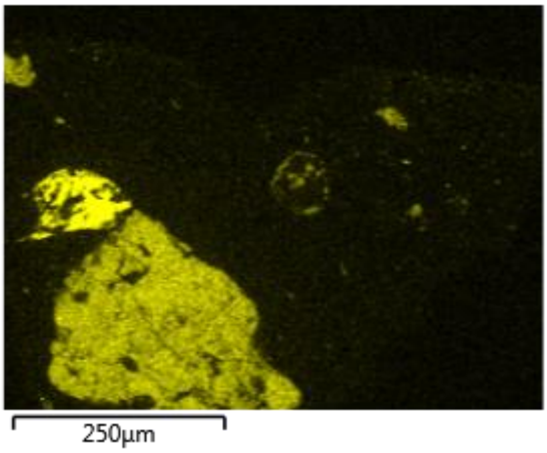

Ca Kα1




Si Kα1

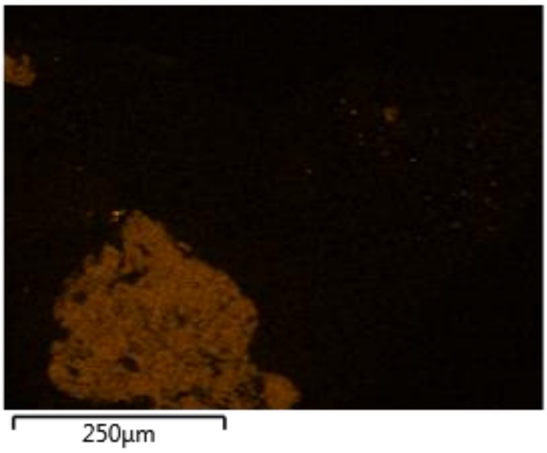



Al Kα1

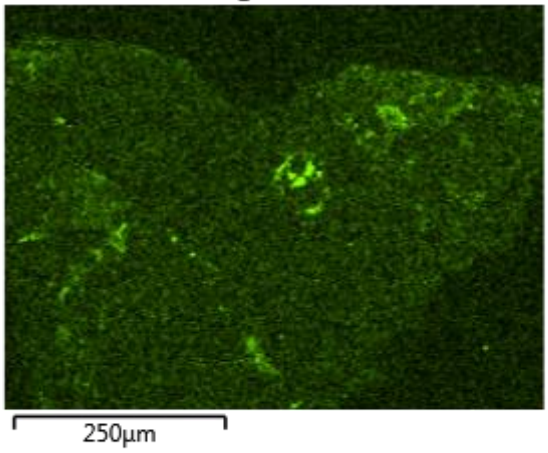


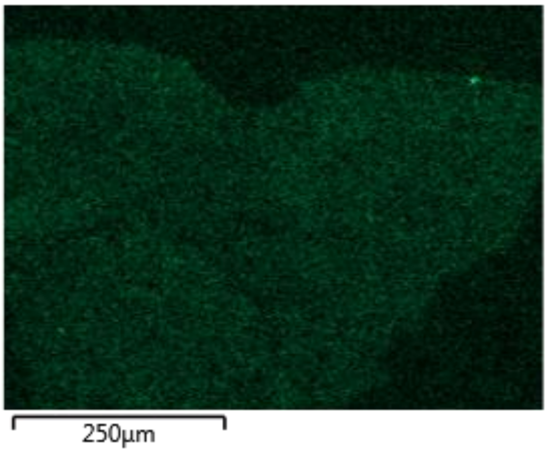
Na Kα1,2



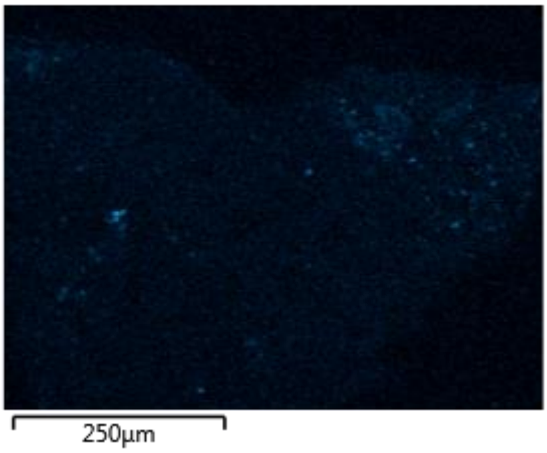

Mg Kα1,2



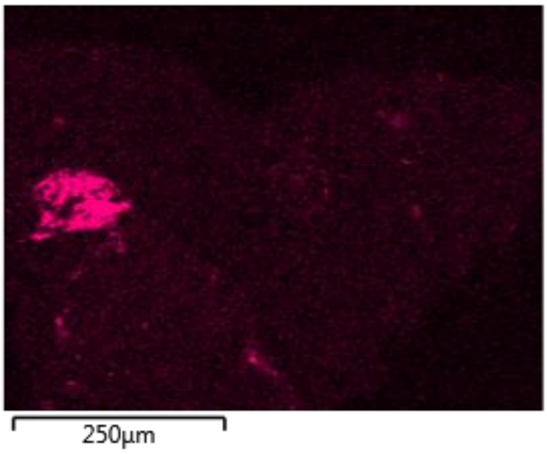

S Kα1




Cl Kα1



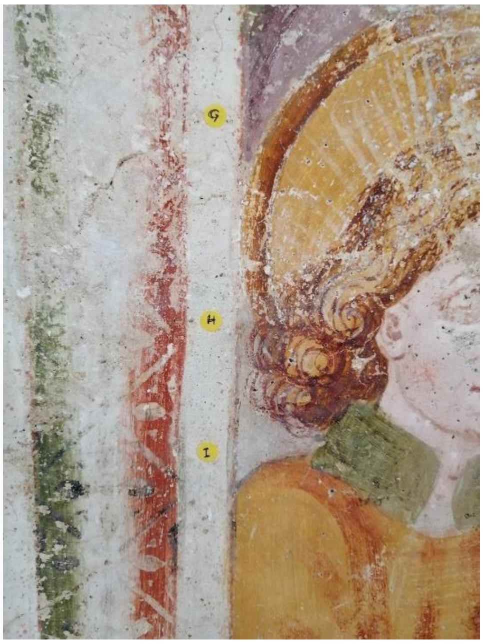

K Kα1



**SAMPLE CODE** | **SAMPLE MICROLOCATION**

**GDC 40**
(not labelled, below label I)

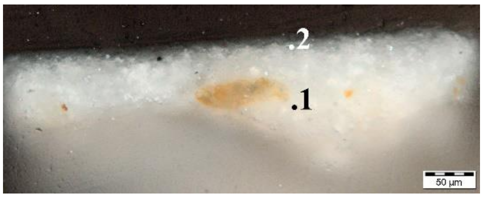
white, S wall, right of the window, under 1st niche, frame, left from yellow drapery



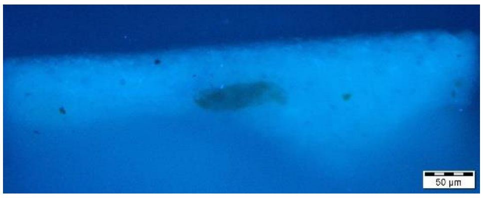

**STRATIGRAPHY**

2- white
1- plaster

**VIS PHOTOGRAPHY**

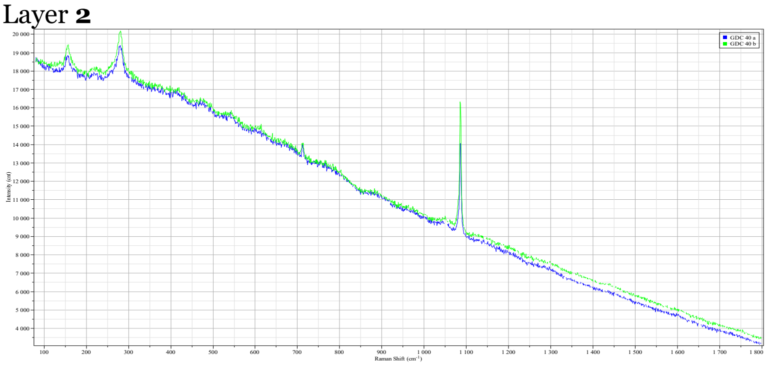



**UVF PHOTOGRAPHY**




## *Raman spectroscopy*

Layer **2**

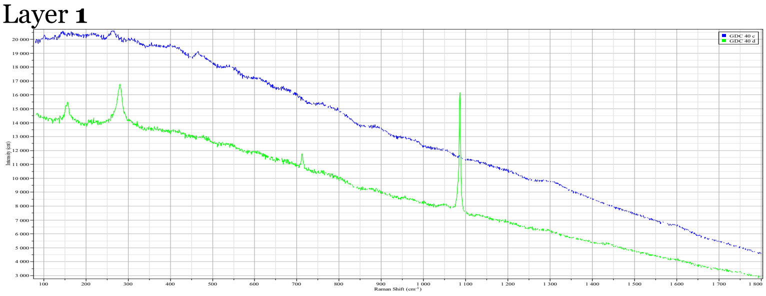


Results

- calcite

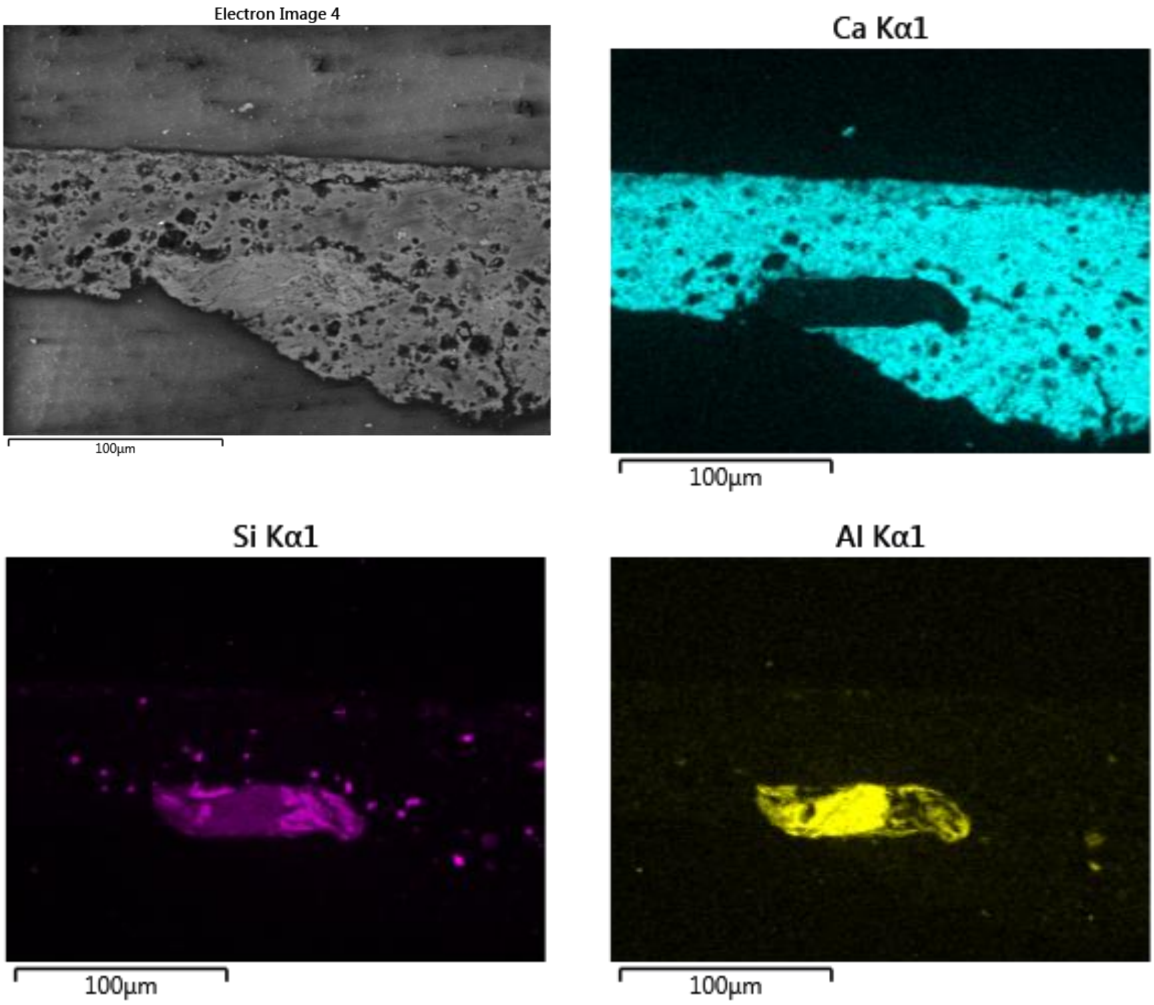
Layer 1



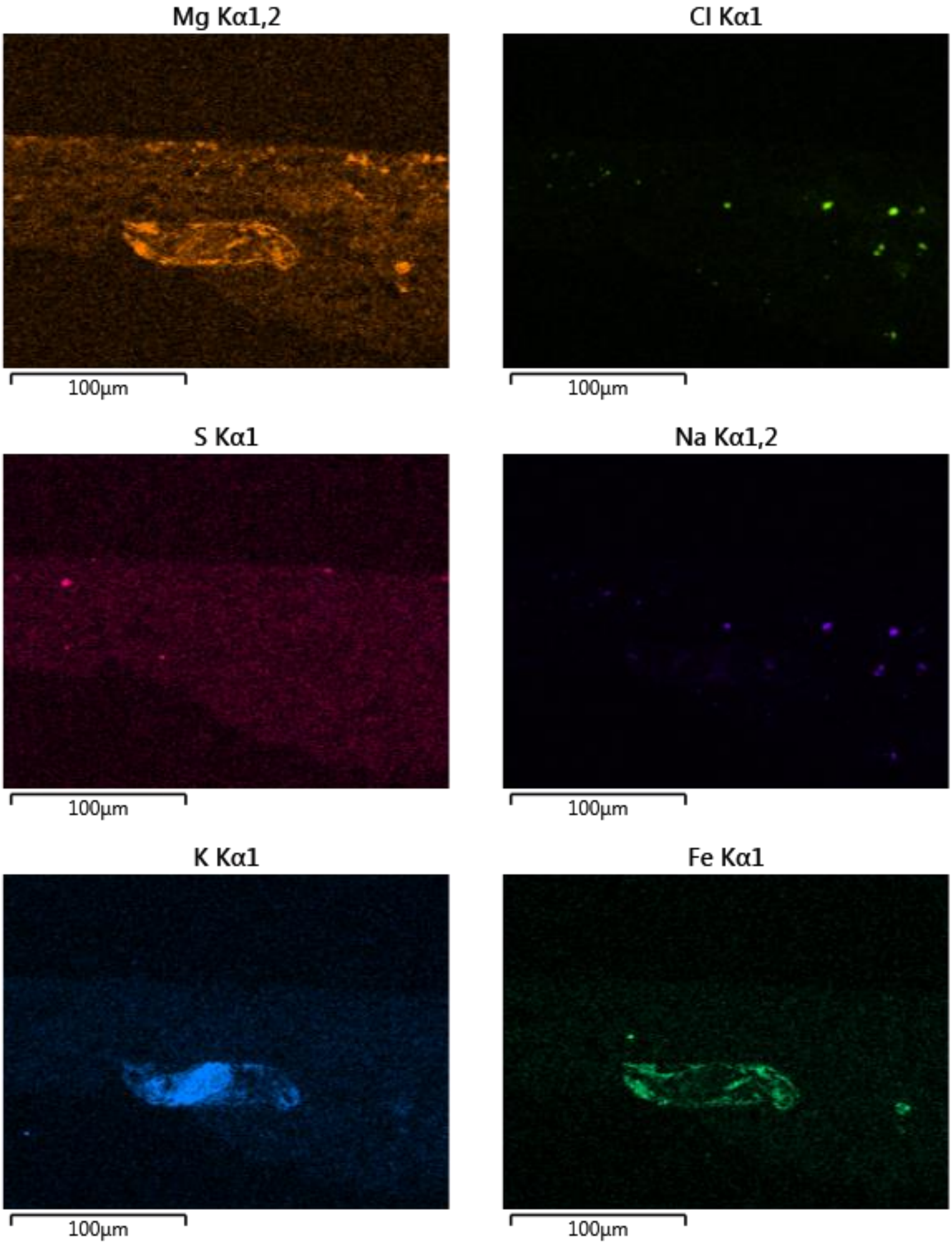
Results

- calcite
- quartz

***SEM EDS***



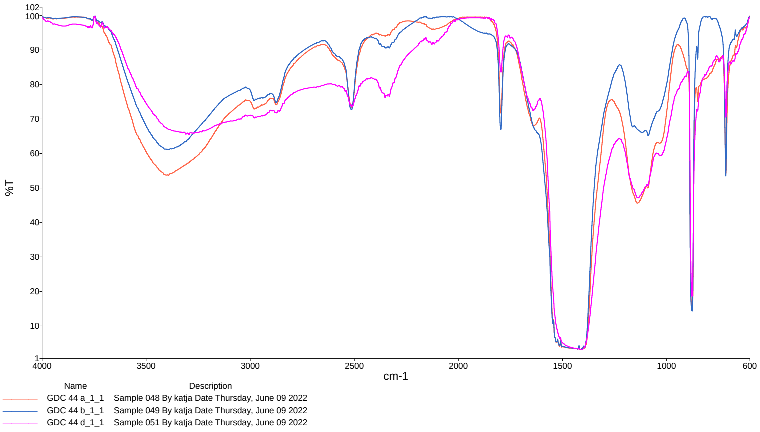

 


Mg Kα1,2
100µm
Cl Kα1
100µm
S Kα1
100µm
Na Kα1,2
100µm
K Kα1
100µm
Fe Kα1
100µm

| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 44** | powder from the area near the fox, white haze after cleaning |

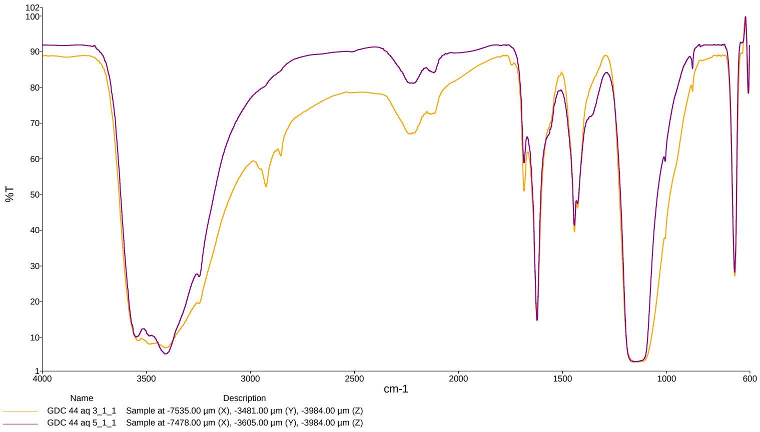
## *FTIR spectroscopy*

### Raw sample



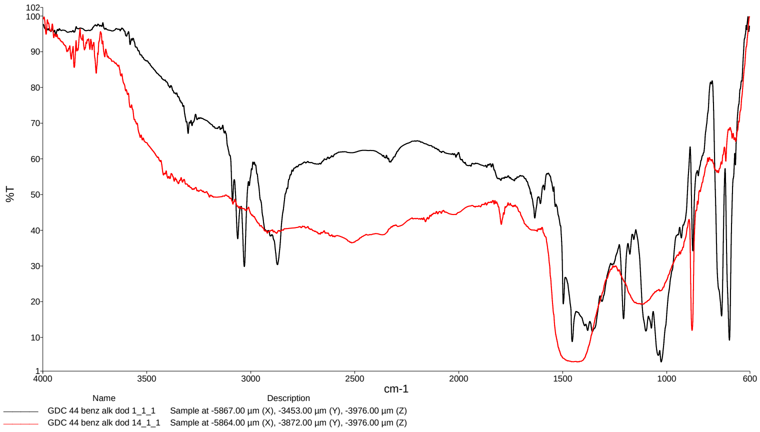

Results
- calcite
- proteins or calcium oxalate
- silicates

### Extraction with water



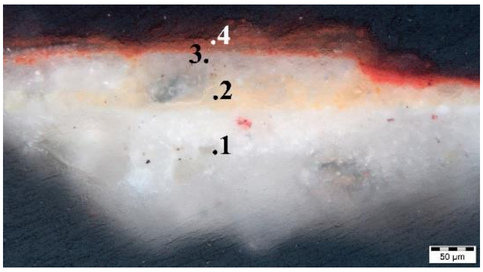
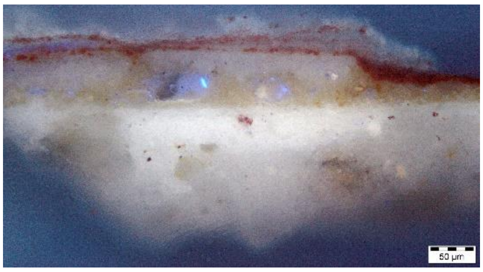

Results
- gypsum
- unidentified material (1442, 1427 cm$^{-1}$)
- calcite

### Extraction with benzyl alcohol



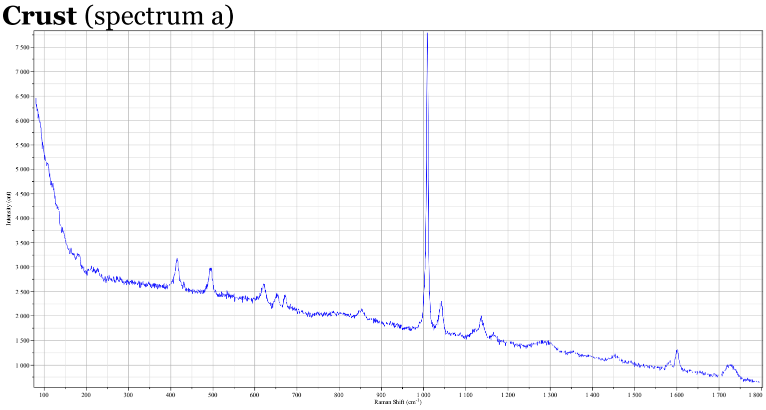

Results
- calcite
- carbonyl band (from benzyl alcohol)

| SAMPLE CODE | SAMPLE MICROLOCATION | |
|---|---|---|
| **GDC 45** | red, N wall, man on the left, back, incrustation on surface | |
| |  |  |
| **STRATIGRAPHY** | **VIS PHOTOGRAPHY** | **UVF PHOTOGRAPHY** |
| 4- orange and white, exchanging<br>3- white<br>2- ochre<br>1- plaster |  |  |

### *Raman spectroscopy*

**Crust** (spectrum a)



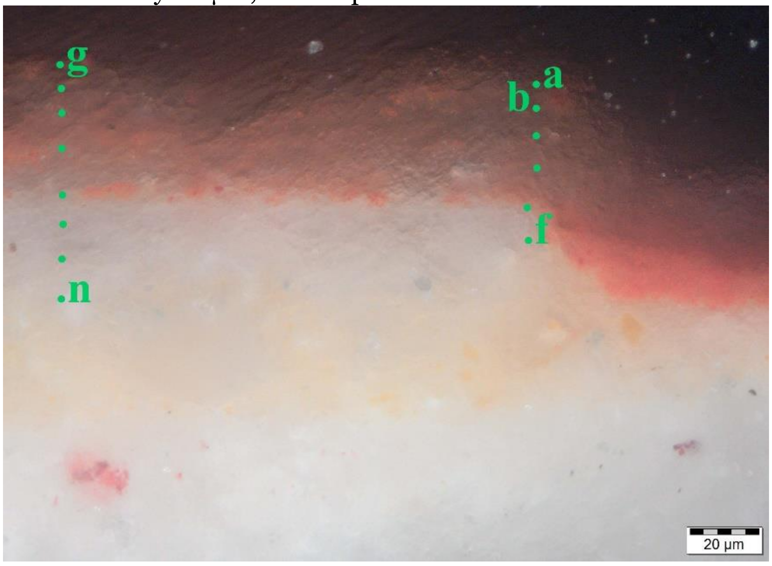
Results

- gypsum

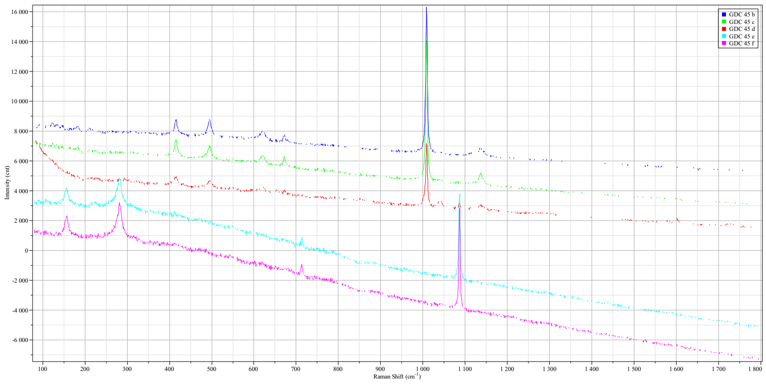
 

**Profile** every 20 µm, from top towards bottom

Results

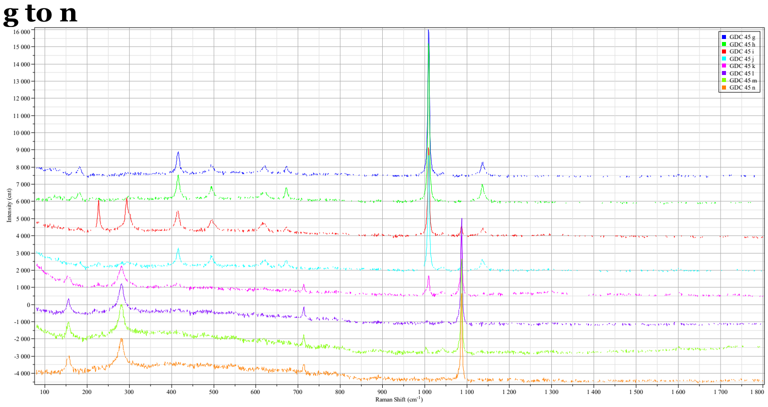



**b to f**



- close to the surface only gypsum is observed
- gypsum disappears after 60 µm approx.
- in spectrum d (red line) nitrates appear (1040 $cm^{-1}$)

**g to n**

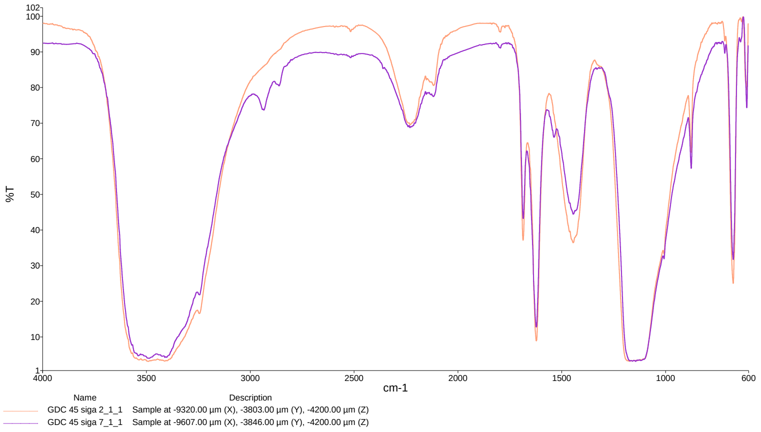


- gypsum in top layers, no calcite
- in depth (after approx. 80 µm) amount of gypsum relative to calcite, is smaller, and different amounts can be observed in different spots
- in some spots nitrates are present

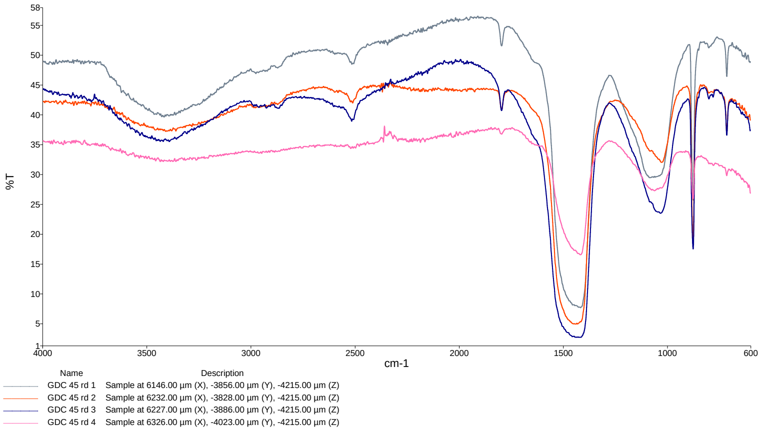
## *FTIR spectroscopy*

**Crust** (peels easily of the paint surface)




Results
- calcite
- gypsum
- organic material (Sloggett et al., 2010)
  Area typical of metal soaps, however, no such binder is present to form soaps.

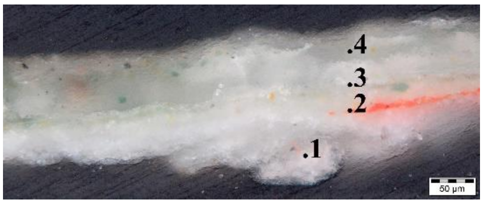
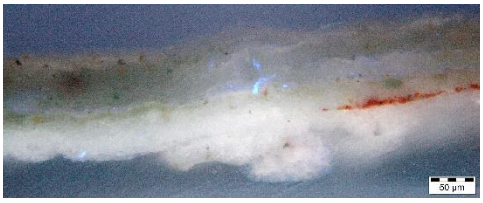
**Layer 4**




Results
- calcite
- silicates
- proteins or calcium oxalate

| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 46** | green, N wall, grass under bottle, after cleaning with ammonium bicarbonate salt-like efflorescence appears |

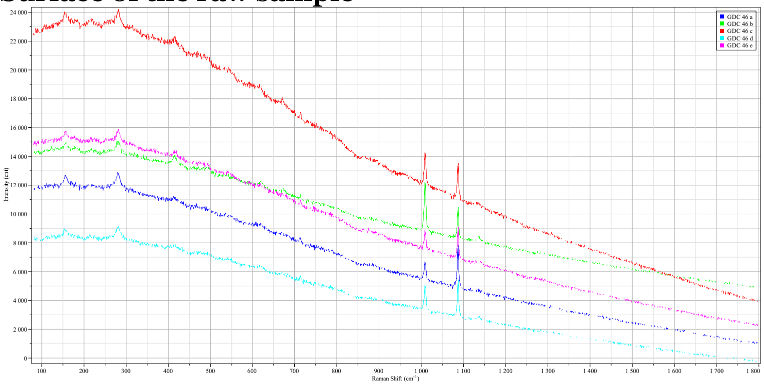
 

| STRATIGRAPHY | VIS PHOTOGRAPHY | UVF PHOTOGRAPHY |
|---|---|---|
| 4- green<br>3- green<br>2- red (underdrawing?)<br>1- plaster |  |  |



## *Raman spectroscopy*

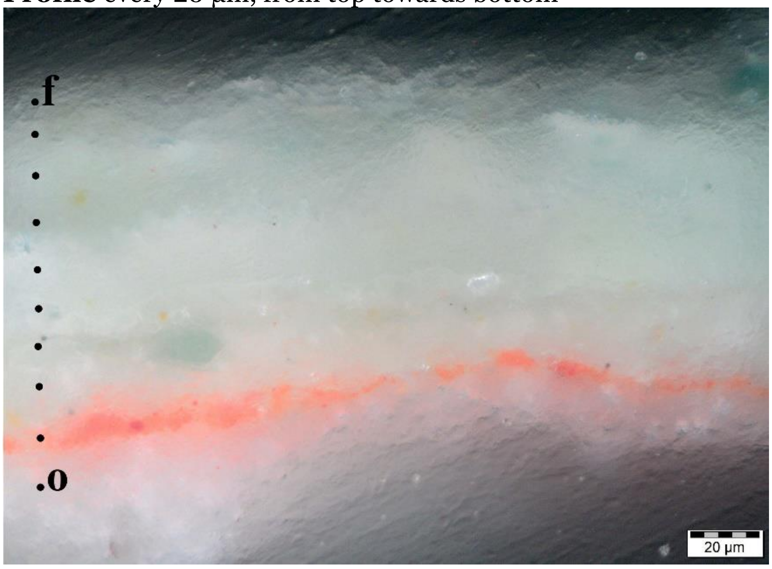
### Surface of the raw sample



Results
- calcite
- gypsum

(both visible in all analysed points, ratio slightly differs)

**Profile** every 20 µm, from top towards bottom

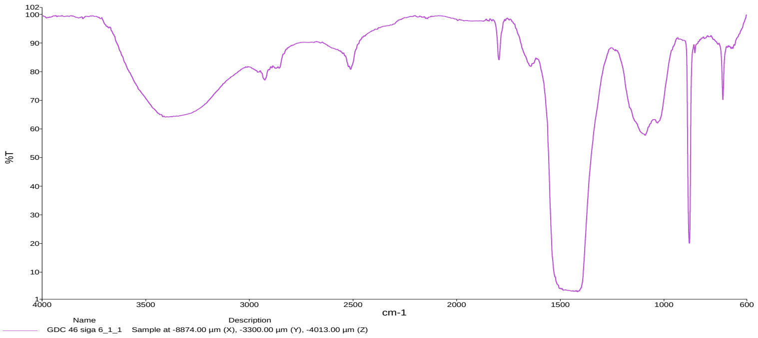



Results

- gypsum on surface, together with calcite
- their ratio varies
- amount of gypsum drops after ca 100 µm and it disappears ca 50 µm later

## *FTIR spectroscopy*

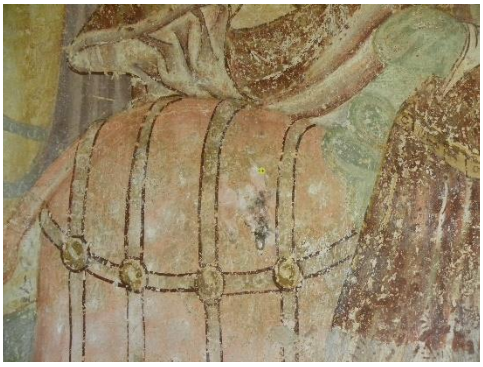
### Crust

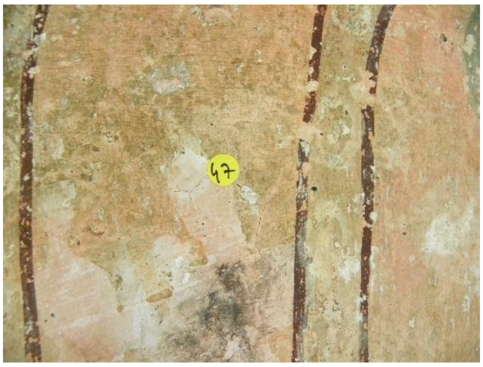



Results

- calcite
- probably silicates
- probably calcium oxalate

| SAMPLE CODE | SAMPLE MICROLOCATION |
|---|---|
| **GDC 47** | red, back of the horse of the first Magi, coating |






**STRATIGRAPHY**

2- red

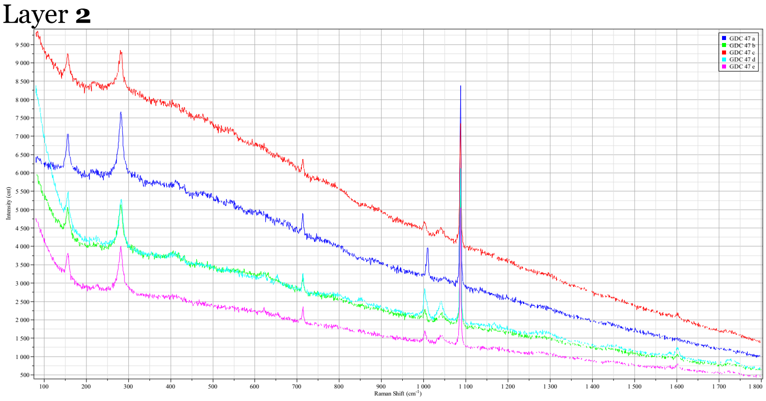
1- plaster

**VIS PHOTOGRAPHY**


**UVF PHOTOGRAPHY**


## *Raman spectroscopy*

### Layer 2

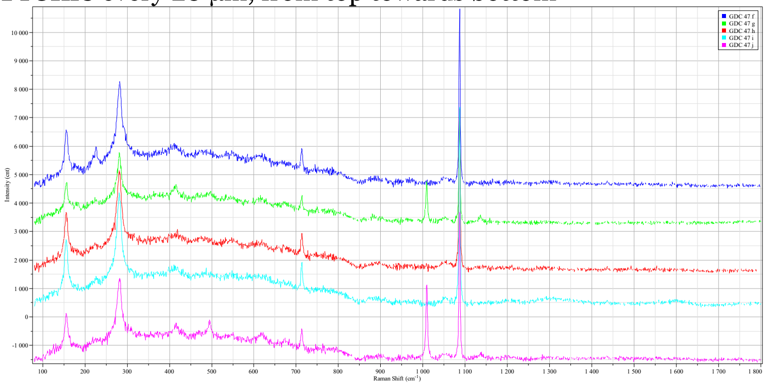


Results

- mainly calcite
- slight amount of gypsum in all analysed samples

**Profile** every 20 µm, from top towards bottom

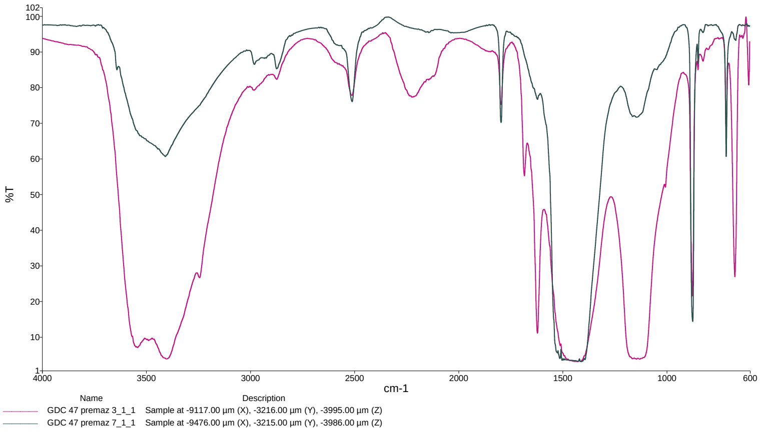


Results

- gypsum visible in some analysed point
- no clear profile like in other samples can be observed

***FTIR spectroscopy***

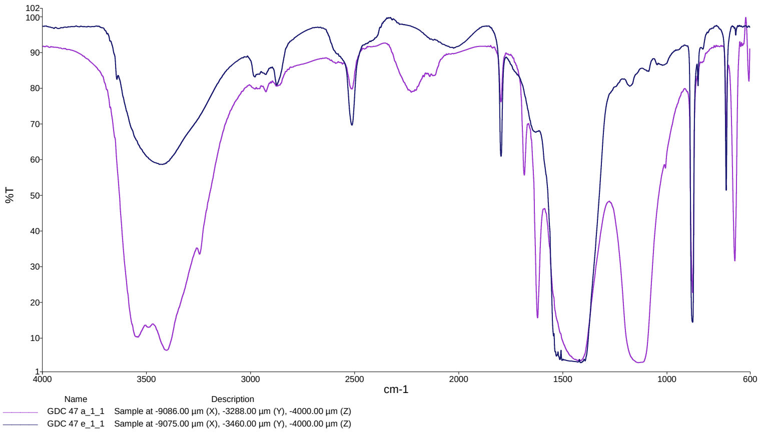
**Coating**




Results

- gypsum
- calcite
- hydrated alumosilicates (ochre)
- muscovite (825 cm$^{-1}$; Fišter, 2018)
- slight possibility of presence of proteinaceous material

**All layers**




Results

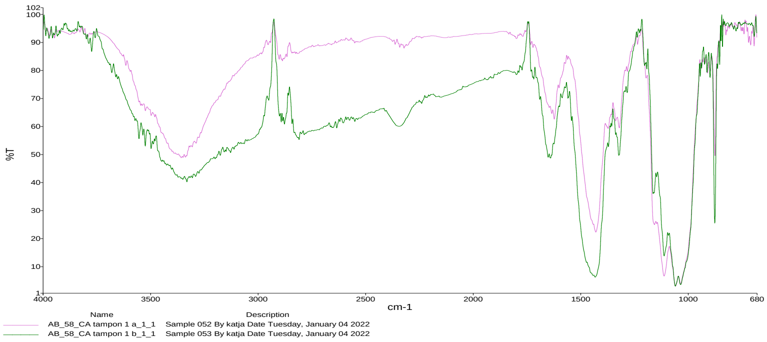
- calcite
- gypsum
- silicates and alumosilicates
- calcium oxalates or (less probable) proteins

## 6.3 Microscopic and spectroscopic analyses of cotton swabs

AB_58_CA

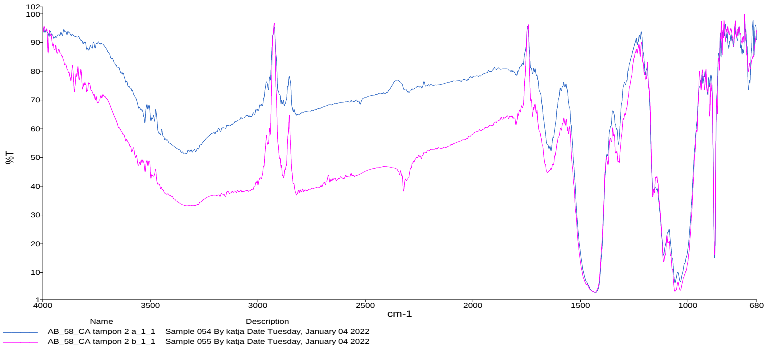
Cotton swab 1

- calcite
- calcium oxalate



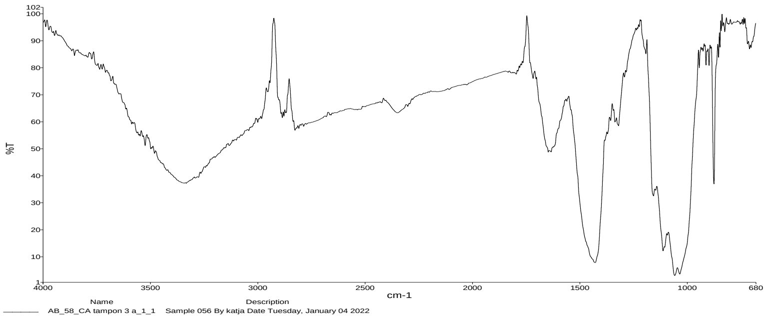

Cotton swab 2

- calcite
- calcium oxalate




Cotton swab 3

- calcite
- calcium oxalate

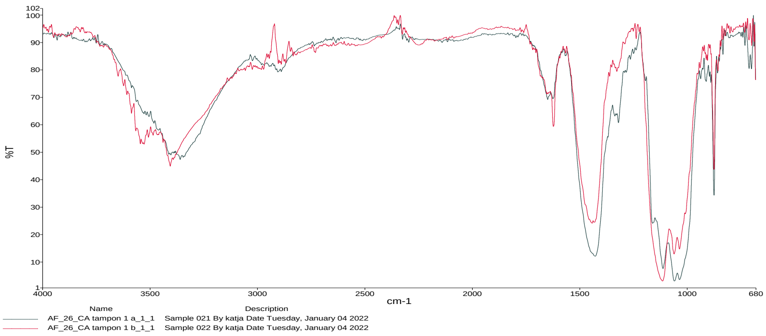


## AF_26_CA

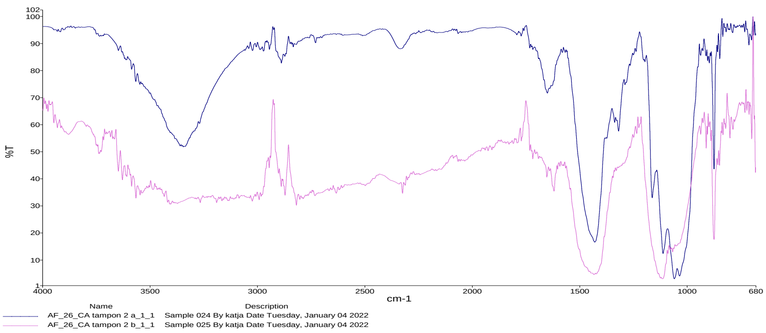



Cotton swab 1



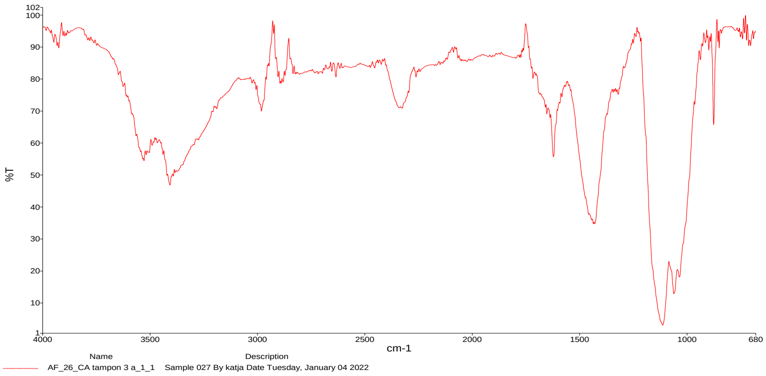

- calcite
- gypsum
- calcium oxalate

Cotton swab 2




- calcite
- gypsum
- calcium oxalate

Cotton swab 3

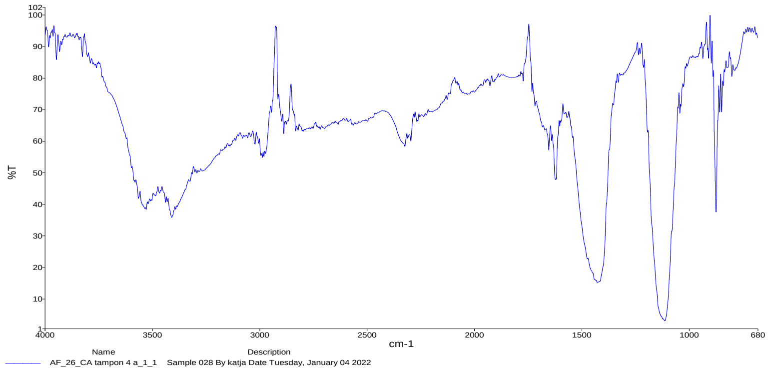



- calcite
- gypsum
- calcium oxalate (not much)

Cotton swab 4

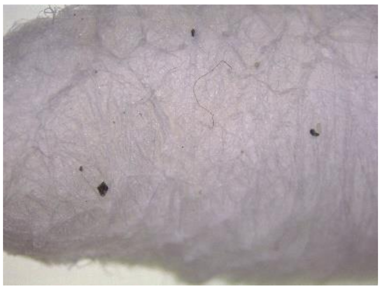
- calcite
- gypsum




MB_06_CA

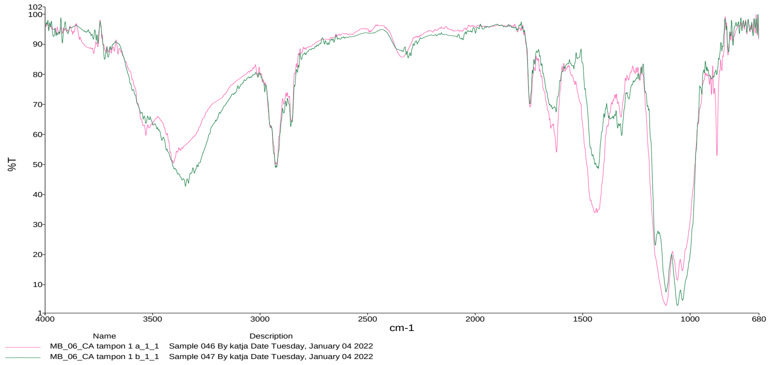
amount of gypsum seems to decrease with every next cotton swab (in contrast to calcite, where no pattern can be observed)





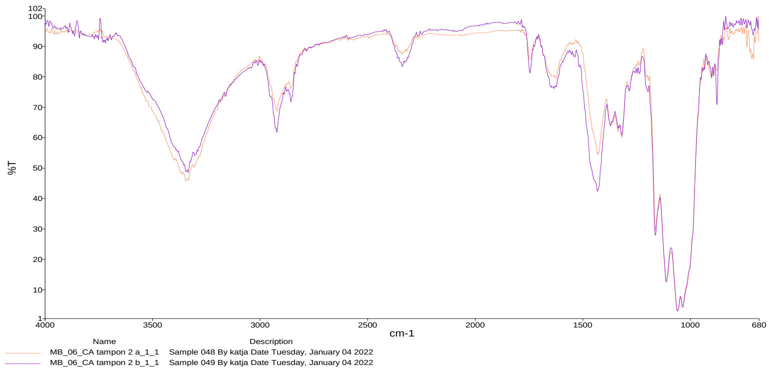
Cotton swab 1

- calcite
- gypsum
- calcium oxalate




Cotton swab 2

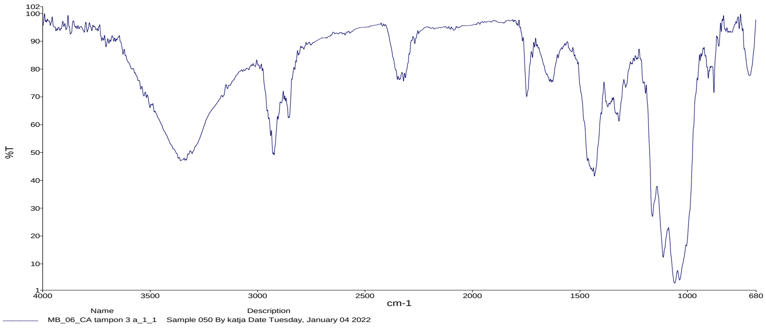
- calcite
- calcium oxalate
- gypsum



Cotton swab 3

- calcite
- calcium oxalate

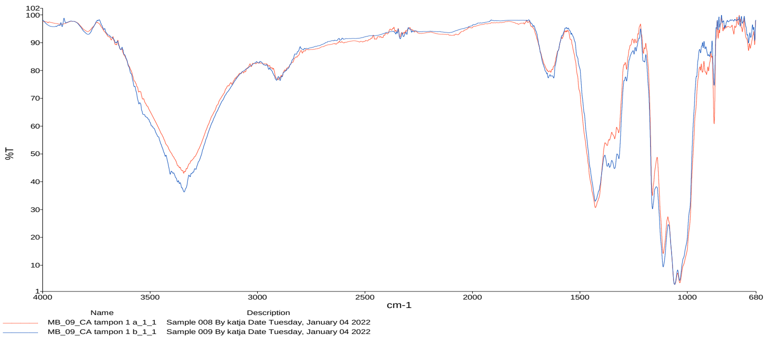



MB_09_CA

amount of gypsum increases after 1st cotton swab

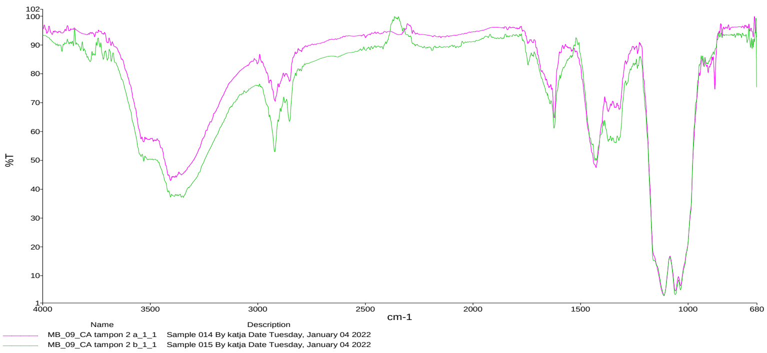
Cotton swab 1

- calcite
- maybe gypsum
- maybe calcium oxalate



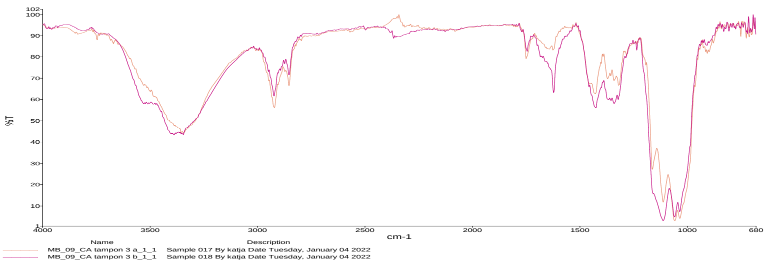

Cotton swab 2

- calcite
- gypsum
- calcium oxalate




Cotton swab 3

- gypsum
- calcite (very small amount)

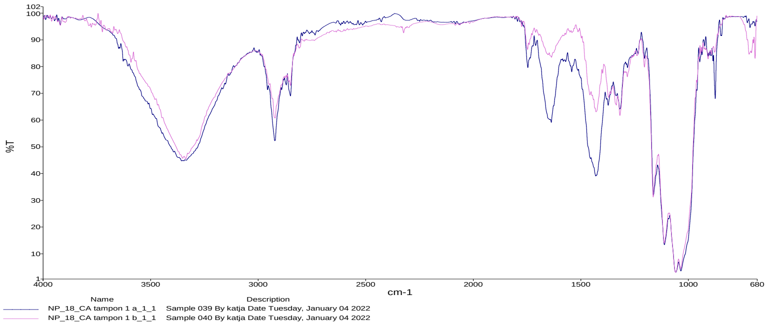


## NP_18_CA



Cotton swab 1

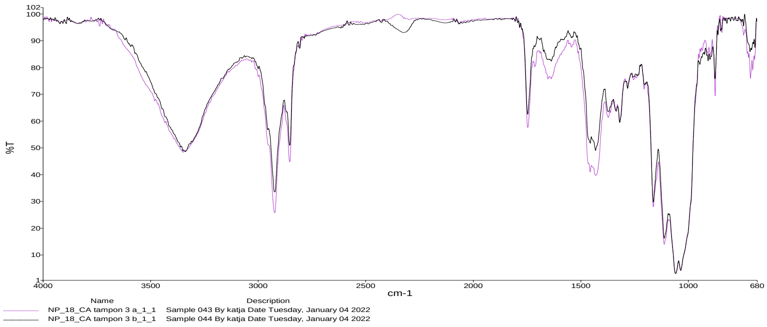



- calcite
- calcium oxalate (small amount)

Cotton swab 2


- calcite
- maybe calcium oxalate

Cotton swab 3

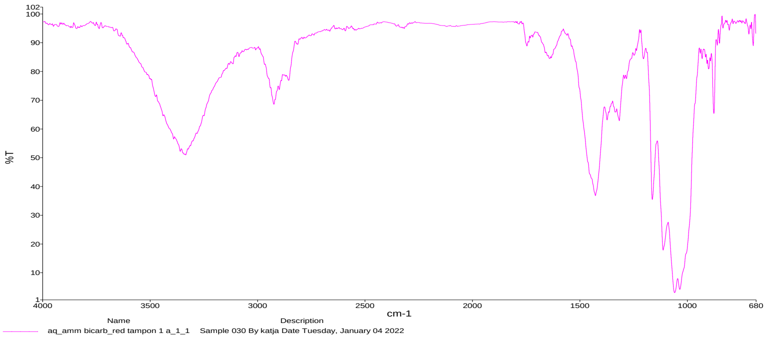



- calcite
- maybe calcium oxalate
- unidentified material (1455, 1430 $cm^{-1}$)

water cleaning after ammonium bicarbonate

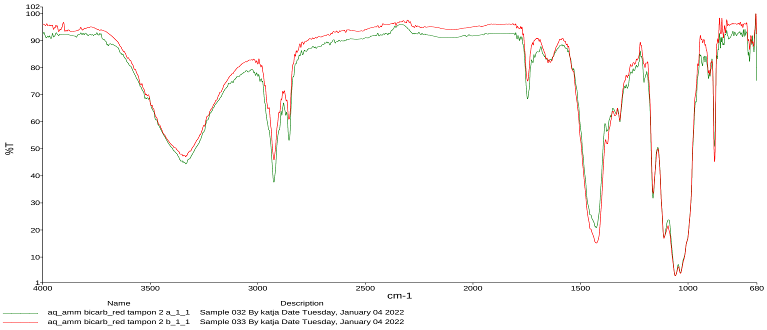
Cotton swab 1

- calcite
- calcium oxalate



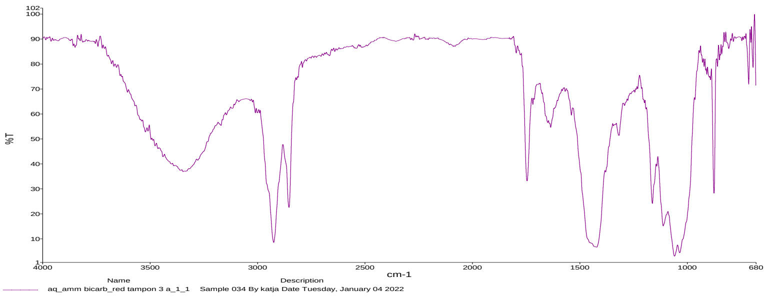

Cotton swab 2

- calcite
- calcium oxalate




Cotton swab 3

- calcite
- calcium oxalate
- carboxylates, probably zinc (1539 $cm^{-1}$)



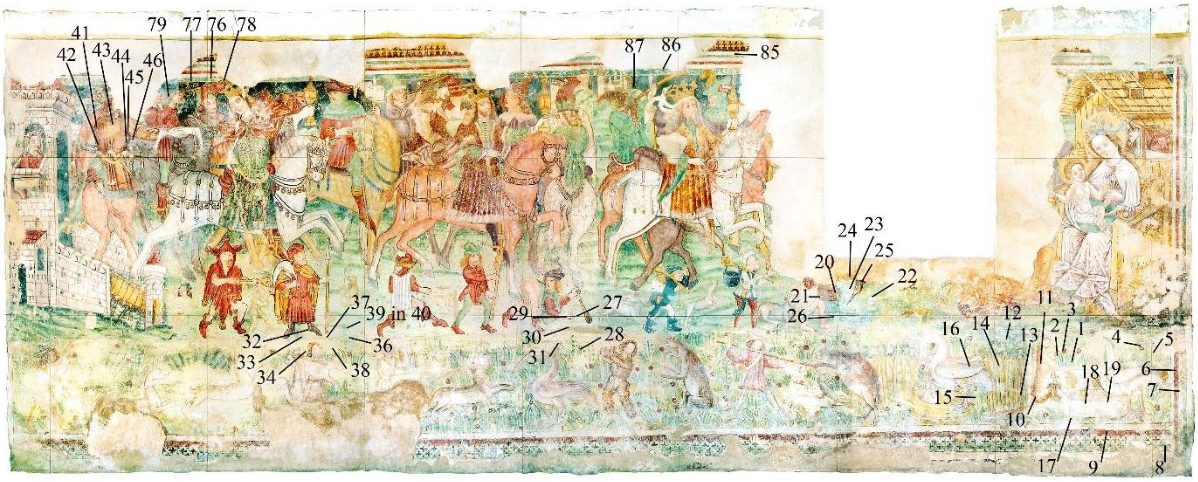

water cleaning after anionic resins

- probably anionic resin residues

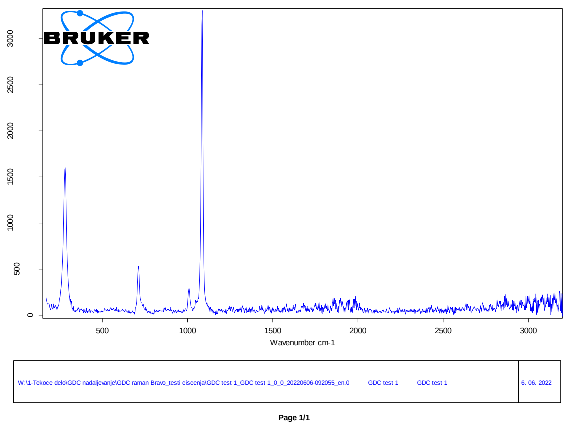

 

## 6.4 Raman evaluation of cleaning tests, June 2022

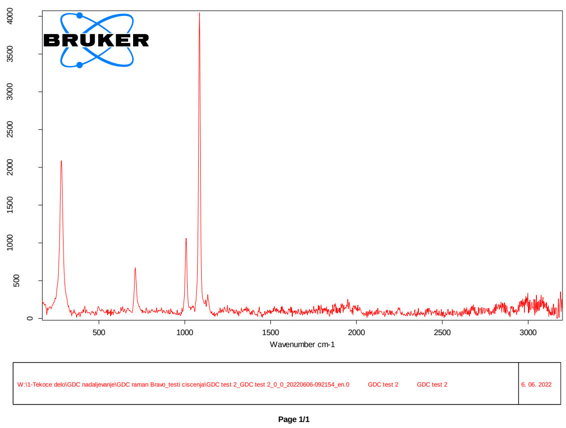
### *a) Northern wall*



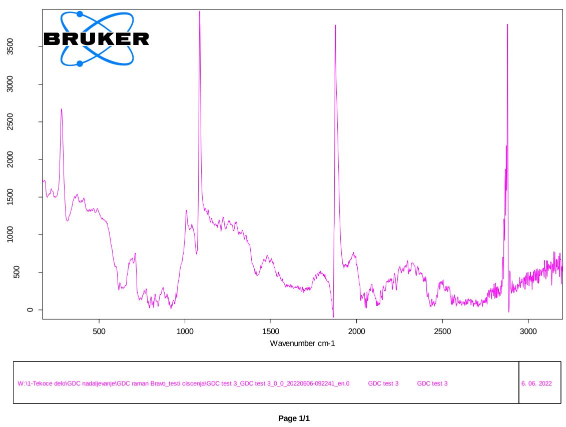

### *Reference spectra*




1- light green, between grases:
calcite, gypsum



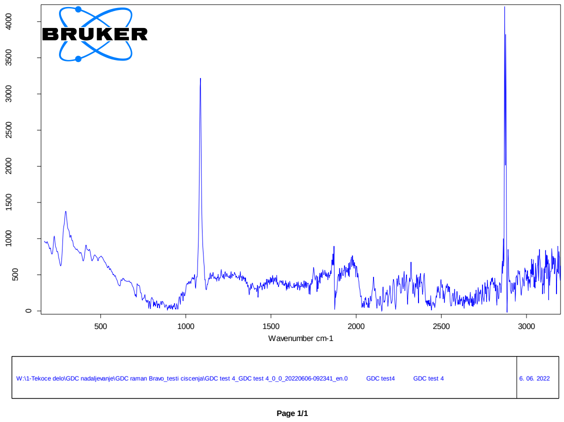

2- dark green, grass:
calcite, gypsum (1134 cm$^{-1}$ from gypsum)



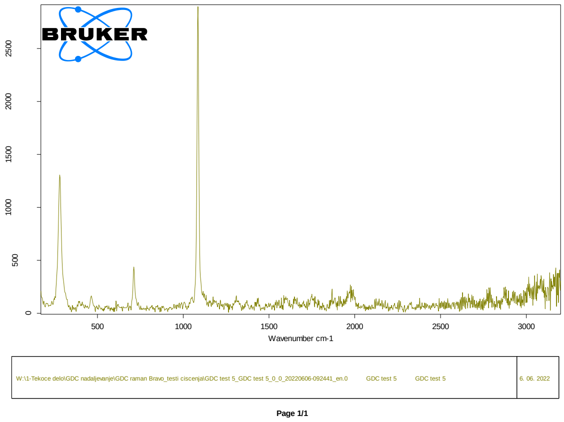

3- red, flower:
calcite, gypsum, haematite, unknown material (1875 cm$^{-1}$)

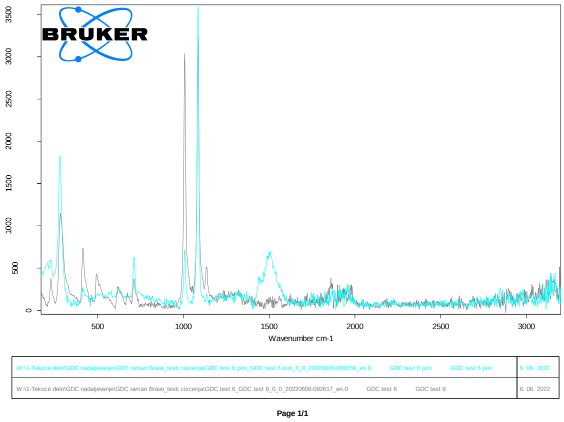
***Ammonium bicarbonate, 30'***



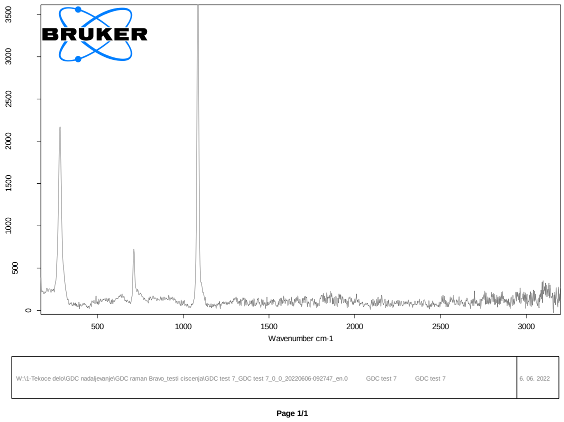

4- red, flower:
calcite, haematite, maybe nitrates



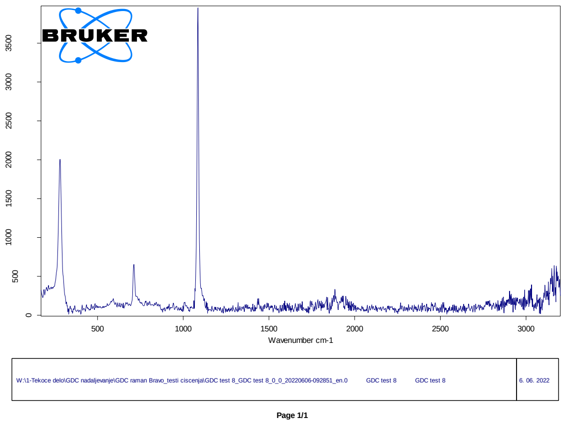

5- light green:
calcite, quartz



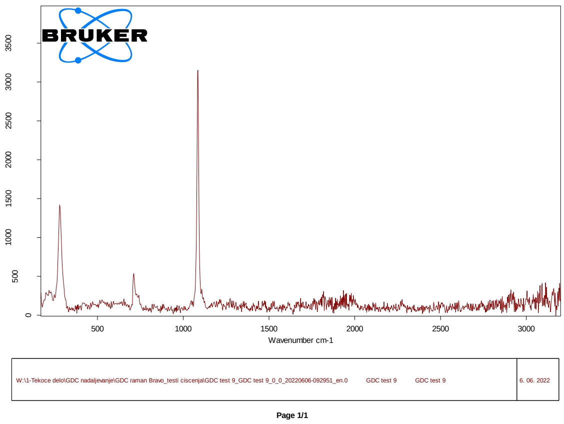

6- red, ornamental border:
calcite, gypsum, haematite
Smaller amount of gypsum in repeated analysis (blue spectrum).




7- white, ornamental border:
calcite



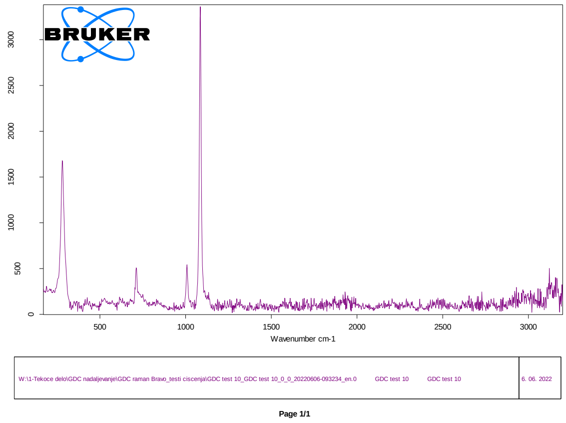

8- green, ornamental border:
calcite, gypsum (very little), unknown material ($592\ cm^{-1}$)



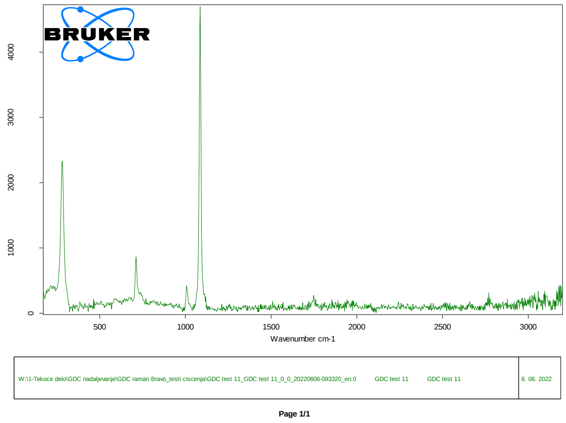

9- red, ornamental border:
calcite

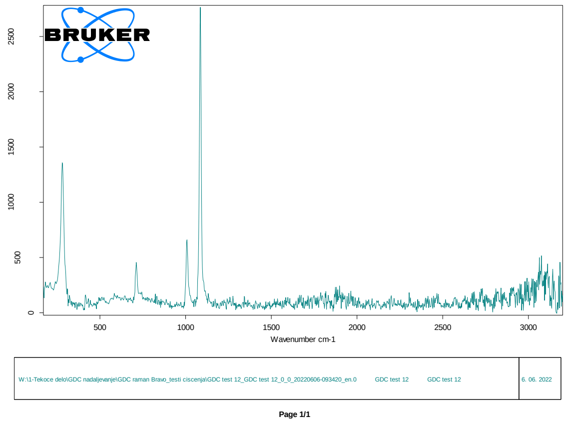
## *Reference spectra*




10- ochre, fox:
calcite, gypsum

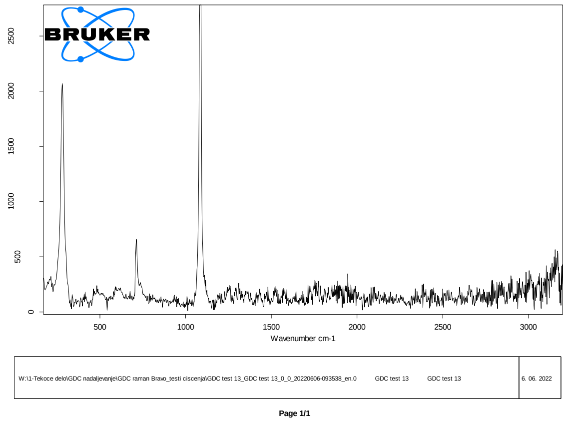



11- ochre, fox, in the middle:
calcite, gypsum

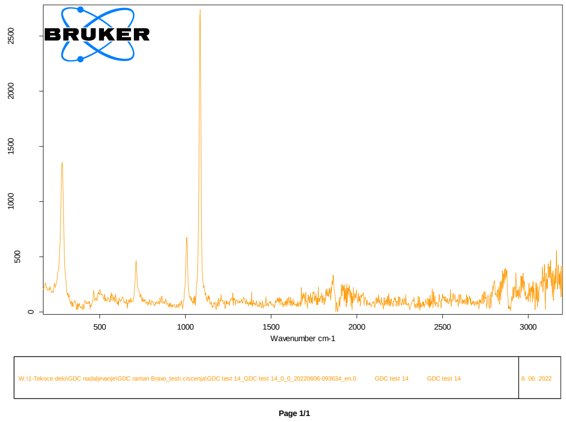



12- green, tree:
calcite, gypsum

## *Ammonium bicarbonate, 45'*

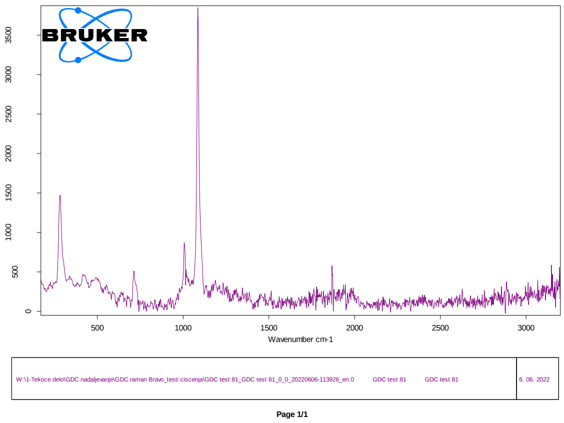



13- ochre, tree:
calcite, unknown material (735 $cm^{-1}$)

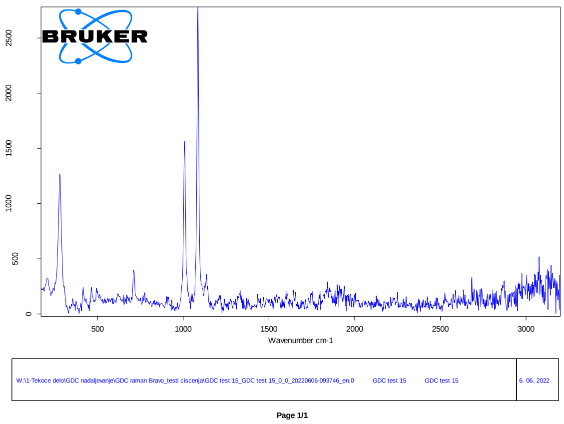



14- pale, between trees:
calcite, gypsum

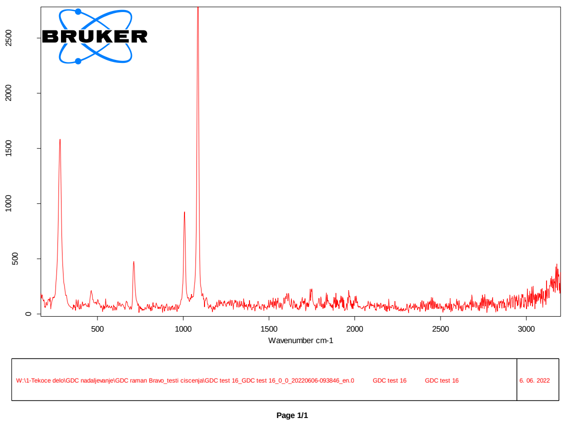
 



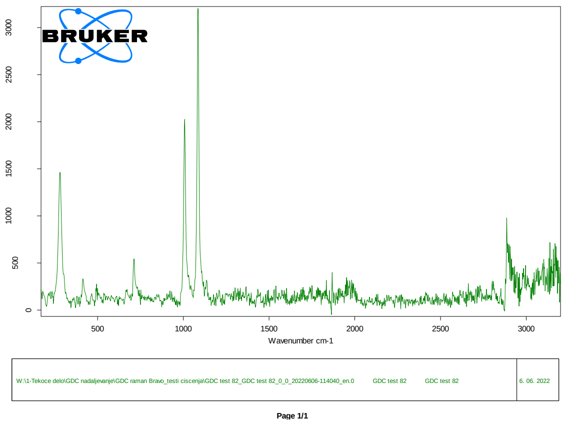

81- 14 after additional rinsing:
calcite, gypsum



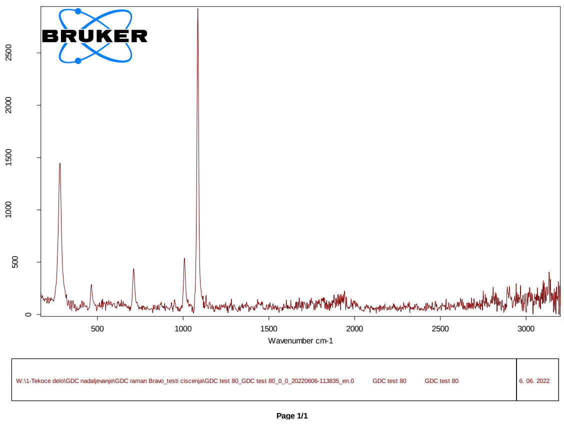

15- green, grass:
calcite, gypsum, quartz, maybe haematite




16- white, swan, wing:
calcite, gypsum, quartz, unknown material (501, 669 $cm^{-1}$)

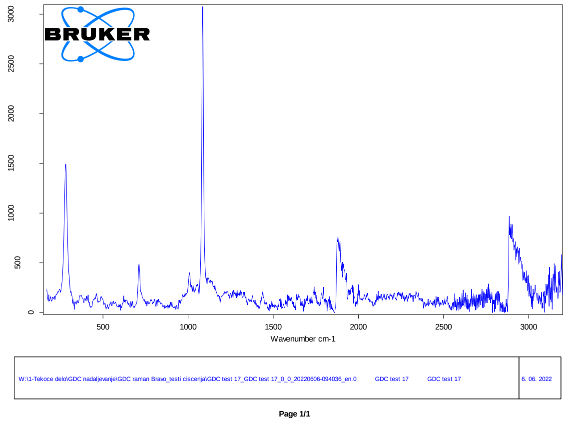



82- 15 after additional rinsing:
calcite, gypsum, quartz, unknown material (670 $cm^{-1}$)

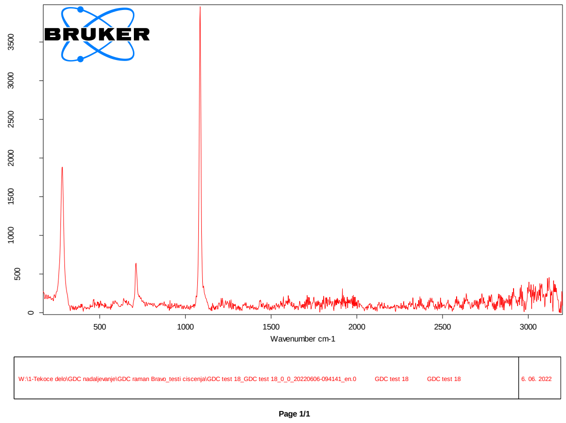



80- 16 after additional rinsing:
calcite, gypsum, quartz

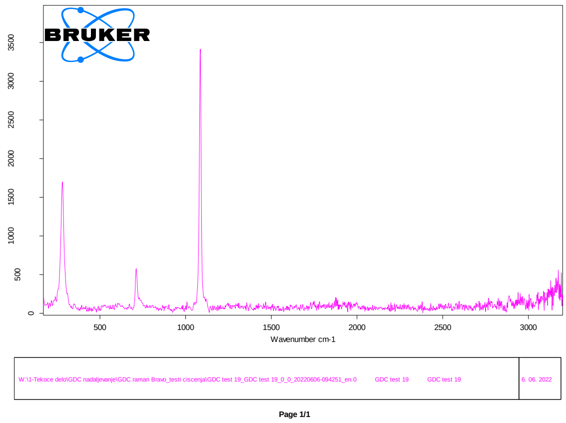
## *Ammonium bicarbonate, 30'*




17- white powder on surface:
calcite, gypsum

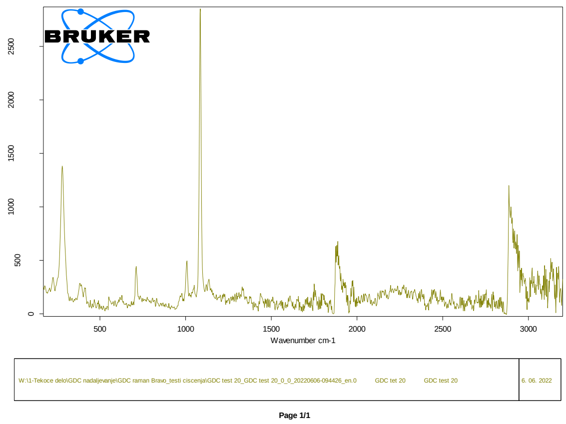



18- white powder on surface:
calcite

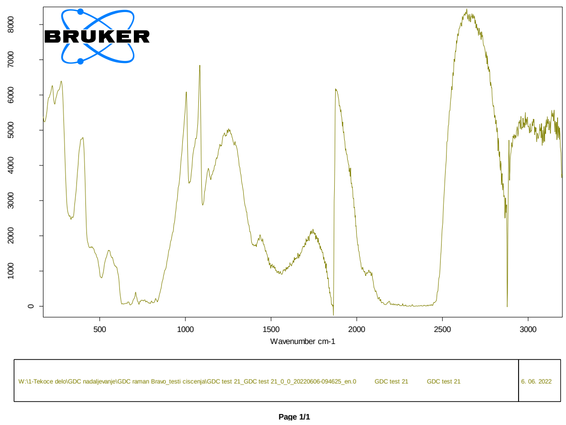



19- white powder on surface:
calcite

## *Reference spectra*

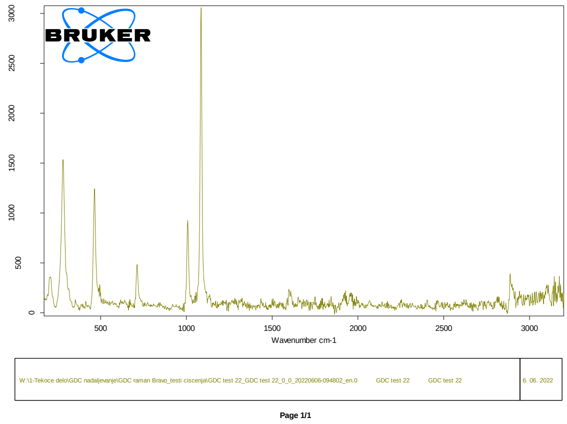



20- lobster in the basket:
calcite, gypsum, haematite, maybe goethite, nitrates



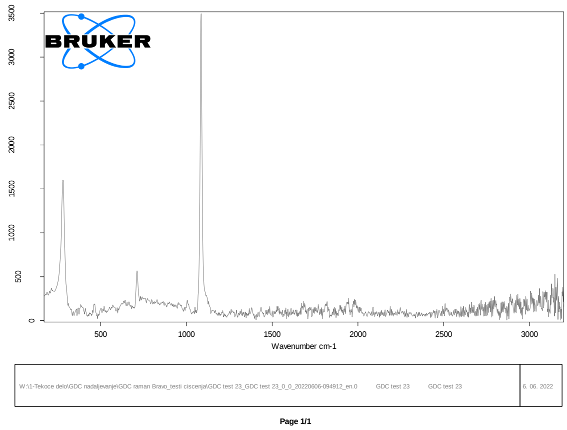

21- basket:
calcite, maybe haematite and goethite
bad spectrum

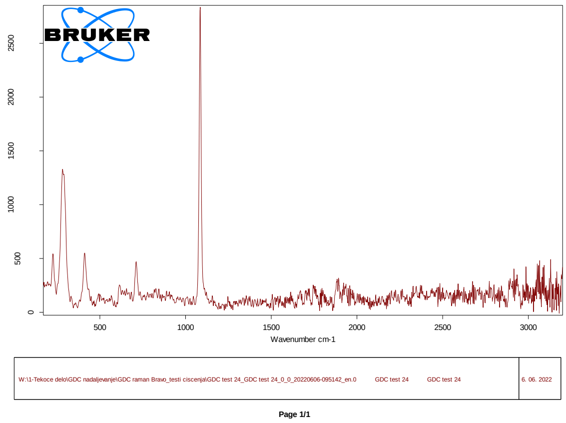



22- green background, under window:
calcite, gypsum, quartz (204, 462 $cm^{-1}$)

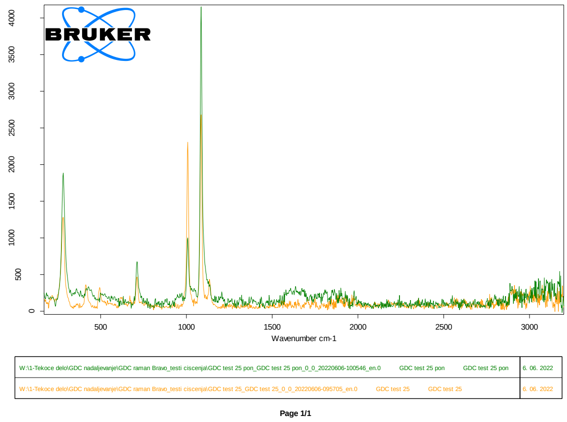
## *Anionic resins*



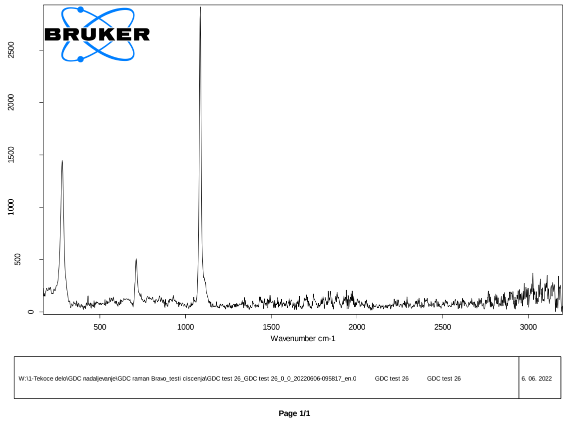

23- green between duck and basket:
calcite, gypsum




24- lobster in the basket:
calcite, haematite



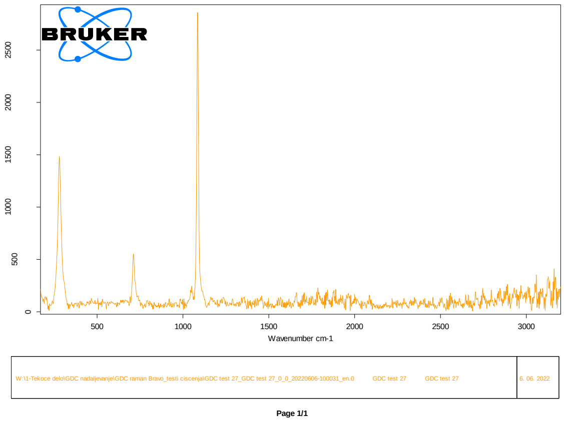

25- white, duck:
calcite, gypsum (relatively large amount, less after additional cleaning with water)



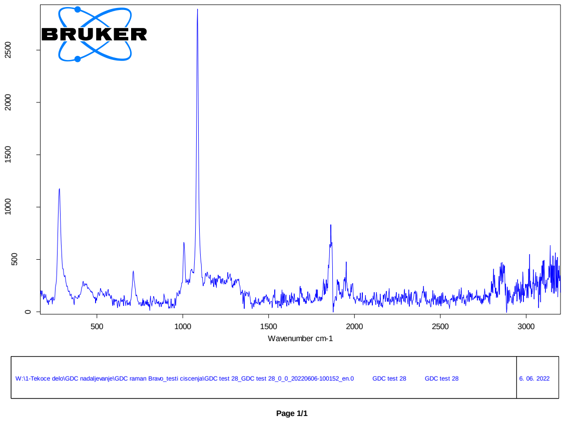

26- green background, possibly an animal:
calcite, gypsum (very small amount)

## *Reference spectra*

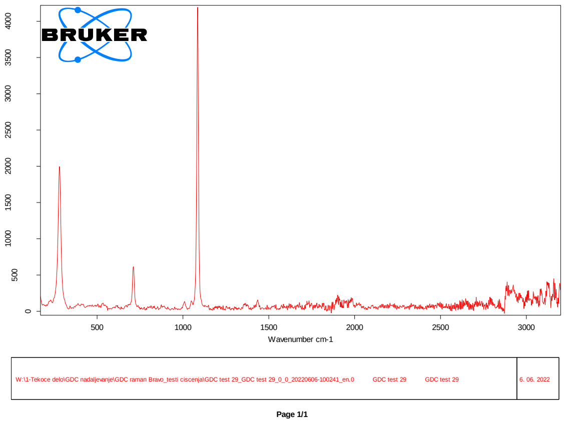



27- light green background, beside ladle:
calcite

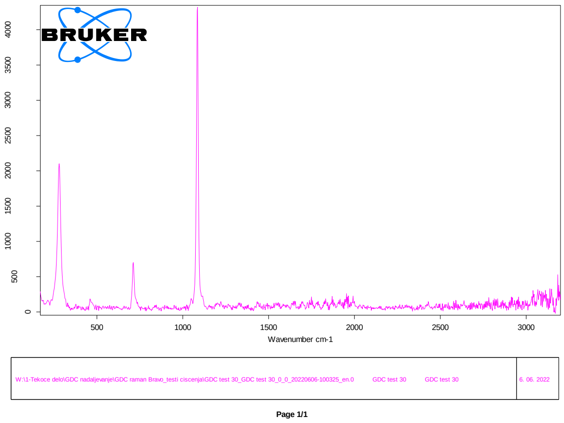



28- green leaf:
calcite, gypsum

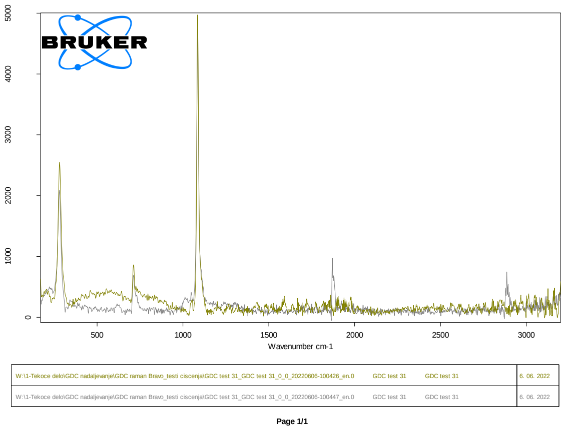
## *Anionic resins*




29- carnation, hand:
calcite (band 1435 cm$^{-1}$, as well; Spoto, 2022), gypsum (small amount), nitrates



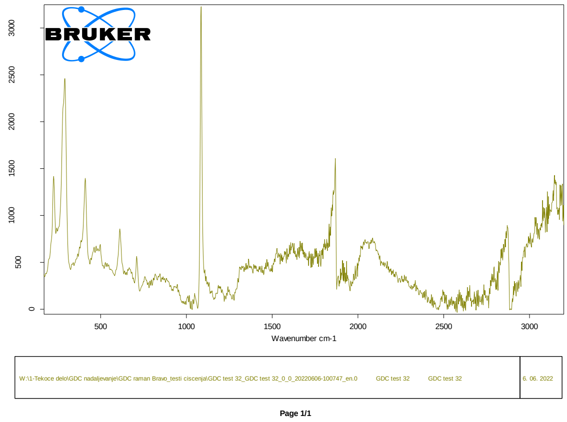

30- green background, under hand:
calcite, quartz, nitrates



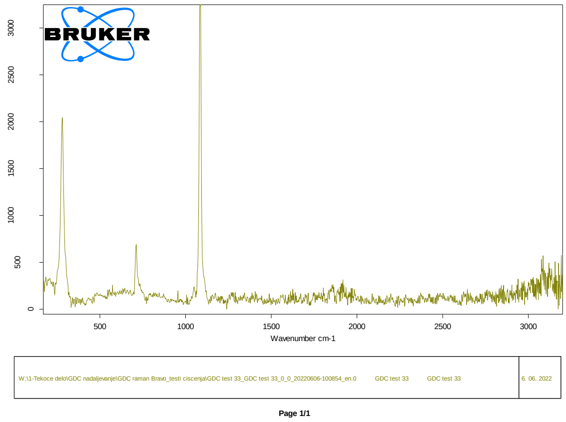

31- red, flower:
calcite, unidentified material (1048 cm$^{-1}$)

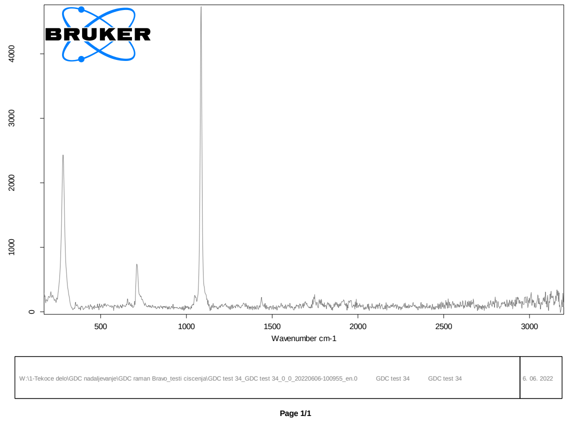
*Reference spectra*




32- purple, shoe:
calcite, haematite

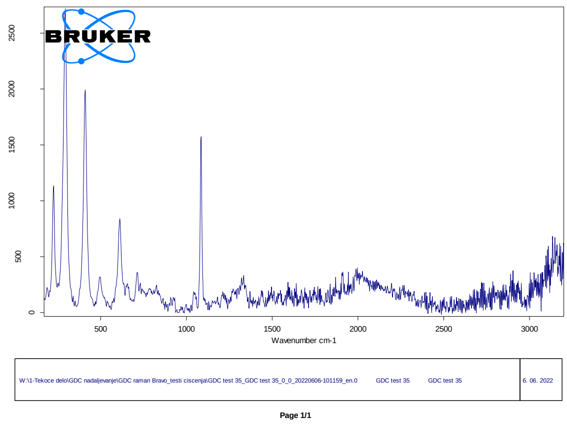



33- bright background, between shoes:
calcite, nitrates

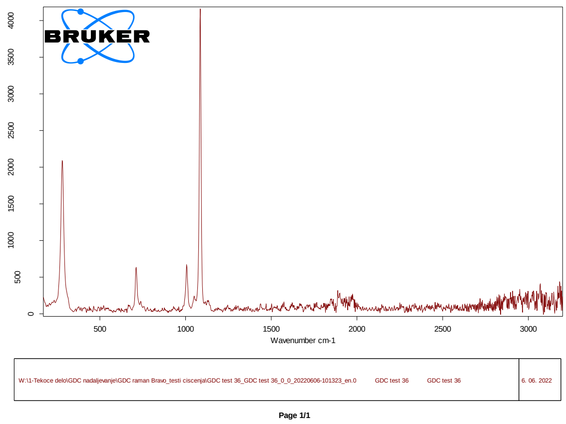



34- bright background, left from hair:
calcite, nitrates

***Anionic resins***

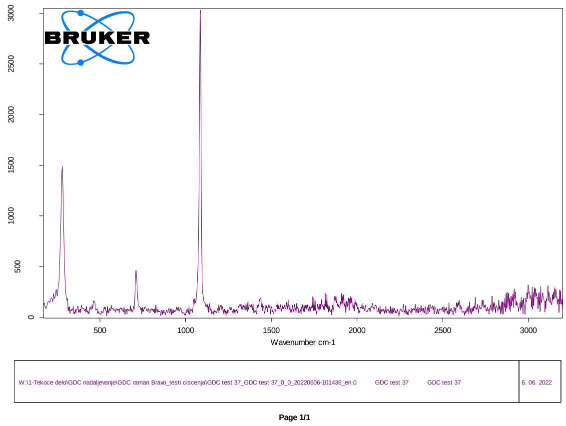



35- pink, shoe, right part:
calcite, haematite (495 cm$^{-1}$, too; Hanesch, 2009), maybe spirilloxanthine (998 cm$^{-1}$; Hernanz et al., 2008)

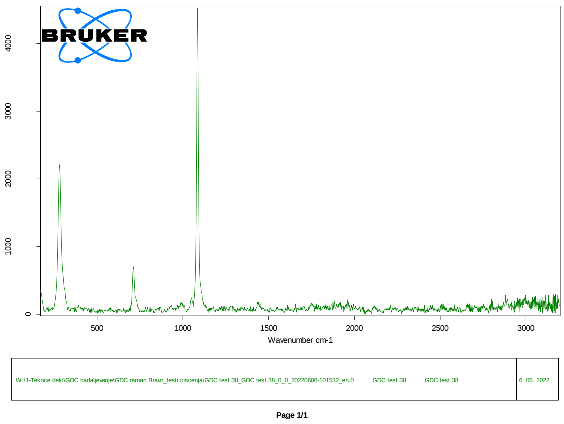



36- green background:
calcite, gypsum, nitrates

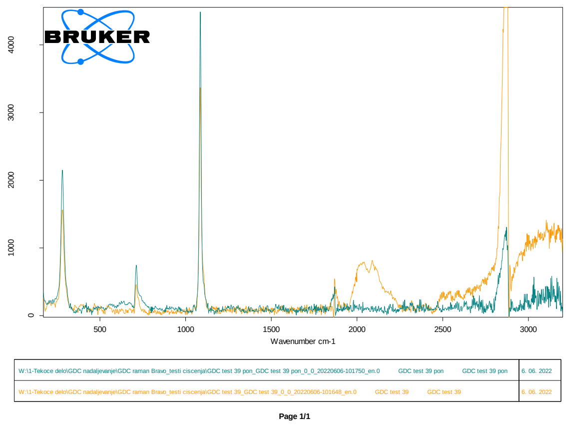
 



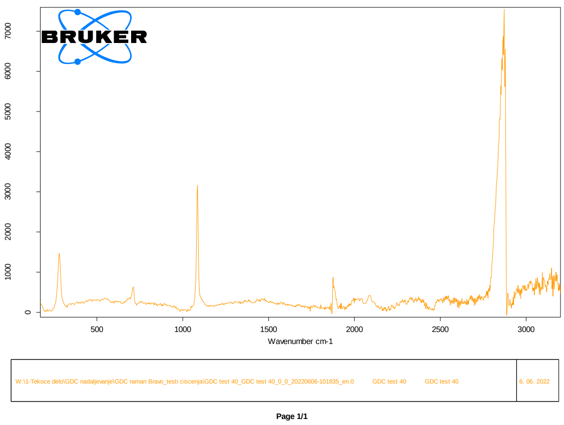

37- green background, under stick:
calcite, quartz




38- green background:
calcite, nitrates

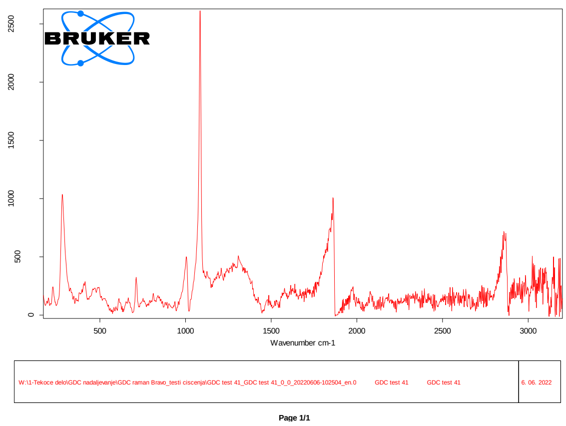



39- green background:
calcite, nitrates

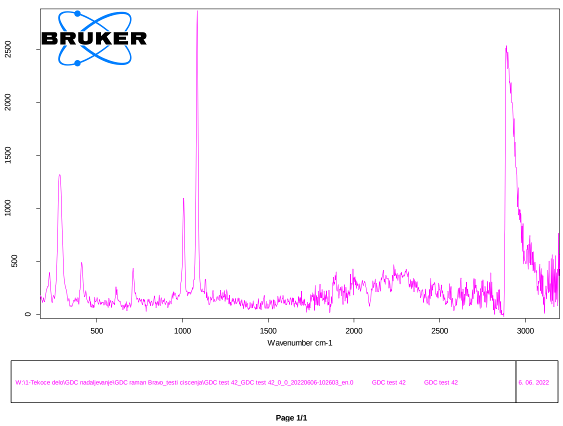



40- plaster near green background:
calcite

## *Reference spectra*

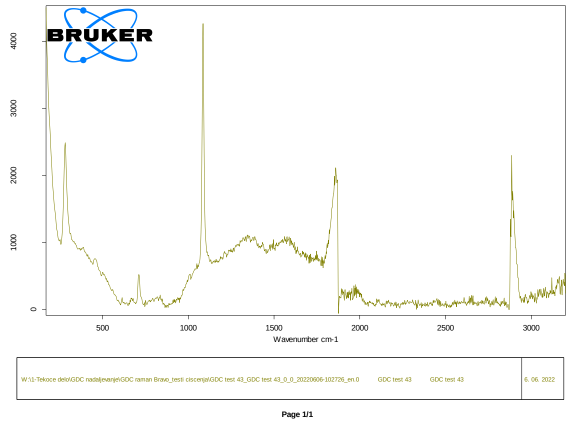



41- back, figure in orange dress:
calcite, haematite, maybe gypsum



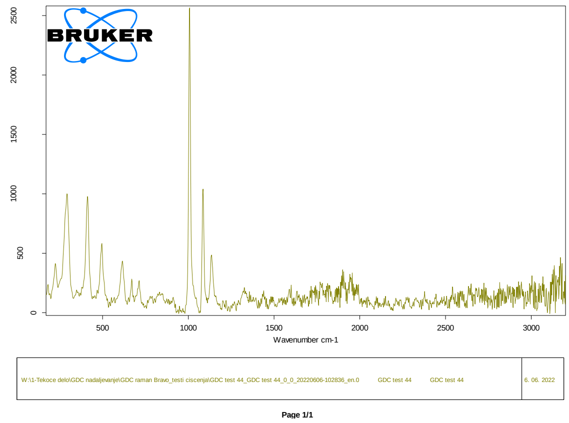

42- same as 41, lower on the back:
calcite, haematite, gypsum

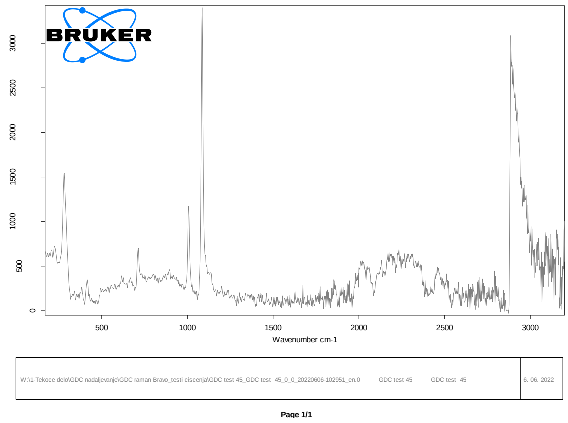



43- ochre, same as 41, below hair:
calcite, gypsum (little amount), unknown material (455 $cm^{-1}$)

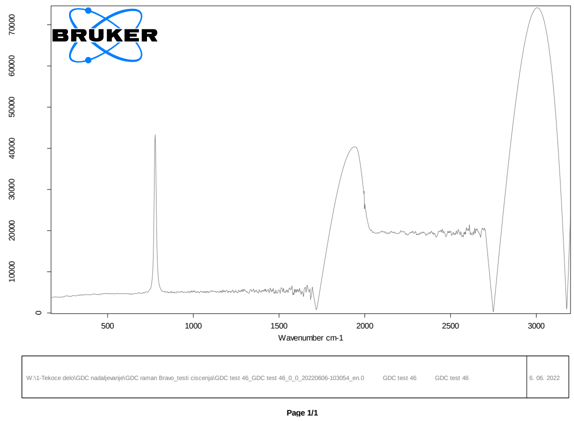
## *Anionic resins*



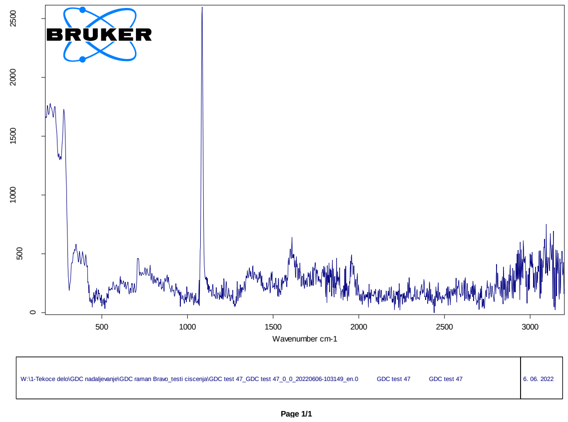

44- back, figure in orange dress, right part:
gypsum (large amount), calcite, haematite




45- same figure as 44, armpit:
calcite, gypsum, haematite



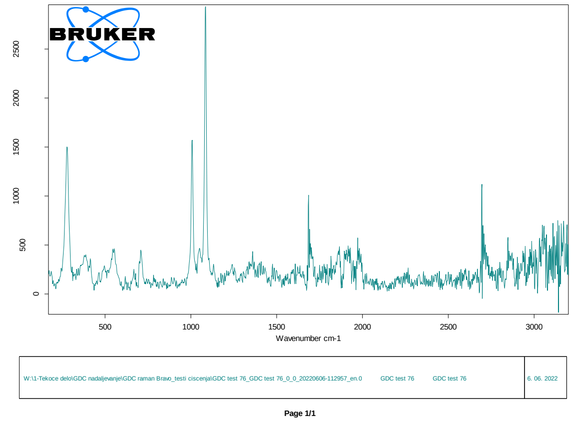

46- red, close to 45:
unknown material 778 $cm^{-1}$



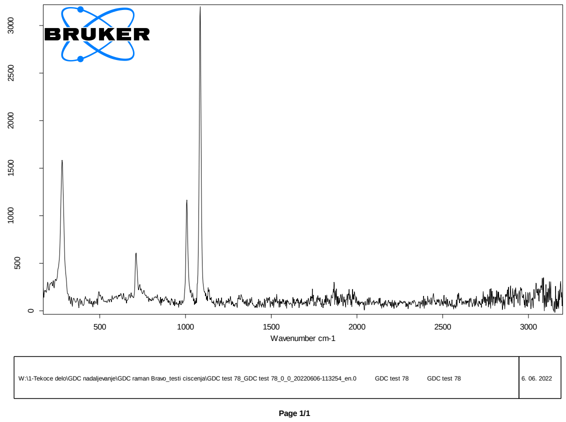

47- purple, horse:
calcite

*Reference spectra*

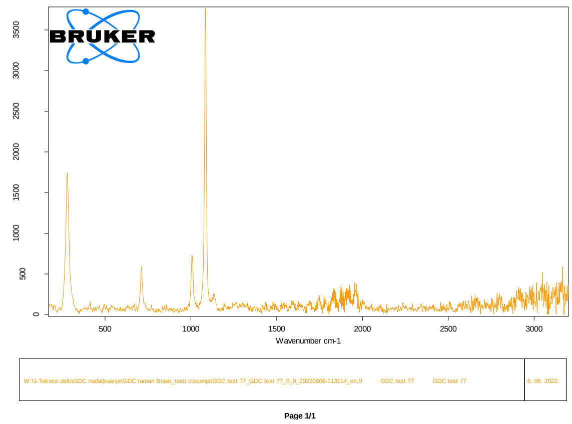



76- green, decorative border:
calcite, gypsum, green earth, maybe goethite (380 cm-1), nitrates

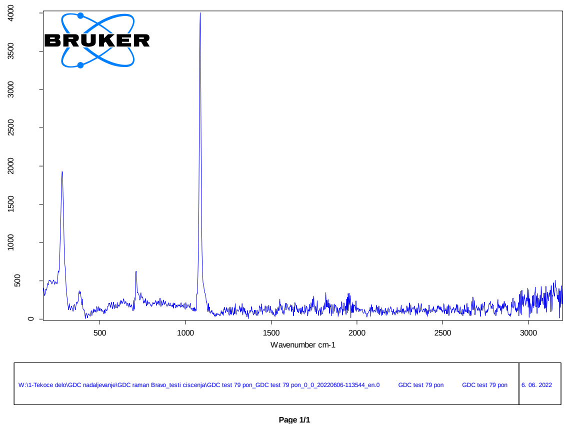



78- ochre, trumpet:
calcite, gypsum

***Ammonium bicarbonate, 30'***

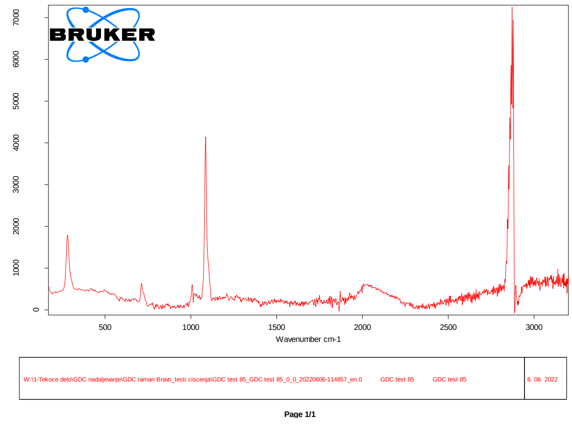



77- green, decorative border:
calcite, gypsum

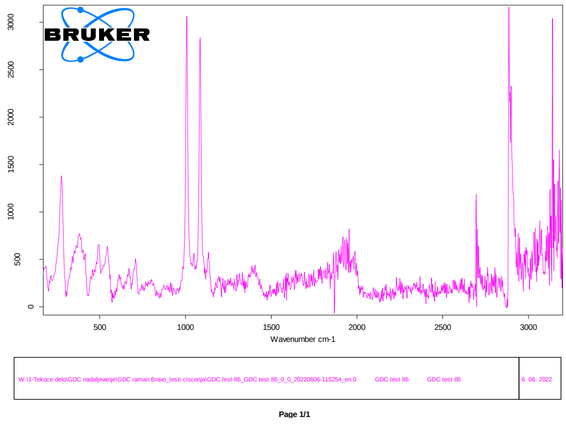



79- ochre, trumpet, left of hand:
calcite, maybe goethite (380 cm-1)

***Reference spectra***

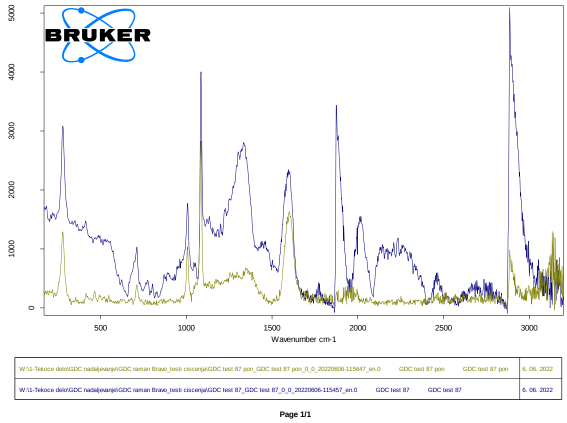



85- white, decorative border:
calcite, gypsum



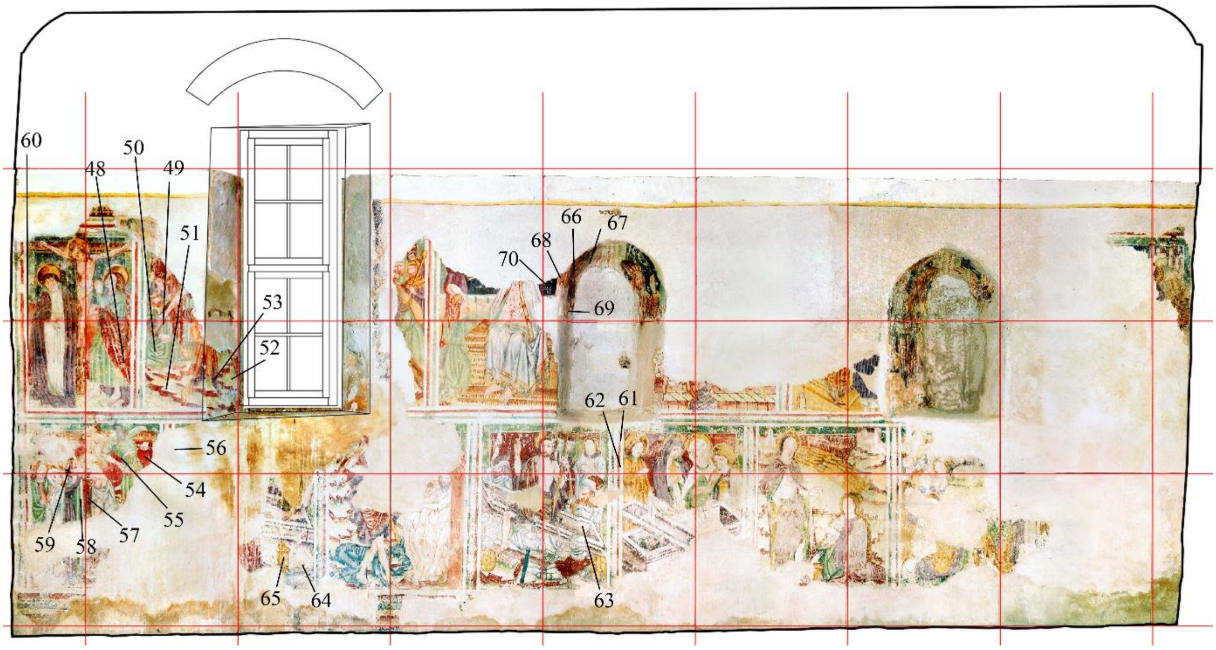

86- green, decorative border:
calcite, gypsum (large amount), maybe ultramarine (544 cm-1), nitrates

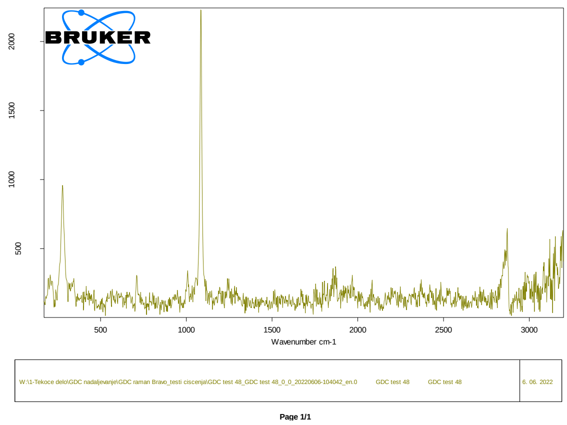



87- green, background beside castle:
calcite, gypsum, carbon black

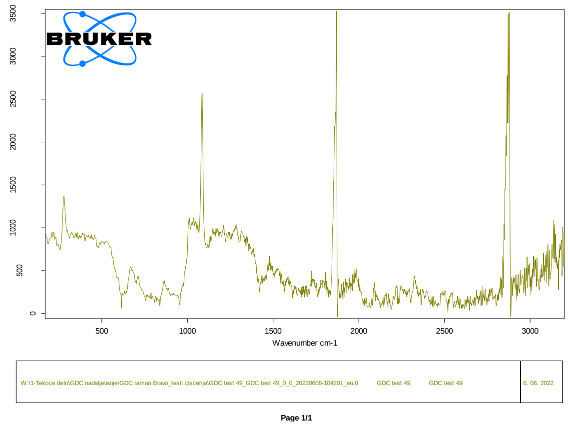
## *b) Southern wall*




## *Reference spectra*

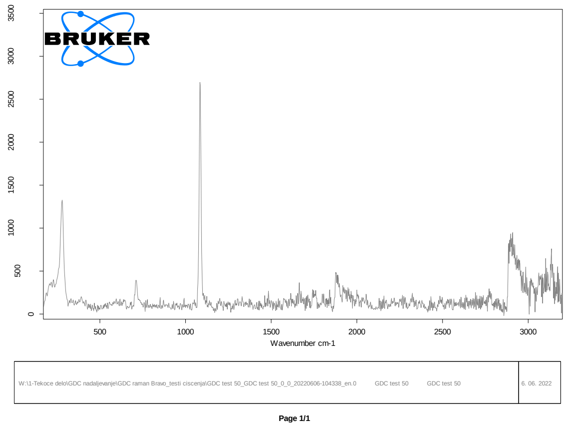



48- green, decorative border:
calcite, gypsum

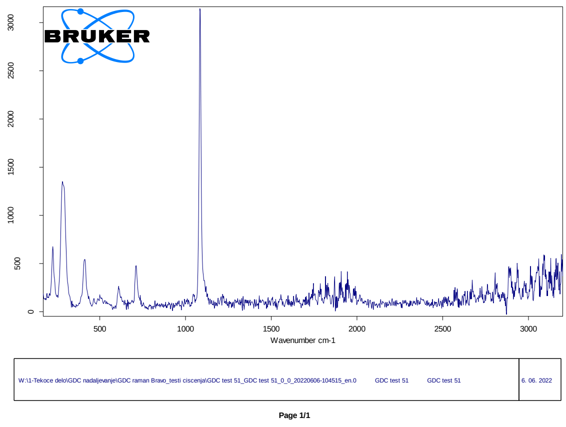



49- green, dress, above the hand:
calcite, gypsum

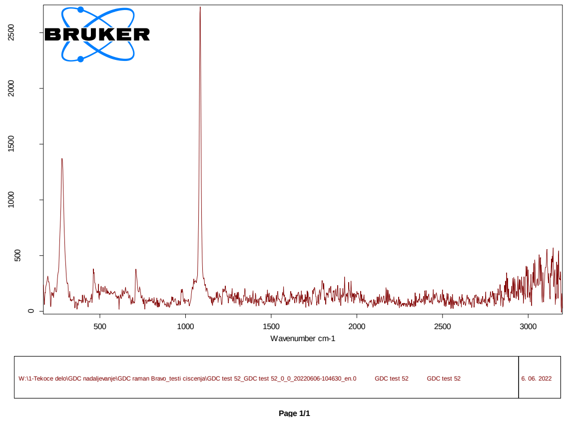
## *Ammonium bicarbonate, 30'*



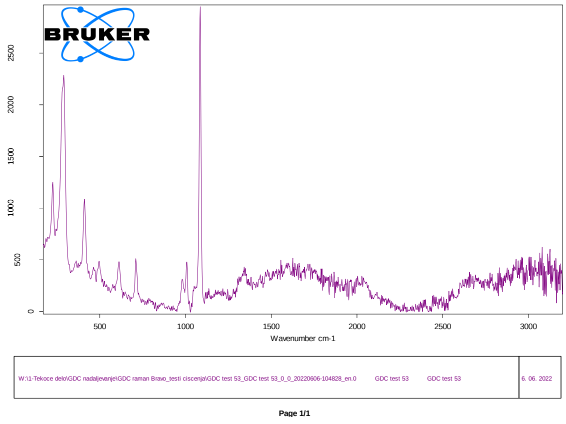

50- green, dress, folds:
calcite




51- red, stairs:
calcite, haematite, nitrates

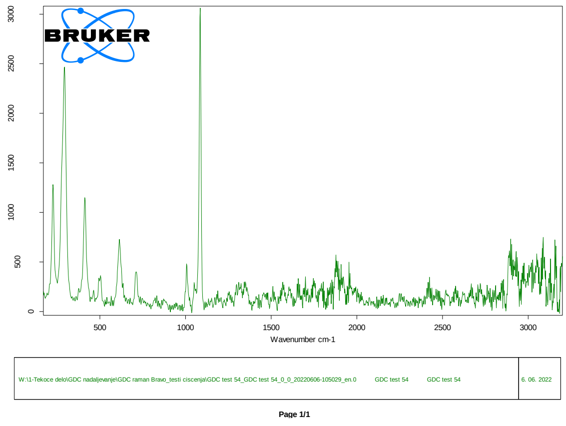



52- bright background:
calcite, quartz, maybe sulphates (978 cm$^{-1}$; Hurley and McCreery, 2003), unknown material (732 cm$^{-1}$)

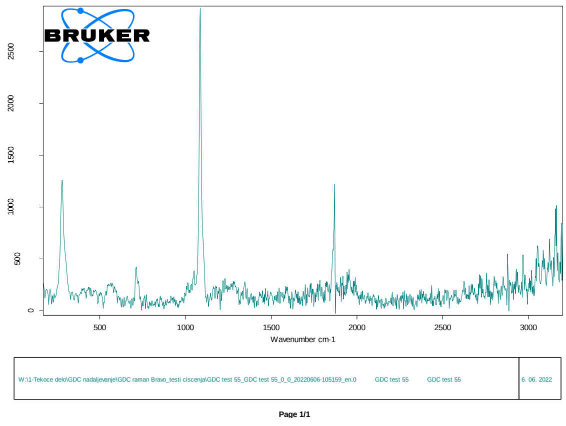



53- purple, foot:
calcite, gypsum, haematite (496 cm$^{-1}$ as well, Pigments Checker), sulphates (981 cm$^{-1}$, Kauffmann et al., 2013)

## *Reference spectra*

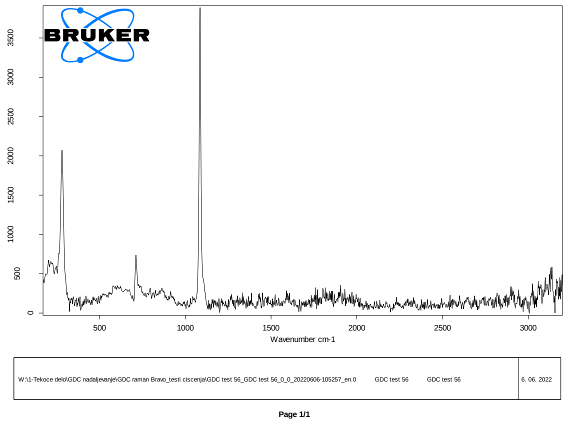



54- red, background:
calcite, gypsum, haematite, nitrates



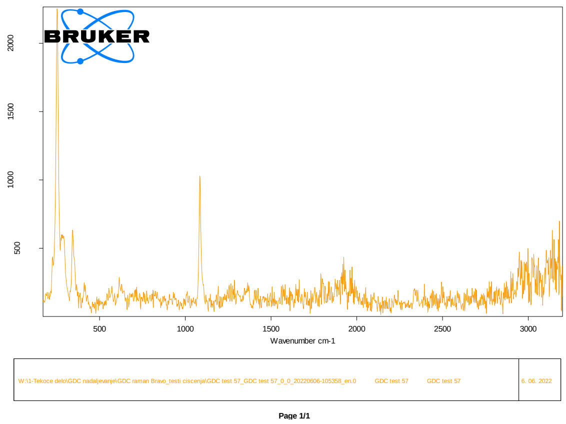

55- green, dress, right of hammer:
calcite, maybe green earth, unidentified material (1346 cm$^{-1}$)

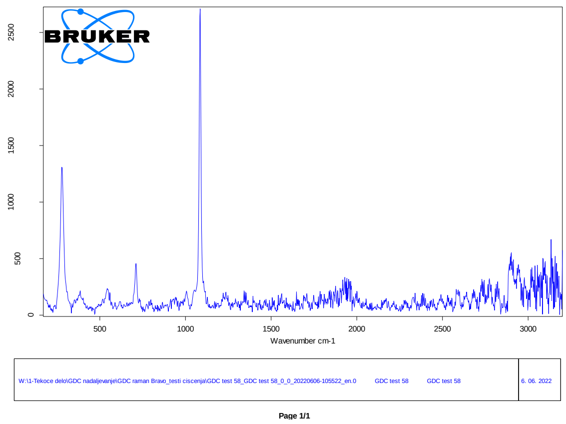



56- filling:
calcite

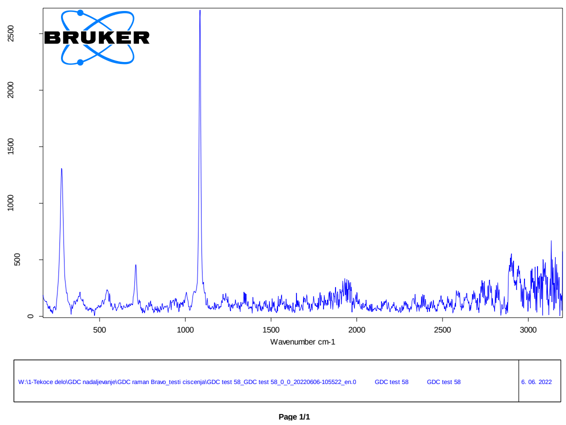
## *Ammonium bicarbonate, 30'*



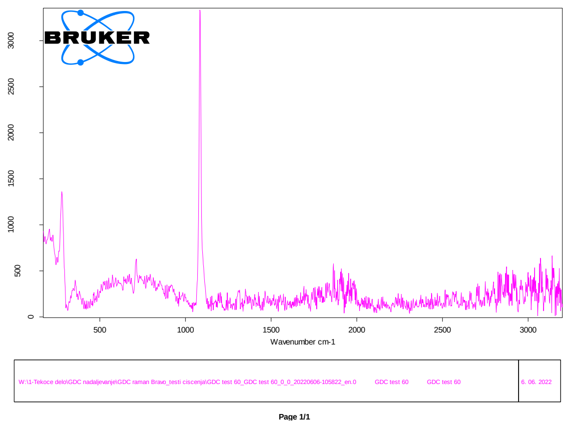

57- red, background, beside cross:
calcite, vermilion, gypsum (little)




58- green, dress:
calcite, green earth



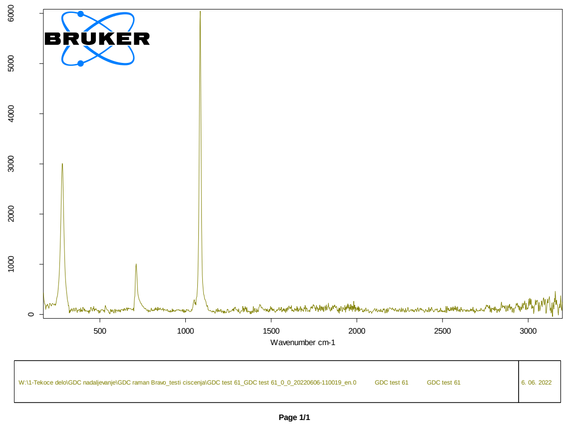

59- purple, dress, sleeve:
calcite, haematite, nitrates




60- red, background:
calcite

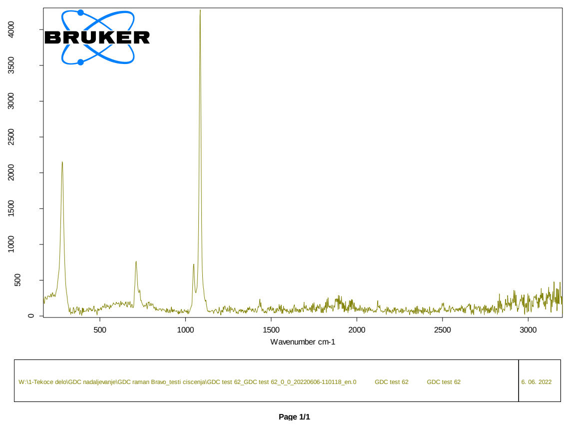
 

*Reference spectra*



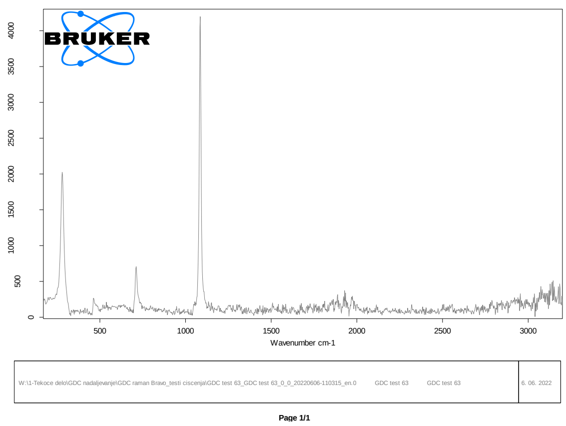

61- white, decorative border:
calcite, nitrates

***Barium hydroxide***




62- white, decorative border, below 61:
calcite, nitrates, unknown material (732 $cm^{-1}$)

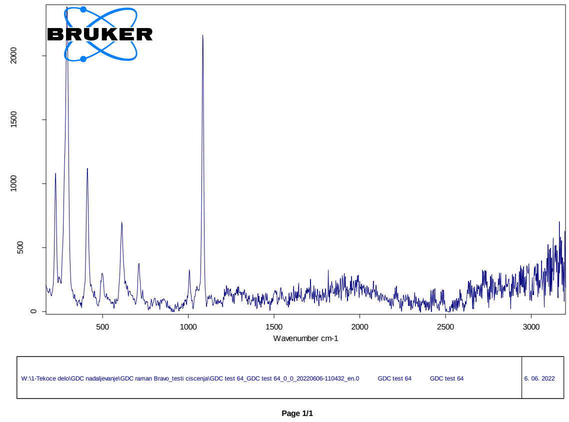
***Anionic resins***



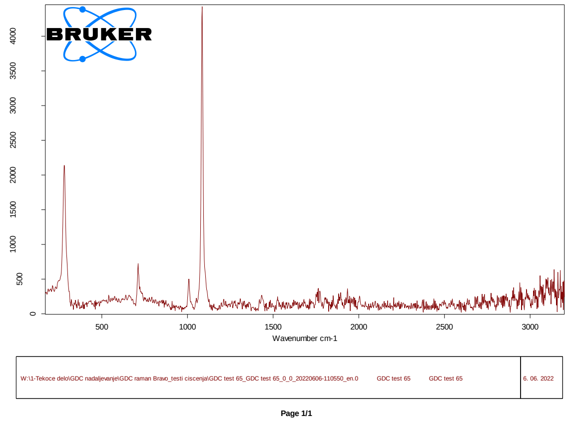

63- purple, coffin:
calcite, quartz

*Reference spectra, no cleaning*

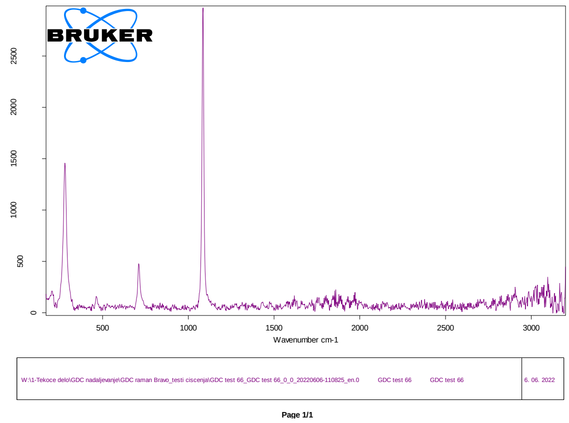



64- purple, coffin:
calcite, gypsum, haematite

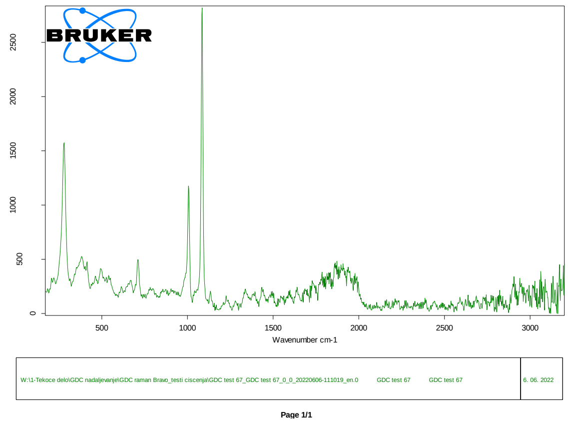



65- ochre, pot with spices, Calxnova:
calcite, gypsum, unidentified material ($1432\ cm^{-1}$)

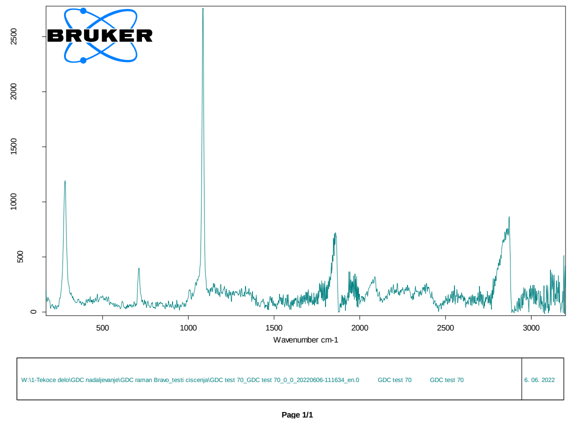
***Reference spectra***




66- orange, dress:
calcite, quartz, probably haematite



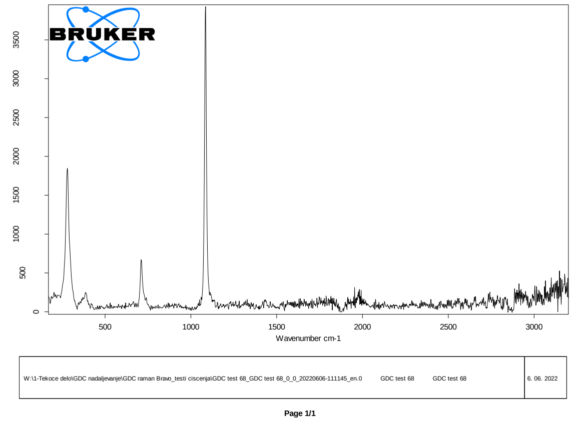

67- green, hat:
calcite, gypsum



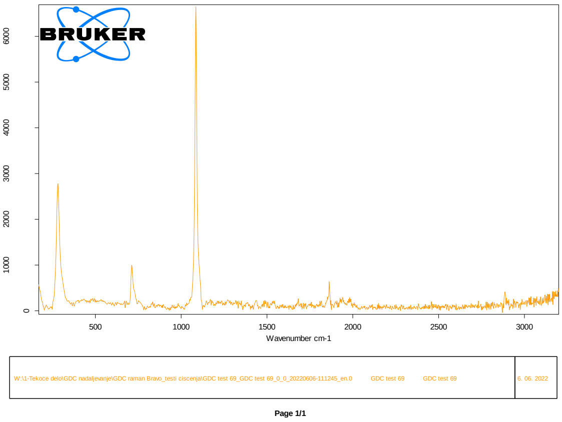

70- white, dress:
calcite, gypsum (small amount), unknown material $615\ cm^{-1}$ (maybe Mg-jacobsite; Buzgar et al., 2010)

### *Ammonium bicarbonate*



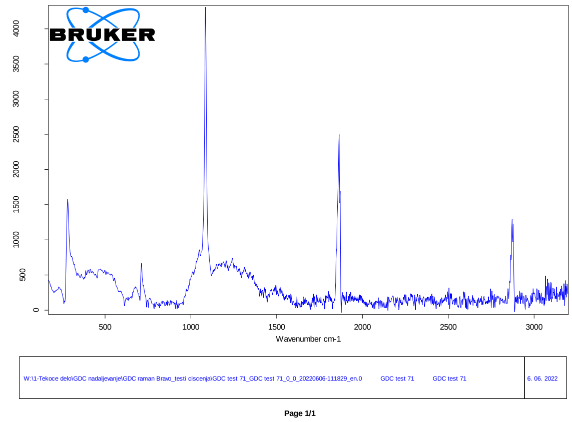

68- orange, belt:
calcite, maybe goethite, unknown material (740 cm$^{-1}$)



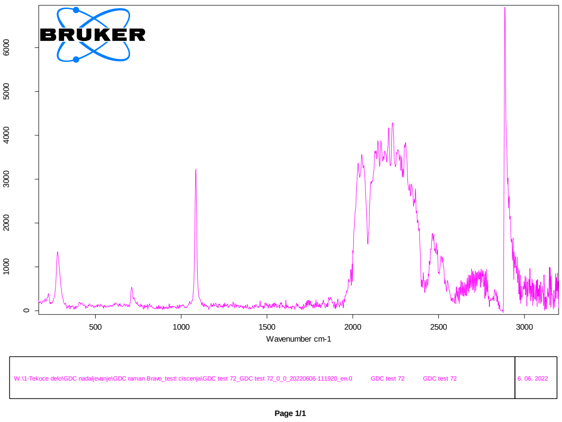

69- carnation, foot:
calcite

### c) *Western wall*


### *Reference spectra*



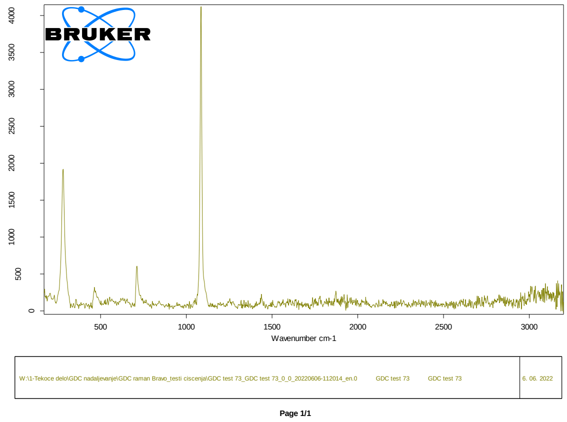

71- yellow, dress:
calcite, nitrates, unknown material (1241 cm$^{-1}$)




72- yellow, skirt:
calcite, nitrates, unknown material (726 cm$^{-1}$)

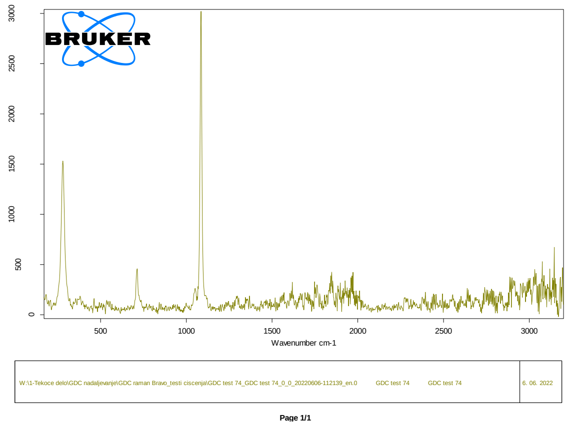
 

### *Anionic resins*

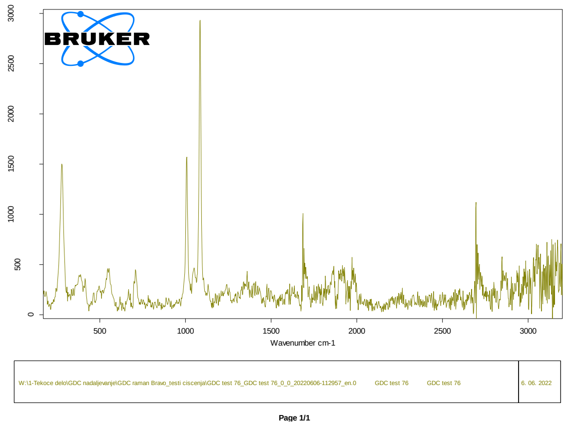



73- yellow, dress, chest:
calcite, quartz

### *Reference spectra*

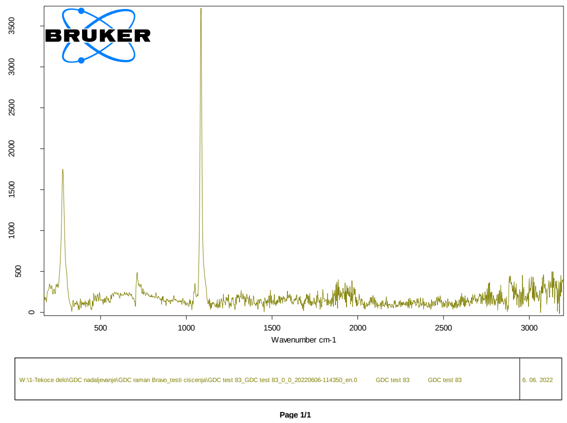



74- green, dress, below donkey:
calcite, nitrates

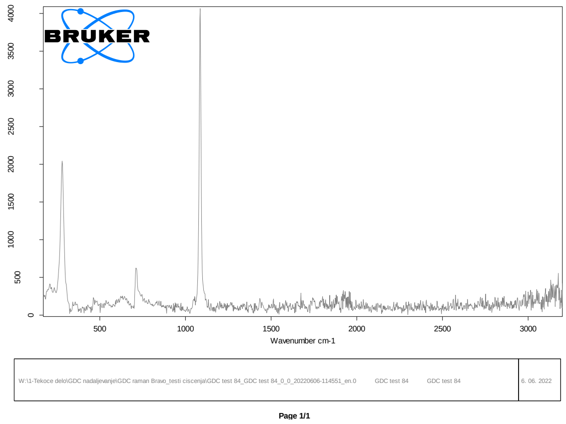



75- red:
calcite, gypsum, nitrates, maybe red lead (550 $cm^{-1}$)

### *Ammonium bicarbonate*



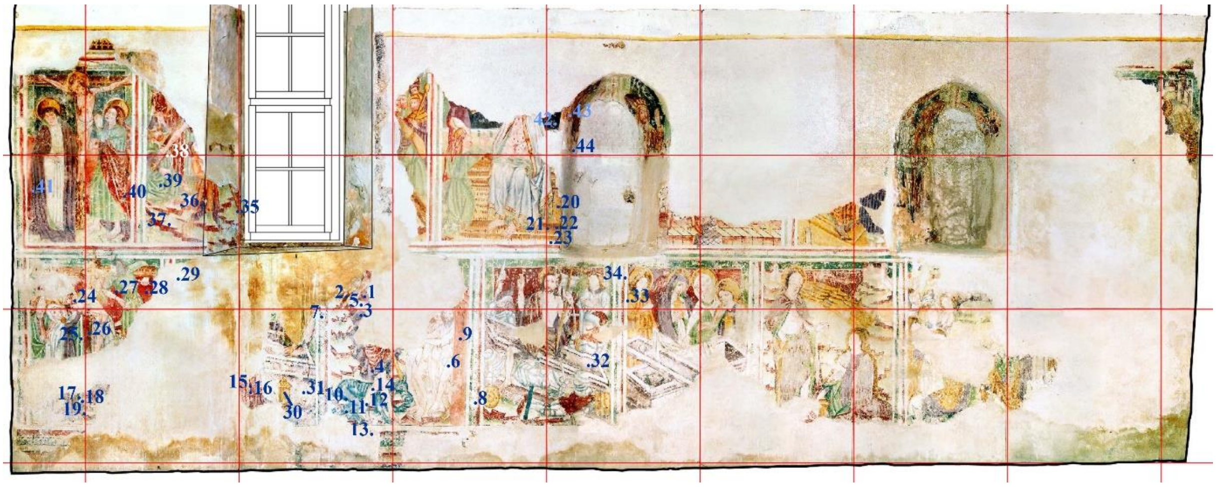

83- ochre, background:
calcite, nitrates




84- white, ornamental border:
calcite, nitrates

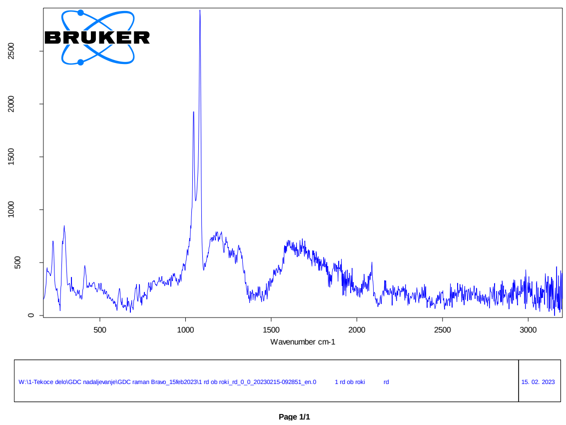
## 6.5 Raman evaluation of cleaning and consolidation tests, February 2023

### *a) Southern wall*

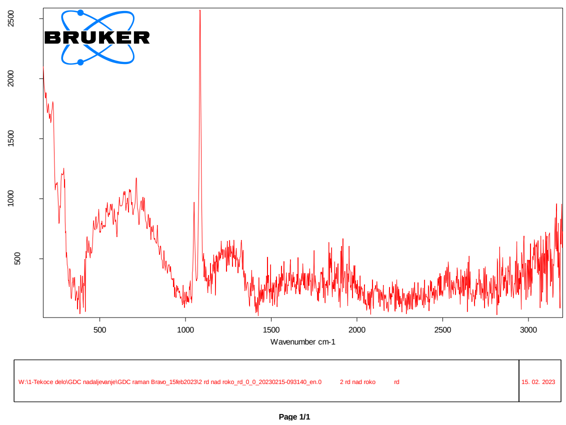


### *Barium hydroxide*

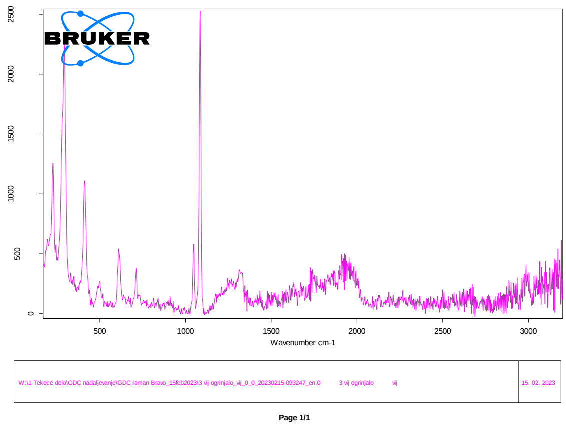
*Scene under the window*



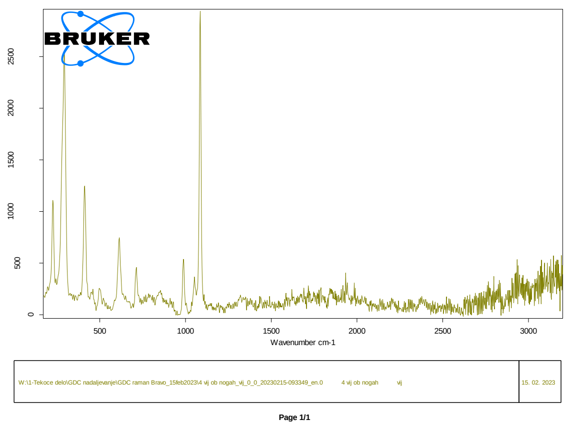

1- red background, right of Christ's hand, BaOH: calcite, haematite, nitrates, unidentified material (730 cm$^{-1}$), maybe dolomite




2- red background, left of Christ's hand, BaOH: calcite, haematite, nitrates

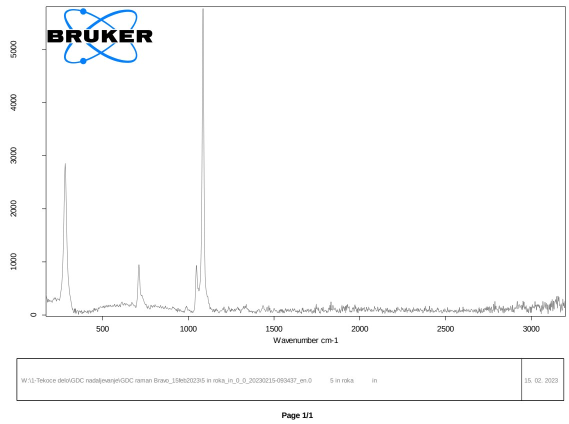



3- violet coat, BaOH: calcite, haematite (caput mortuum), nitrates

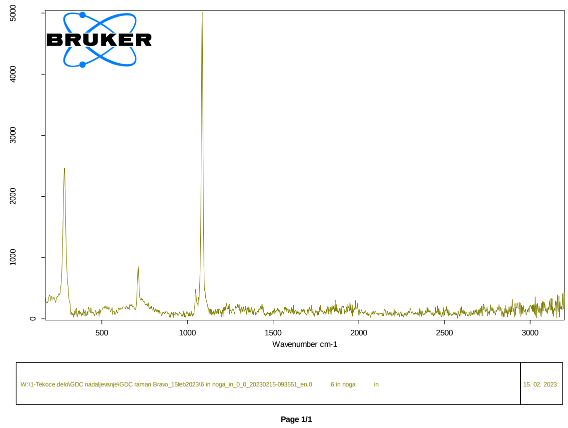



4- violet coat, close to feet, BaOH: calcite, haematite (caput mortuum), nitrates, barium sulphate (988 cm$^{-1}$)

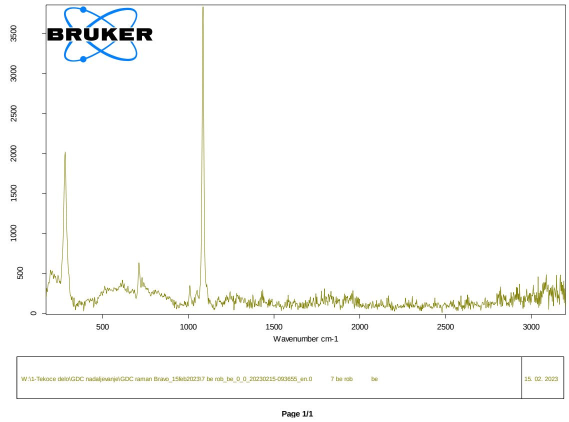
 



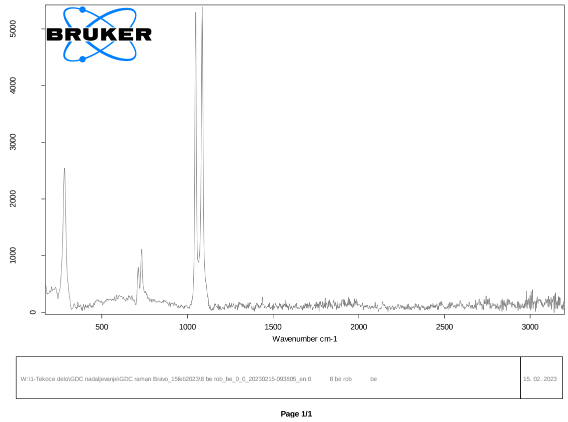

5- carnation, arm of the Christ, BaOH:
calcite, barium sulphate, nitrates



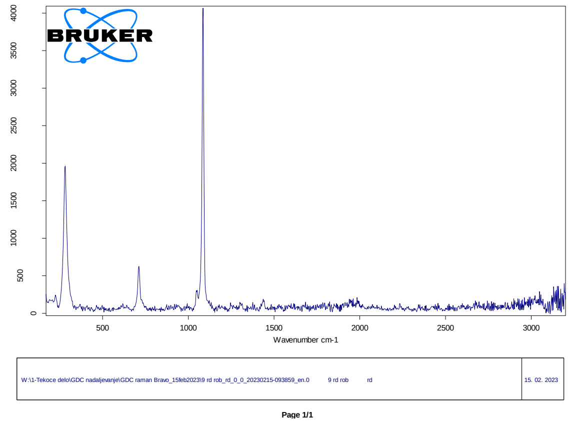

6- carnation, leg to the right, BaOH:
calcite, nitrates



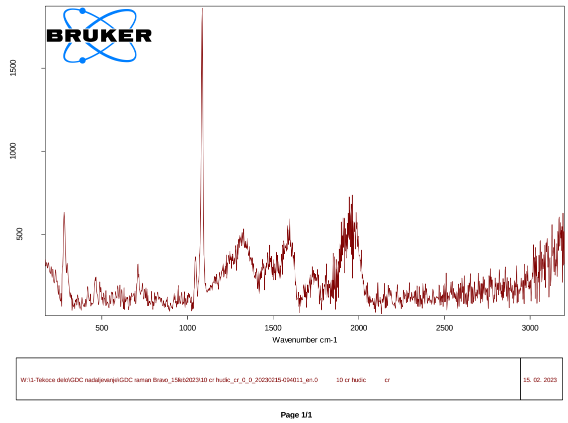

7- white, border line, left from Christ, BaOH:
calcite, gypsum, nitrates, unidentified material ($730\ cm^{-1}$), maybe dolomite




8- white, border line, right from Christ, BaOH:
calcite, nitrates, unidentified material ($730\ cm^{-1}$), maybe dolomite

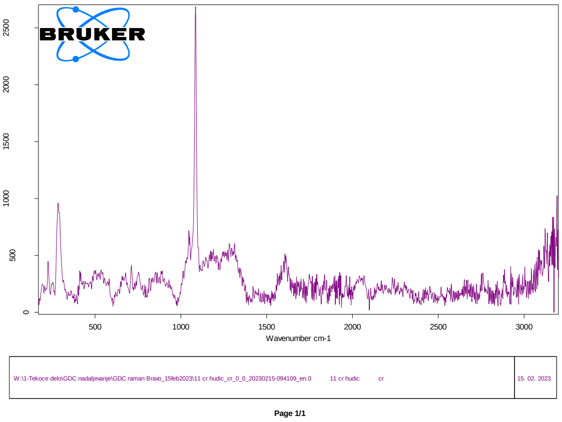



9- light red background, BaOH:
calcite ($1435\ cm^{-1}$ too), nitrates

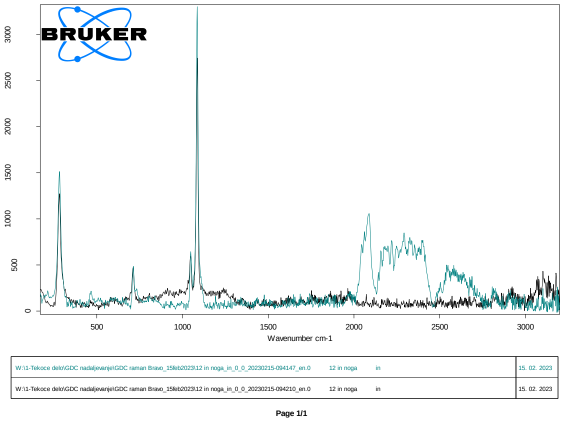



10- black, devil, BaOH, white haze:
calcite, carbon black, quartz, haematite, nitrates, unidentified material ($730\ cm^{-1}$), maybe dolomite

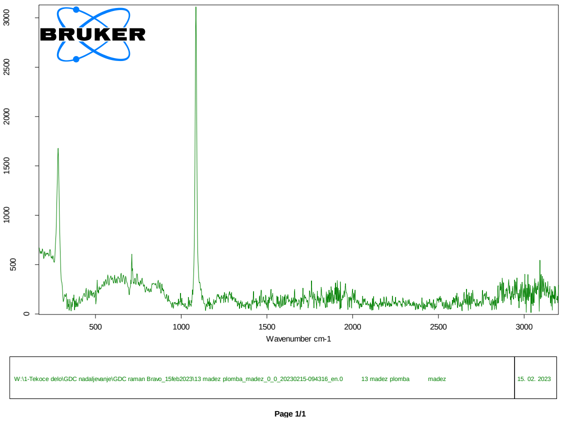
 



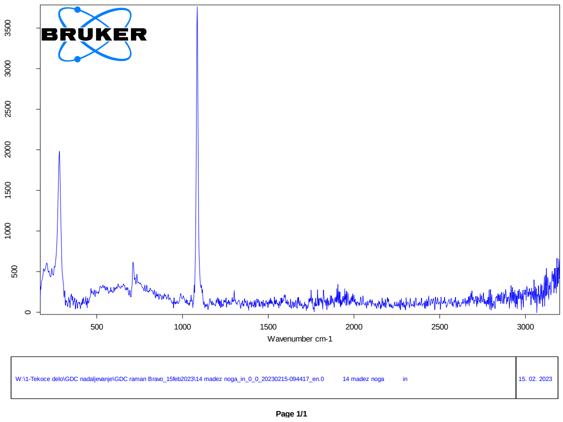

11- black, devil, BaOH, white haze:
calcite, carbon black, haematite, nitrates, possibly clay/ silicates (768; 754 cm$^{-1}$; Buzatu and Buzgar, 2010)



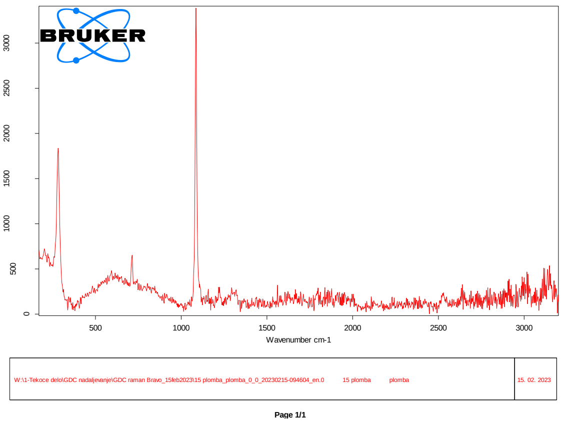

12- carnation, Christ, BaOH, white haze:
calcite, quartz, nitrates, unidentified material (730 cm$^{-1}$), maybe dolomite, unidentified material (2000-2500 cm$^{-1}$)



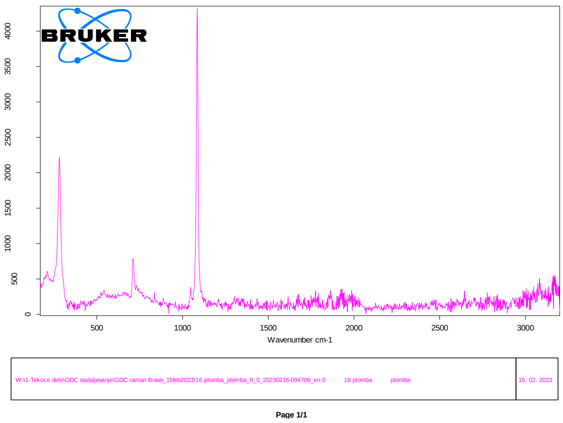

13- filling, stain/ drop:
calcite




14- carnation, Christ, BaOH, stain/ drop:
calcite, barium sulphate (little), gypsum (little), nitrates (little), unidentified material (730 cm$^{-1}$), maybe dolomite



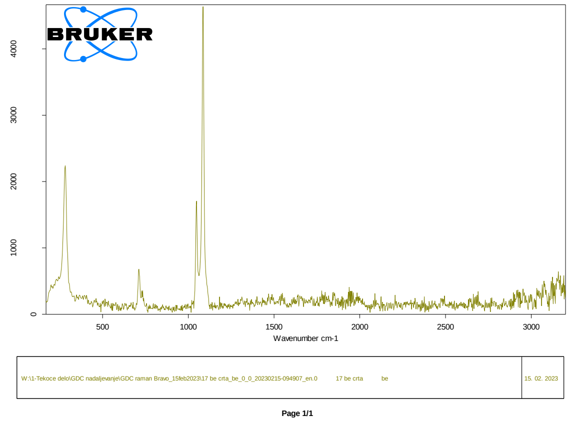

15- filling, red, coat, BaOH:
calcite



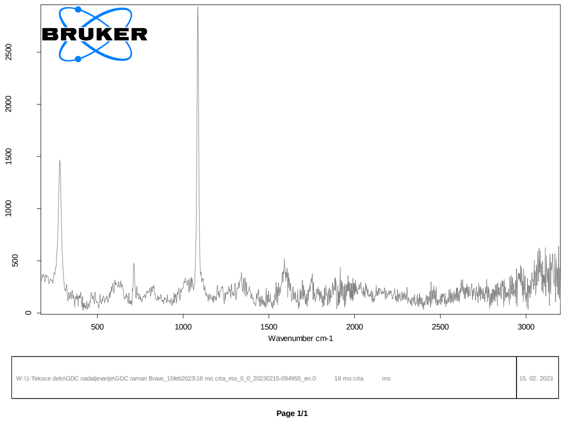

16- filling, red, coat, BaOH:
calcite, nitrates

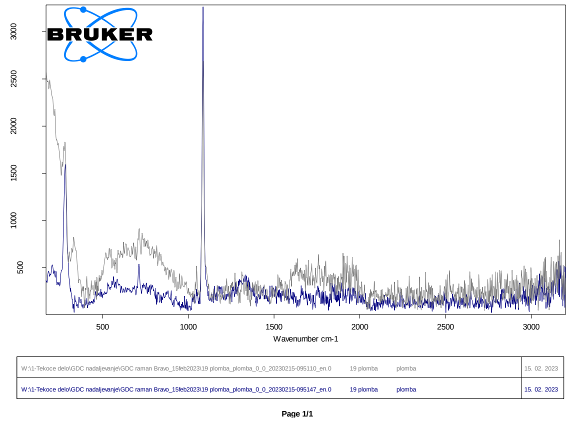
*Scene Deposition from cross*




17- white line, BaOH:
calcite, nitrates, unidentified material (730 $cm^{-1}$), maybe dolomite




18- blue, BaOH, white haze:
calcite, carbon black

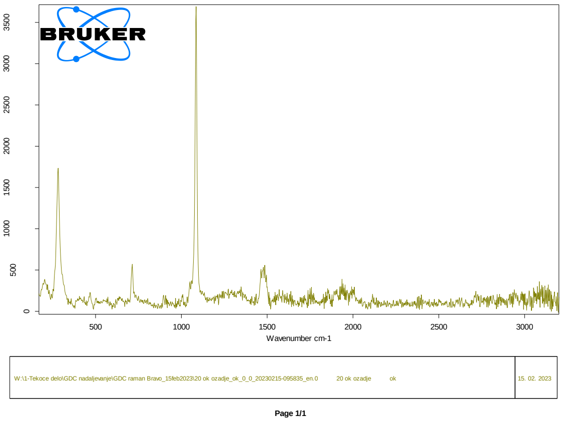



19- left of cross, BaOH, white haze:
calcite, nitrates

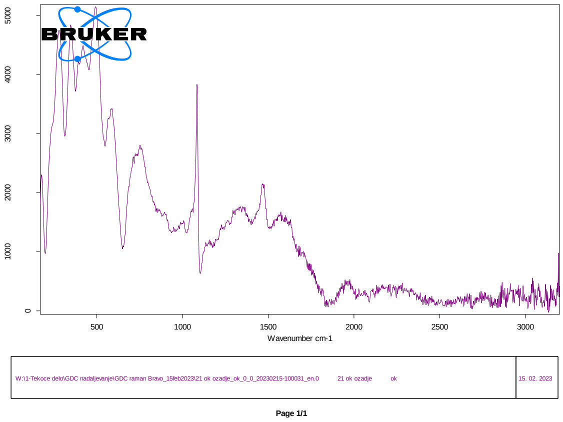
 

*Ammonium oxalate*

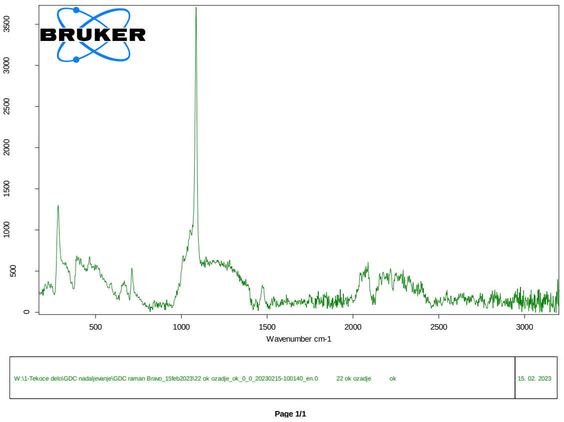
Scene with Herod



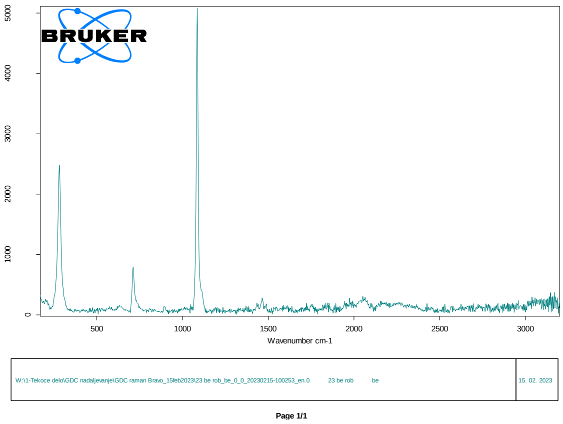

20- light ochre, background, AmOx: calcite, calcium oxalate, gypsum, nitrates, calcium oxalate weddellite (1475 $cm^{-1}$), calcium oxalate whewellite (896 $cm^{-1}$; Hernanz et al., 2006), unidentified material (1060 $cm^{-1}$), probably not barium carbonate




21- dark ochre, background, AmOx: calcite, calcium oxalate
bad spectrum




22- dark ochre, background, AmOx: calcite, quartz, gypsum, calcium oxalate, nitrates, unidentified material (2000-2500 $cm^{-1}$)



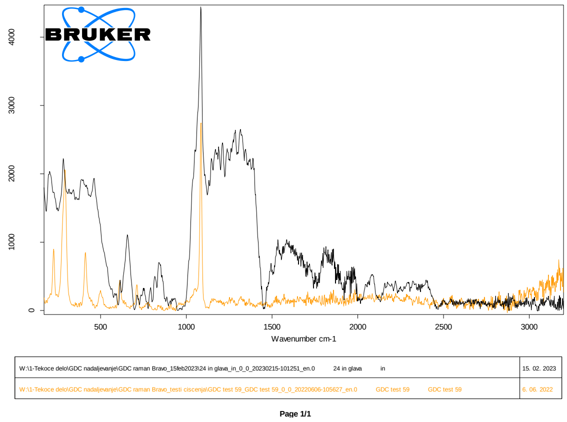

23- white, border, AmOx: calcite (1433 $cm^{-1}$ too), calcium oxalate (895, 1465, 1489 $cm^{-1}$ whewellite; Hernanz et al., 2006)

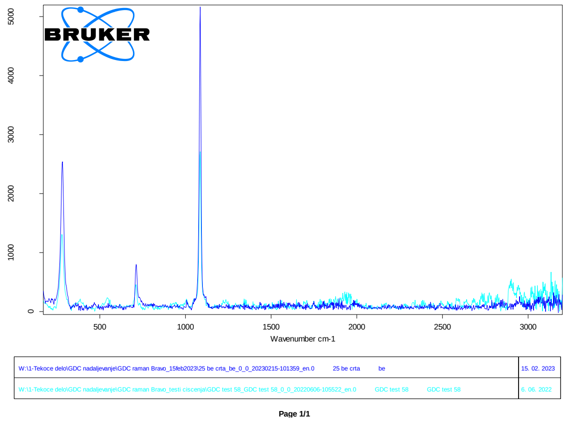
*Comparison with spectra from June 2022 (see chapter 6.4)*

*Number in brackets is from previous analysis. Darker spectrum is from current analysis; lighter spectrum is comparison from the past analysis on the same position. Letter "C" stays for "comparison".

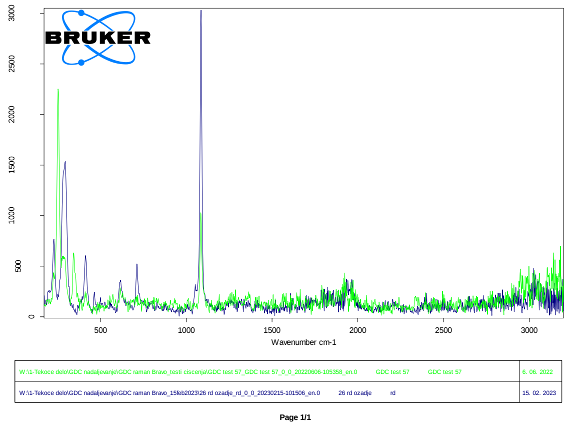
*Scene Deposition from Cross*



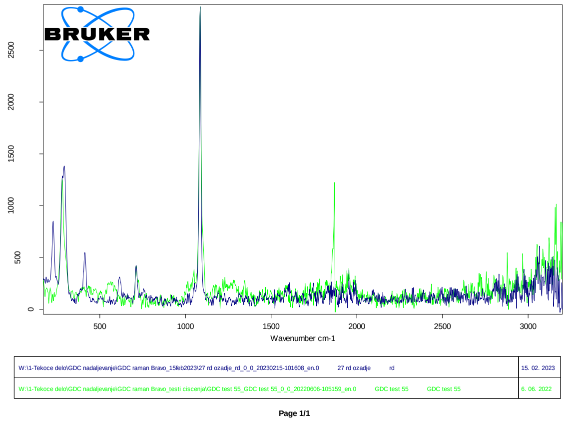

24 (59)- carnation, Christ:
calcite, quartz, haematite (barely visible), unidentified material (650 to 850 cm$^{-1}$, 1120-1400 cm$^{-1}$ and 2000-2500 cm$^{-1}$)
C: worse spectrum; hidden vibrations for haematite; smaller band 1052 cm$^{-1}$ (for nitrates), additional unidentified material, possibly organic




25 (58)- white, dress:
calcite, gypsum
C: gypsum still visible, possibly even larger amount than previous measurement

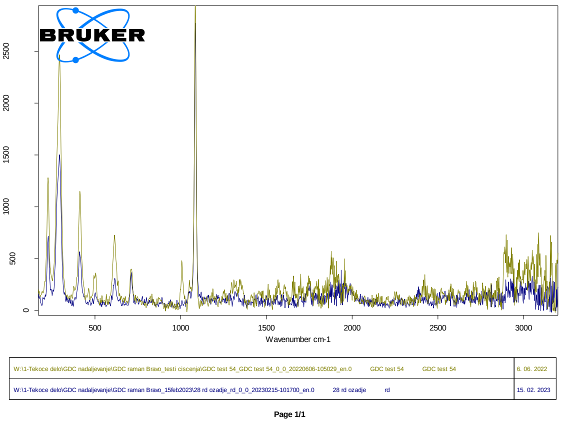



26 (57)- red background, right from 25:
calcite, haematite, quartz, nitrates
C: not visible vermilion, but haematite instead; less/ no gypsum

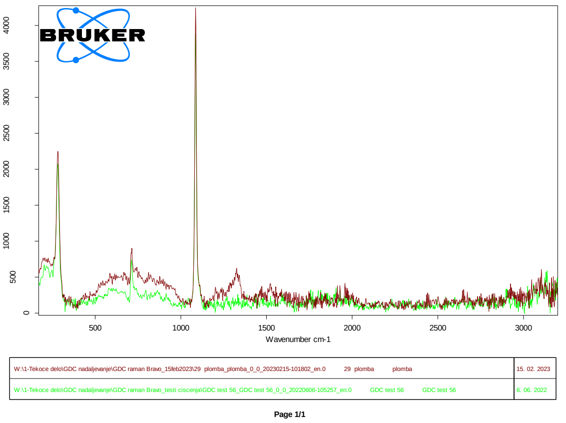



27 (55)- red background, right from green dress:
calcite, haematite, nitrates
C: visible hematite beside calcite

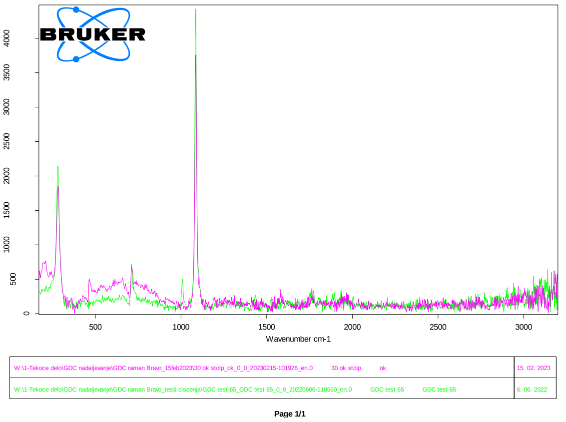


28 (54)- red background, right from green dress:
calcite, haematite, nitrates
C: disappears gypsum

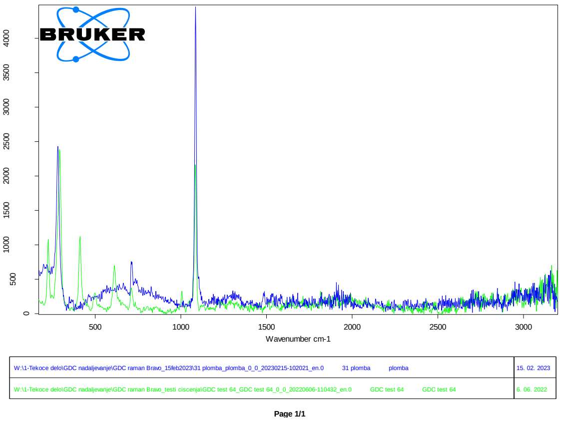


29 (56)- filling beside scene Deposition from Cross:
calcite, gypsum (little)
C: slightly more gypsum, although barely present

*Scene The Entombment*

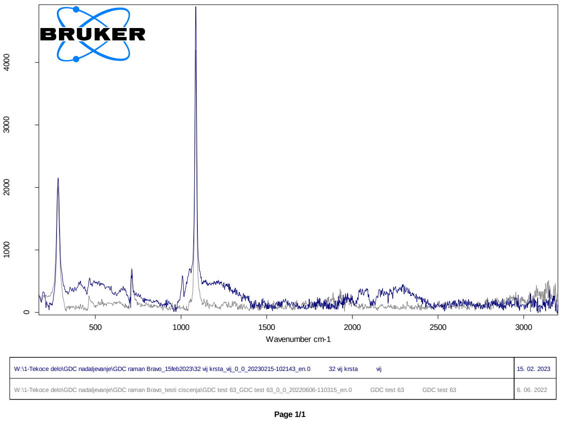


30 (65)- ochre, pot:
calcite, quartz, gypsum
C: less gypsum

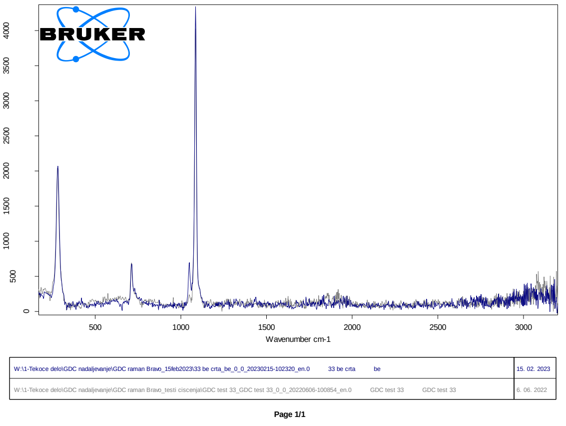


31 (64)- filling:
calcite
C: no gypsum, no haematite

*Scene Resurrection*

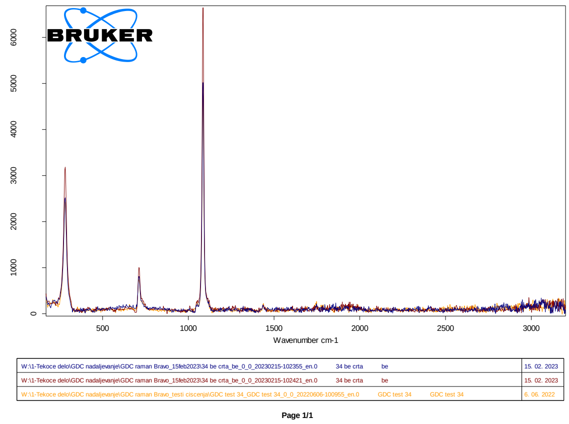


31 (63)- violet, grave:
calcite, quartz, gypsum, nitrates
C: more gypsum, similar amount of nitrates



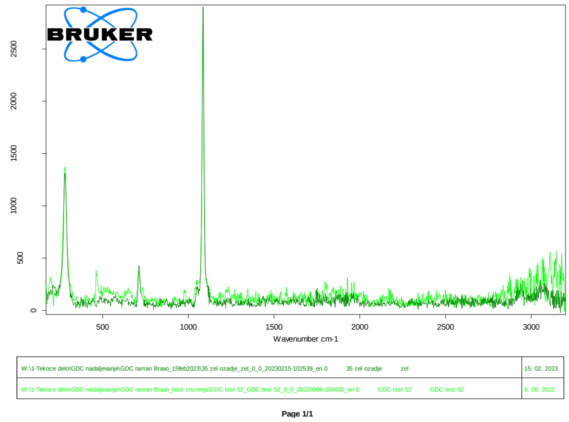
33 (62)- white, decorative belt:
calcite, nitrates
C: more nitrates

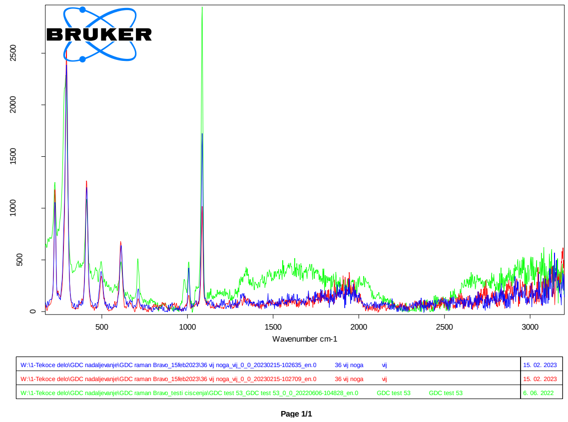


34 (61)- white, decorative belt (2 spectra):
calcite (1437 $cm^{-1}$ too), gypsum (little), nitrates (little)
C: more gypsum in one spot

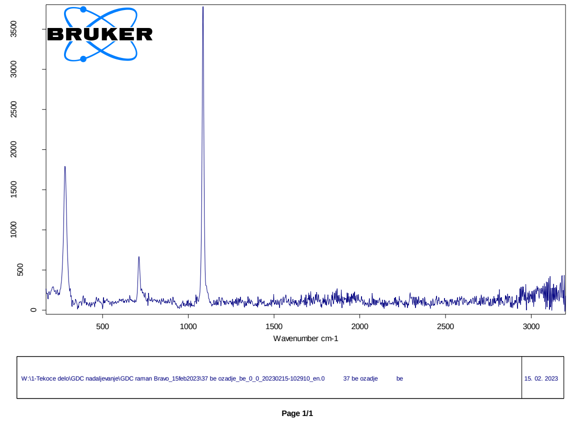
*Scene Crucifixion*



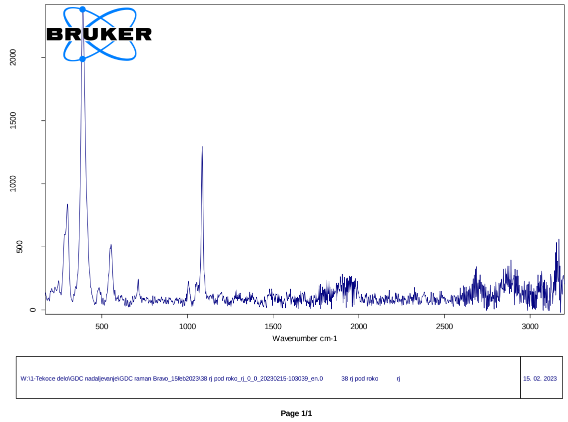
35 (52)- bright green, background:
calcite, nitrates
C: missing quartz, 977 $cm^{-1}$ (sulphates) and unidentified material (730 $cm^{-1}$), possibly dolomite



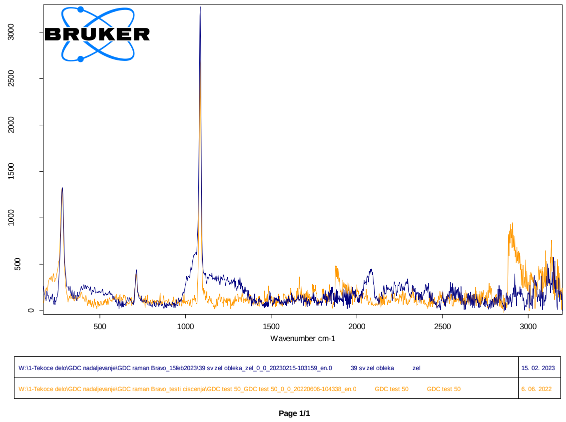
36 (53)- violet, leg:
calcite, haematite, gypsum, nitrates
C: missing 980 $cm^{-1}$; similar height for gypsum or even higher



37 (51)- white, background:
calcite
C: not possible, because previous sample was measured on red area

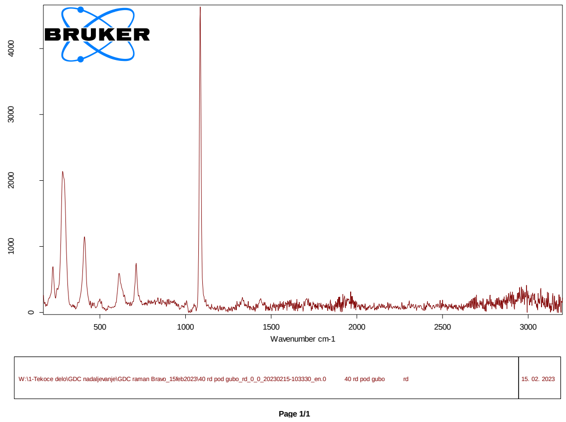


38 (49)- brown, under a hand:
calcite, goethite, gypsum, nitrates
C: not possible, because previous sample was measured on green area

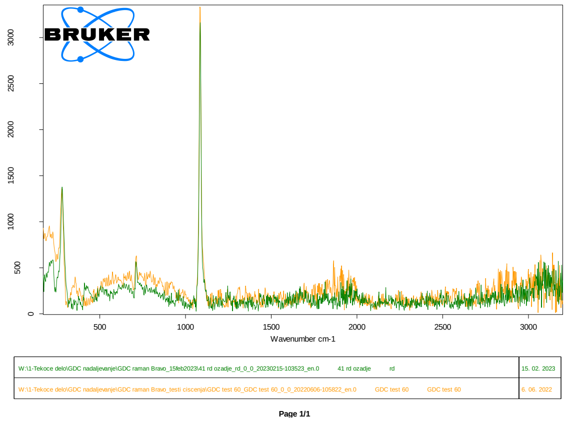



39 (50)- green dress, white fold:
calcite
C: no differences

*Scene Crucifixion 2*

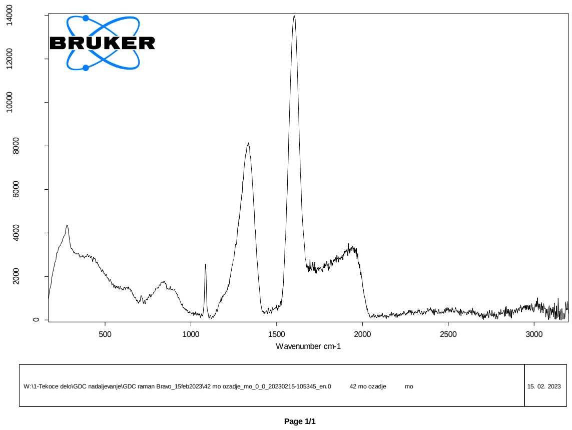



40 (48)- red, dress, fold:
calcite, haematite, gypsum, nitrates
C: not possible, because previous sample was measured on green area

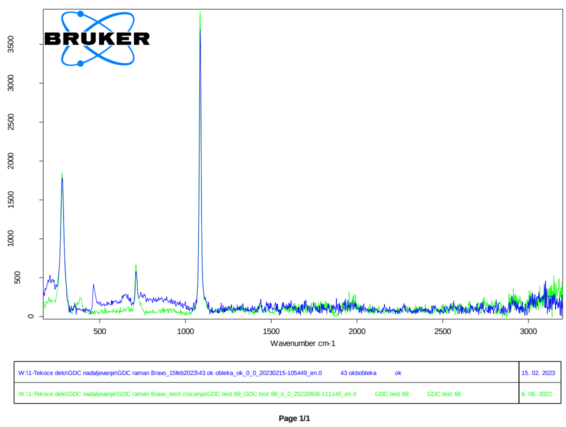



41 (60)- red, background:
calcite
C: no differences

*Scene with Herod*

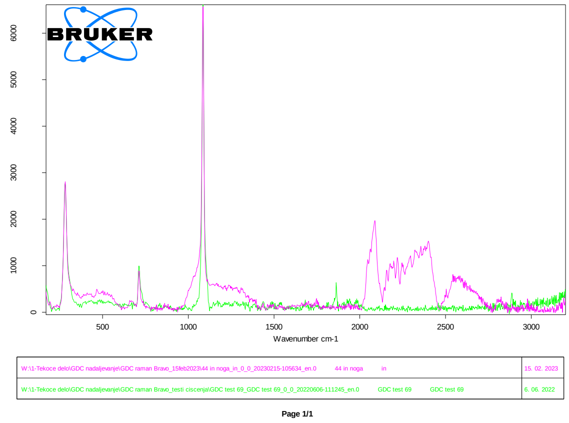



42 (70)- blue, background:
calcite, carbon black
C: not possible, because previous sample was measured on white area




43 (68)- ochre, dress:
calcite, quartz, nitrates, unidentified material ($1062\ cm^{-1}$), probably not barium carbonate
C: no goethite, additional quartz

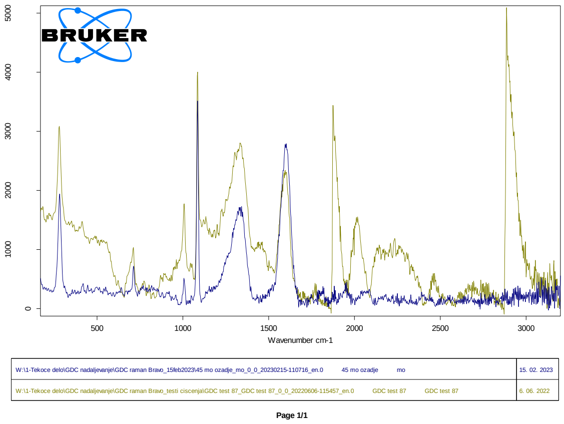
 



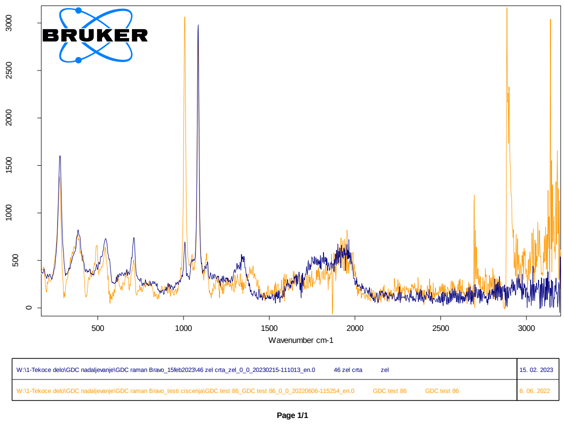

44 (69)- carnation, leg:
calcite, quartz
C: additional quartz

### *b) Northern wall*

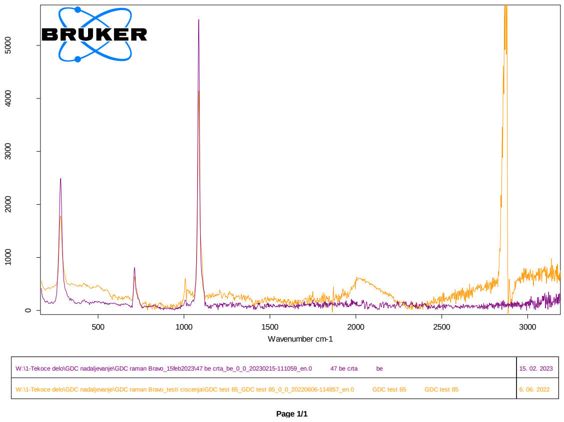

 




45 (87)- blue, background, right form castle:
calcite, carbon black, gypsum, nitrates
C: less gypsum, nitrates




46 (86)- green, boarder line-
calcite, green earth, gypsum, unidentified material (2000 to 2500 $cm^{-1}$; not shown)
C: less gypsum, missing 492 $cm^{-1}$ for silicates (Tournié et al., 2010)

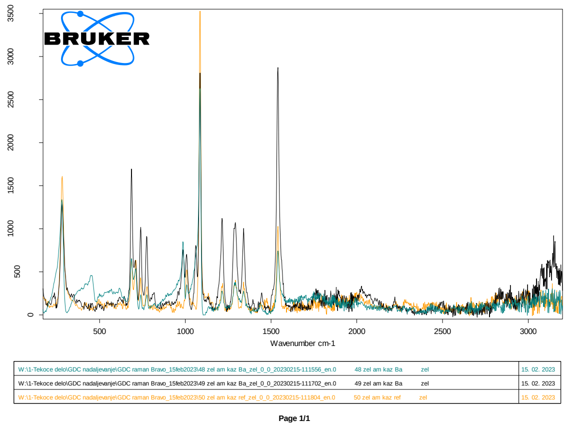



47 (85)- white, boarder line:
calcite, gypsum
C: less gypsum

## 6.6 Raman evaluation of mock-up tests, February 2023

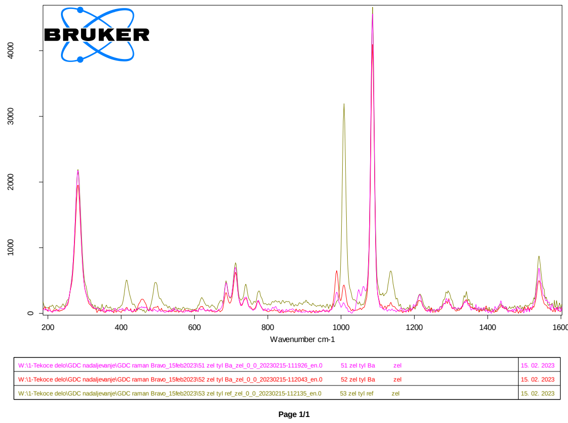
### *a) Southern wall*

*Barium hydroxyde on green areas*



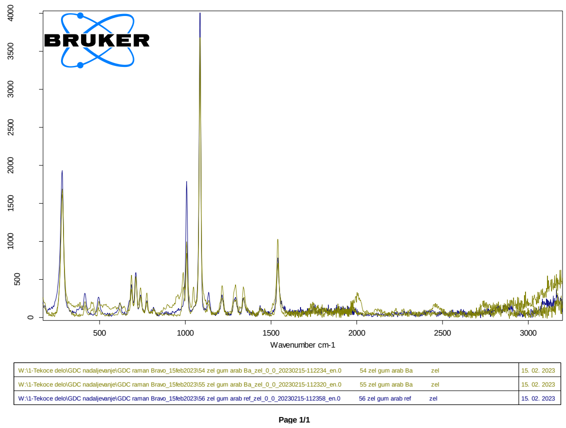

- consolidated spectra peak 986 cm$^{-1}$ and some minor peaks for barium sulphate, which are not observed in reference
- barium carbonate (1060 cm$^{-1}$) in one consolidated spectrum and as a shoulder in the second (Xiang et al., 2019)
- casein bands visible only in sp. 49
- phthalocyanine green

48 & 49- green, ammonium caseinate, BaOH
50- green, ammonium caseinate, reference (orange spectrum)




- gypsum in reference, less in treated areas
- Ba sulphate in treated areas
- Ba carbonate in one treated spectrum
- in the same as above small band for nitrates (1048 cm$^{-1}$)
- ferrous sulphate (457 & 480 cm$^{-1}$; Buzgar et al., 2009)

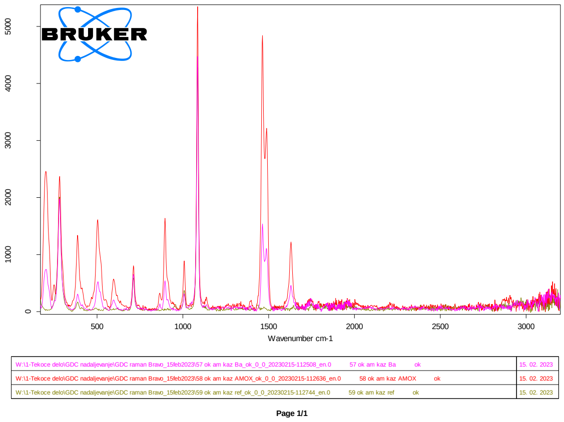
51 & 52- green, tylose, BaOH
53- green, tylose, reference (grey spectrum)




- gypsum in reference, less in treated areas
- Ba sulphate in treated areas
- slight shoulder for Ba carbonates
- nitrates in one treated spectrum
- ferrous sulphate
- unidentified material (955 cm$^{-1}$)

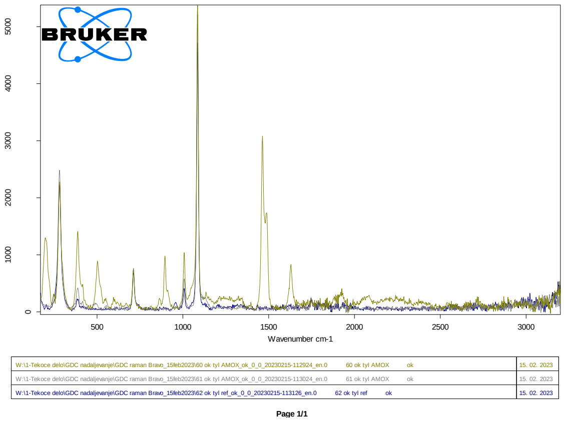
54 & 55- green, Arabic gum, BaOH
56- green, Arabic gum, reference (blue spectrum)

*Ammonium oxalate on ochre paint areas*



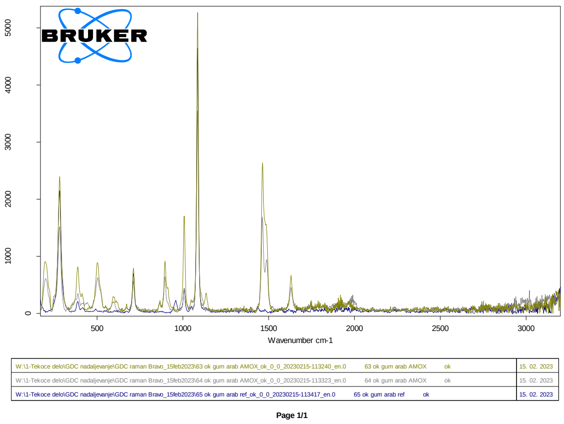

57 & 58- ochre, ammonium caseinate, ammonium oxalate
59- ochre, ammonium caseinate, reference (grey)

- intense bands of calcium oxalate monohydrate (whewellite, more, and weddellite, less)
- same amount of gypsum (maybe even more) than before consolidation




60 & 61- ochre, tylose, ammonium oxalate
62- ochre, tylose, reference (blue)

- intense bands of calcium oxalate monohydrate (whewellite, more, and weddellite, less)
- same amount of gypsum (maybe even more) than before consolidation

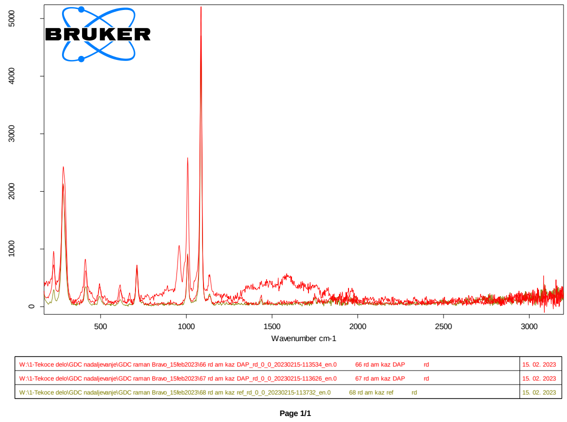



63 & 64- ochre, Arabic gum, ammonium oxalate
65- ochre, Arabic gum, reference (blue)

- intense bands of calcium oxalate monohydrate (whewellite)
- in one spectrum no oxalate is visible
- same amount of gypsum (maybe even more) than before consolidation
- disappears band at 958 $cm^{-1}$

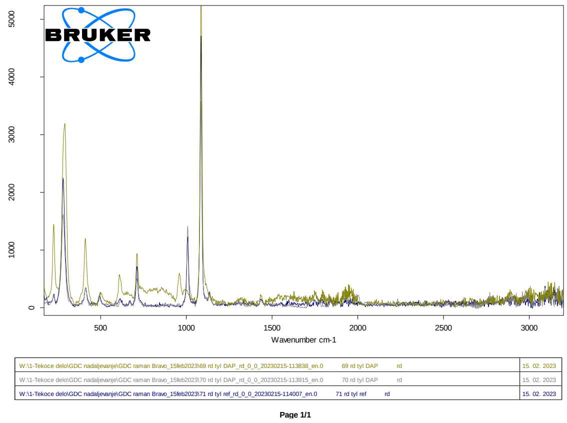
 

*Diammonium phosphate on red painted areas*



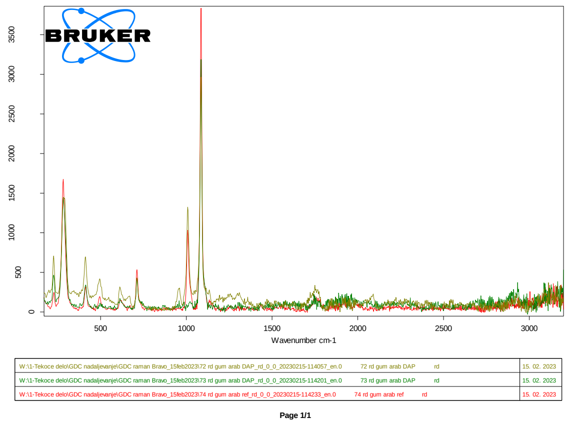

66 & 67- red, ammonium caseinate, DAP
68- red, ammonium caseinate, reference (grey)

- calcium phosphate
- unidentified material (615 and 669 $cm^{-1}$)
- gypsum still present, maybe even higher
- some nitrates visible




69 & 70- red, tylose, DAP
71- red, tylose, reference blue)

- calcium phosphate
- gypsum disappears in one treated spectrum, but remains same in the other

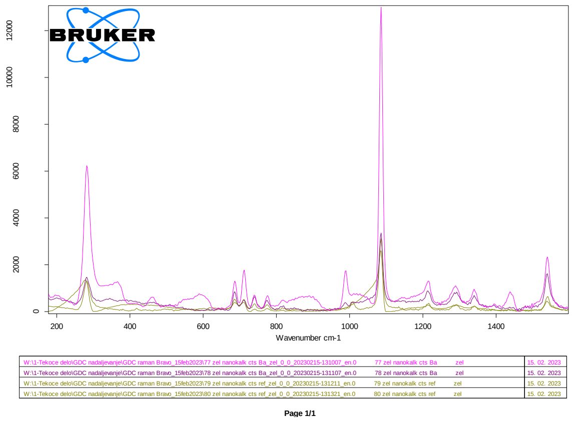



72 & 73- red, Arabic gum, DAP
74- red, Arabic gum, reference (red)

- calcium phosphate
- gypsum disappears in one treated spectrum, but remains same in the other

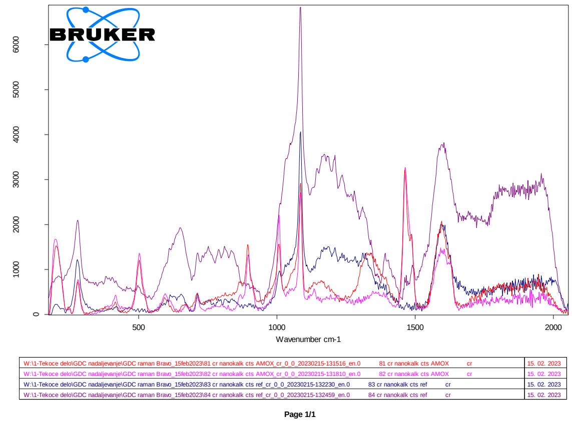
 

### b) Northern wall




- barium sulphate, no barium carbonate
- no gypsum in treated areas (and in one untreated)

77 & 78- green, nanokalk CTS, BaOH
79 & 80- green, nanokalk CTS, reference (grey spectra)




- calcium oxalate
- more gypsum than in reference

81 & 82- black, nanokalk CTS, AmOx
83 & 84- black, nanokalk CTS, reference (blue spectra)

## 6. DISCUSSION

Diagnostic investigations in Church of St. Helen in Gradišče pri Divači (EŠD 1566) started in 2001 when algae on northern wall were sampled. They continued with extensive sampling and different types of non-invasive analyses from 2003 onwards. In the present report, we present and discuss results of material and stratigraphic analyses as well as microclimatic monitoring, carried out between 2003 and 2010 as well as in 2021. In those years, church has been sampled several times for different purposes. However, it is expected that in the following years, when work will continue on conservation of wall paintings, additional analyses will be carried out to monitor cleaning and consolidation efficiency and possible influences of selected methods.

Analyses can be divided into several groups: *in situ* analyses and laboratory analyses, material characterisation, state of preservation monitoring, cleaning and consolidation efficiency analyses as well as microclimatic monitoring.

To obtain as much of the above mentioned information as possible, several non-invasive as well as micro-invasive methods were applied: on site microclimatic monitoring using dataloggers, thermography, in situ Raman and XRF non-invasive analyses, whereas on extracted micro samples optical and scanning electron microscopies as well as infrared (FTIR) and Raman spectroscopies.

**Microclimatic conditions** are (still being) measured in four positions – on each wall. The measurements can be compared to environmental monitoring at nearby Park Škocjanske Jame. Measurements were carried out in winter 2004-2005 as well as from December 2020 onwards. Measurements show that conditions vary only slightly in different parts of the church. The highest temperatures are, as expected, on the southern wall. They vary considerably more than on other sides of the church, on daily basis as well as within longer time periods. Temperature fluctuations can affect different materials, especially by changing volume of the objects (for composed objects this is especially endangering, since various materials response differently to heat changes). Temperatures have also great influence to relative humidity (RH).

The RH never reached 100% but came close several times, especially in winter months. Humidity fluctuations in the church follow temperature fluctuations – after raising temperature, RH drops – and are slightly more intensive on southern side of the church. Comparing our measurements with weather reports, we can say that external conditions have important influence to RH within the church. Most of the time RH in the church exceeded 68%: 77% of time on southern wall and even 90% of time on northern wall. Such conditions are favourable of microbial growth, metal corrosion and salt efflorescence on walls. As observed by example from beginning of June, opening of the church on warm and dry days can substantially lower the RH in the church. This should be a recommendation for locals taking care of the church. Should passive airing not help, active mechanical ventilation or wall heating should be considered.

**IR thermography** was carried out on parts of the southern and northern walls. Preliminary thermographic analyses do not show colder walls close to the ground, which would suggest capillary water rising from the floor. Larger areas of plaster blistering were observed by this method, as well as positions of stones and mortars under paint layers.

Two **mortar samples** were extracted from interior and exterior of northern church wall. Sample GDC 24 is mortar from the lower part of the north wall. The plaster probably consists of two layers. The boundary between the layers is clearly visible and traceable on part of the thin section, but in some places, this boundary is blurred and we cannot trace it. It is possible that the work was interrupted in the meantime and the plaster dried, and that the same composition of plaster was used and applied later. We conclude this because the aggregate is practically the same in both layers, as well as the size of the grains. An aggregate of silicate composition was used, consisting mainly of quartz grains, but also to a small extent of mudstones and lithic grains of quartz sandstones and siltstones. The grains have a size of 0.05 to 0.65 mm and correspond to the fraction of fine to medium sand. The binder, which is lime, predominates over the aggregates. The possible presence of water-soluble salts in the mortar was verified by FTIR spectroscopy. The results showed that water-soluble salts were not present or were present in such small amounts that they could not be detected by the analysis.

Sample GDC 25 is a mortar between the stones of the outer north facade. Also in this sample an aggregate with silicate composition (quartz, feldspar, lithic grains of quartz sandstone) was used. The grains range in size from 0.05 mm to 0.46 mm and correspond to the fraction of fine to medium sand. The binder is lime and predominates over aggregates. The presence of water-soluble salts was not confirmed by FTIR spectroscopy in this sample either.

**Pigment analyses** were carried out *in situ* as well as on extracted samples, in both cases with Raman spectrometers. Following pigments were detected in the painting: haematite (possibly in some areas caput mortuum), goethite, green earths, magnetite, carbon black and quartz, maybe also vermilion. Additionally, XRF analyses revealed possible, but questionable, presence of copper on dark green garment of Wise Man on the white horse. No copper green pigment was identified by Raman spectroscopy in the same area (GDC 33). Calcite was detected in all analysed samples, as expected, since painting technique is fresco.

Additionally to *in situ* Raman spectroscopy, pigment analyses were carried out on extracted micro-samples, where each different pigment grain can be analysed separately. Additionally to non-invasive analyses, kaolinite was identified and vermilion confirmed, laying over haematite layer.

Blue layer in sample no. 39 is probably just whitewash – no blue pigment was observed neither in cross-section, nor in raw sample.

Different **degradation products** were observed on paintings. Gypsum salt was observed in *in situ* spectra on most of the analysed surface areas on both, southern and northern wall. Interestingly, it was observed only in few micro-samples with Raman spectroscopy. SEM EDS analyses on micro sample cross-sections revealed that it is present in untreated samples, mainly on northern wall, in thin surface layer, whereas from *in situ* analyses it seems that there is more gypsum on southern wall, which is not very probable.

Beside gypsum salts, sodium chloride and nitrates were observed in some analysed samples and *in situ* measurement points (Raman band at 1049 $cm^{-1}$). Band at 1049 $cm^{-1}$ is observed in Ba carbonate treated areas, but not in other Raman spectra of extracted samples. On the other hand, in *in situ* Raman spectra this band is observed in areas, which were not treated with Ba carbonate and are not observed in area treated with Ba carbonate (R8). This pattern does not provide us with a clear picture about the presence of nitrates in different areas.

Relatively scarce presence of calcium oxalates suggests that despite high RH values, biodegradation is not widespread on paintings.

White crust in some areas (e.g. GDC 45) is gypsum. It is present on surface and its amount diminishes with depth and disappears after approx. 150 µm

**Organic materials** were analysed by FTIR spectroscopy in selected micro-samples. Two surface stains were analysed. In one wax was identified with certainty (GDC 29). In the other sample (GDC 28) mainly salts were identified, and maybe some carboxylates which hint to presence of organic materials, containing carboxylic acids (wax, resin or oil). In some analysed samples, presence of either proteins or calcium oxalates were identified. To specify the results, immunofluorescence microscopy was performed for ovalbumin on three samples, extracted in 2003. Analysis confirmed presence of proteins in two samples (GDC 4 and 5), but not on the third one (GDC 10). Samples with ovalbumin were both extracted from green areas and show presence of proteins in plaster layers and in paint layers. It is not clear, whether this was due to consolidation or original material.

Interesting features are (mainly) black surfaces, which under UV light **fluoresce orange**. The orange fluorescence is visible not only *in situ*, but also in cross-sections under the microscope. It seems that there is a fluorescent binder, which connects black particles, but could be also remnants of a coating layer. FTIR spectra of the sample did not give a conclusive information about the fluorescent material.

Beside material identification, aim of the analyses was to support observations from cleaning tests and asses the efficiency of the consolidation trials. **Cohesion assessment** was observed on selected cotton swabs. On the analysed swabs, mainly calcite and salts (mainly gypsum and calcium oxalates) were present. Some of the cotton swabs were coloured by fine pigment dust and single pigment particles were observed.

Cohesion assessment swabs revealed different cleaning dynamics regarding gypsum removal: in some relative amount of gypsum seemed to increase with following swabs but in other it decreased.

**Conservation treatments** were evaluated on white frame on southern wall. Area cleaned with pure water and the one consolidated with barium hydroxide did not reveal presence of gypsum. Untreated sample revealed only some gypsum aggregates and in the area treated by ammonium bicarbonate and barium hydroxide with poultice thin surface layer of sulphate salts (probably gypsum) was observed. Research on single samples without parallels cannot always be regarded as reliable. Since in cross sections more gypsum was observed on northern wall, a comparison of the same group of treatments would be interesting.

The samples treated with barium hydroxide were monitored for depth of penetration. The SEM EDS mapping revealed that barium remained mainly in the surface layers of the paint (it penetrated to approx. 50 µm depths), however in more porous areas (possibly cracks) it penetrated deeper, up to 200 µm.

From the above results, we can conclude that analyses revealed information about material composition and presence of degradation products. However, not all questions were satisfactory answered.

**Cleaning tests** were carried out on selected areas with ammonium bicarbonate and anionic resins. They were analysed by non-invasive Raman spectroscopy and compared with uncleaned areas. There was no clear pattern regarding special distribution of soluble salts. Amount of gypsum was substantially lowered by cleaning process, especially on S and W wall, where its amount was already initially lower. However, some gypsum remained on the surface. Sometimes it even seemed that its amount increased, as if it was soaked from the depth. Different to gypsum, nitrates did not disappear after cleaning tests.

Later **consolidation tests** were carried out and areas were analysed by non-invasive Raman spectroscopy as well as on some extracted samples. On areas consolidated with BaOH barium carbonate and barium sulphate were observed (e.g. spectra 13, 15, 19 and 1, 2, 5, 14, respectively), but this only in certain points. On extracted samples (e.g. GDC 37 and 38) we could observe Ba ions with SEM EDS reaching into depth around 100 µm on solid surfaces and up to 200 µm in cracks. Another tested consolidant was ammonium oxalate, where in all spectra reaction product calcium oxalate was observed.

Nitrates were observed in most of consolidated spectra and gypsum in some.

**In situ mock-up samples** were prepared on presbytery walls to test different retouching binders: ammonium caseinate, tylose and Arabic gum, and pigments earth green, yellow and red ochre and carbon black. During the analysis, it turned out that the green earth actually contains phthalocyanine green pigment, a synthetic pigment discovered in the 1930s, which is considered stable, but differs greatly in its composition from the green earth used in the original painting. (Eastaugh et al. 2004).

The surfaces were consolidated with BaOH (5%), ammonium oxalate (5%), diammonium phosphate (DAP, 5%) and nanolime. In samples consolidated with BaOH, we observe both vibrations for barium sulphate in all analysed spectra, and in certain spectra also for barium carbonate. We conclude from the spectra that the amount of gypsum on the surface of surfaces consolidated with this treatment has decreased. After consolidating with ammonium oxalate, calcium oxalate formed on the surface, but the amount of gypsum did not decrease. Calcium phosphate, a poorly soluble material, is visible on the surface of DAP treated samples, a product of the chemical reaction of calcium ions from the painting or gypsum salts with phosphate ions from a consolidant (Molina-Piernas et al., 2017). Gypsum disappeared in some DAP treated areas, while the same amount as before treatment remained in others.

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# REPORT: SUMMER SCHOOL GRADIŠČE PRI DIVAČI (SLOVENIA)

2nd to 27th of August 2021

## CHURCH OF ST. HELEN CONSERVATION-RESTORATION OF WALL PAINTINGS

## ANNEX n. 6 Photodocumentation

**Students/authors:** Katarina Bartolj, Cecile Roulin.

**Mentors:** Alberto Felici, Neva Pološki, Suzana Damiani, Blaž Šeme, Anka Batič.

Introduction

By Cecile Roulin, Supsi

In the framework of the 2021 Summer school in the Church of St. Helen in Gradišče pri Divači in Slovenia, numerous photos have been used to document the work carried out. Some of them are previous photos, bellowing to the historical documentation and some others have been taken directly on the site of St. Helen.

Historical photos

All the historical photos of the church could be collected on the MS Teams interface dedicated to the project, in the folder called "**Historical_documentation**" (jpeg and pdf format). This is a series of black and white photos of the interior of the church, taken during the years 1965-1966. There are also two exterior photos from 1995, taken by the "*Turistička zajednica Istarske županije*" (Istrian County Tourist Board).

On site photos

All the on site photos are photos that illustrate the whole investigative work carried oud from August 2 to 27, 2021 in the church of St. Helen. This observation's work has been done thanks to the technical photography:
with a digital camera: visible light, raking light, UV-photos (with an UV-LED light);
with a portable microscope.
All the photos are collected on the MS Teams interface dedicated to the project. They are divided into different folders according to their functionality:
in the "**Building**" folder, the general photos of the building can be find: exterior, photos that are not directly related to the work done during the Summer school, past inspections, etc (raw, tiff, jpg format).
The "**Photos_of_the_church**" folder is dedicated to the work carried out during the Summer school: sometimes focused on a particular detail, other times much more general, the photos illustrate the investigations, the experiments, and the results. The folder is divided into 3 sub-folders, corresponding to each wall of the church. Each sub-document is in turn divided into 5 sub-folders, corresponding respectively to: the reference photo, the executive technique, the previous interventions, the degradation phenomena and the intervention. In one other sub-folder "General", general photos of the working' site can be find, which simply illustrate the daily life of the project (raw, tiff or jpg format.)

In the “**Investigation**” folder, the photos are intended to be a precise illustration of the investigations carried out, and a tool for understanding the results. The folder is divided into the portable microscope’s photos, the multispectral imaging, the thermovision photos, and the sampling photos (raw, tiff, jpg format).

Naming of the on site photos
Each photo taken on the working ‘site is named according to a specific nomenclature, that corresponds to the location / edifice / wall / date / initials of the author / number of the photo.
Here for example: **g_ch_nw_20210308_fl_01.**

| Location | Edifice | Wall | Date | Initials of the photo’s author | Photo number |
|---|---|---|---|---|---|
| **G**radišče | **C**hurch St. **H**elen | **N**orth **W**all | Yyyymmdd | **F**irst name of the author **L**ast name of the author | XX |
| **g** | **ch** | **nw** | **20210308** | **fl** | **01** |

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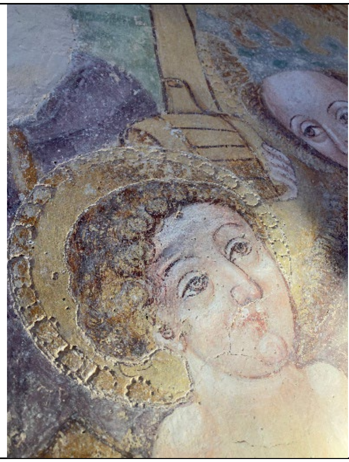
|  |  |
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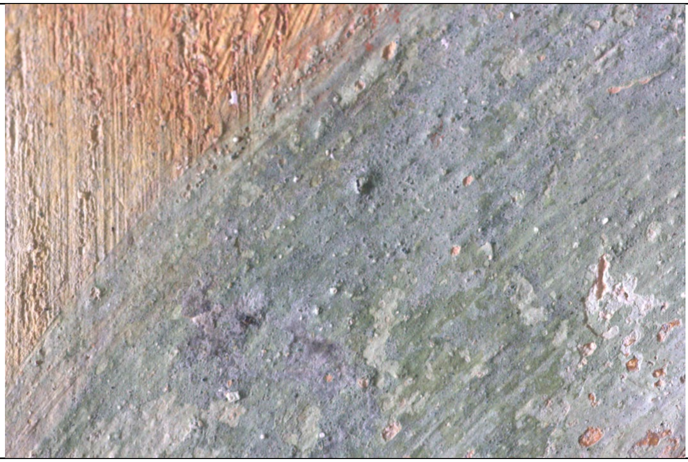
|  |  |
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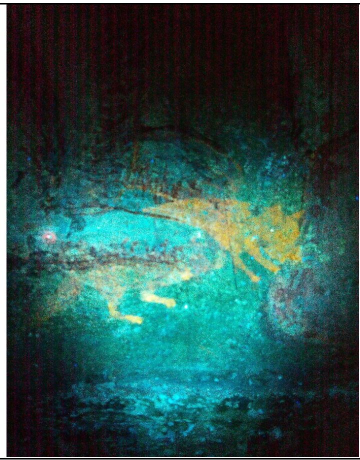
|  |  |
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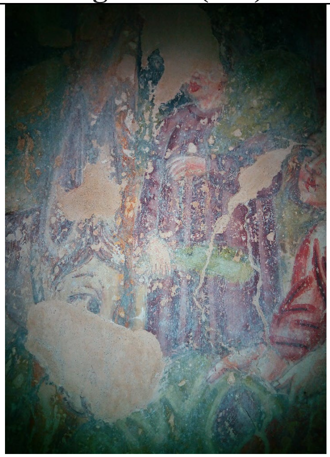
|  |  |
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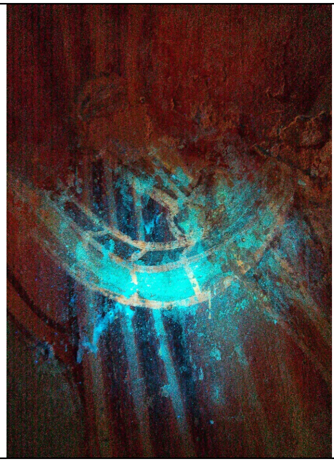
|  |  |
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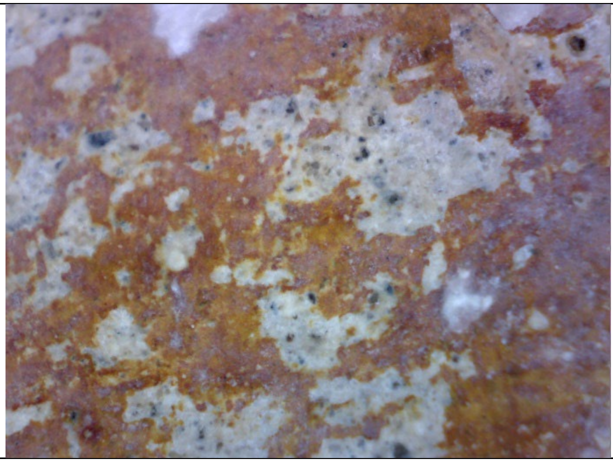
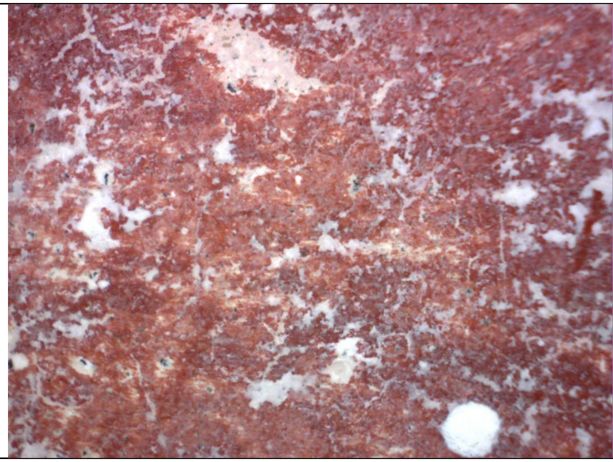
|  |  |
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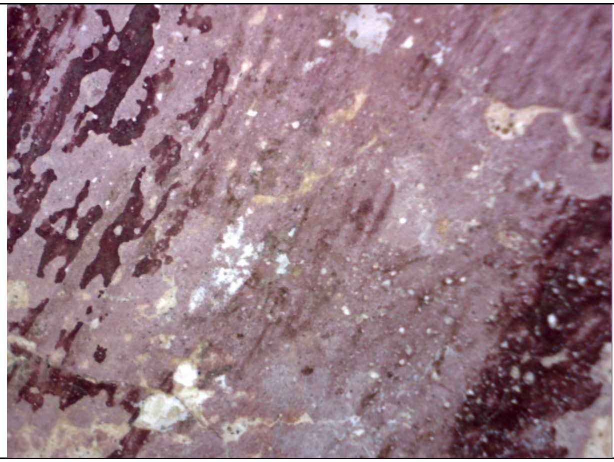
|  |  |
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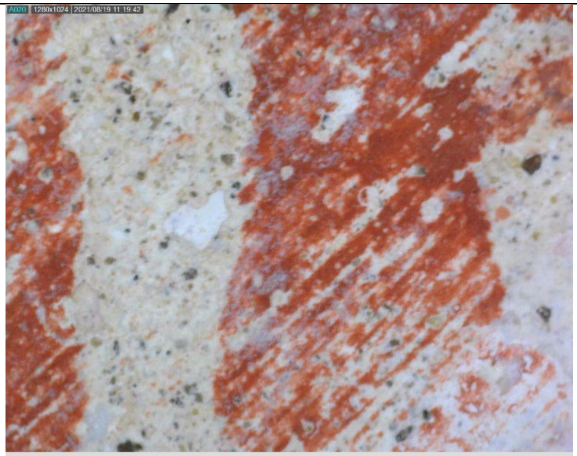
|  |  |
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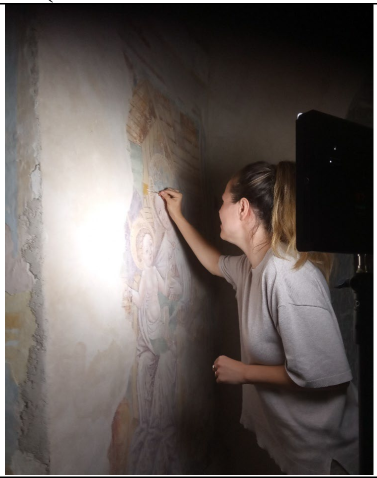
|  |  |
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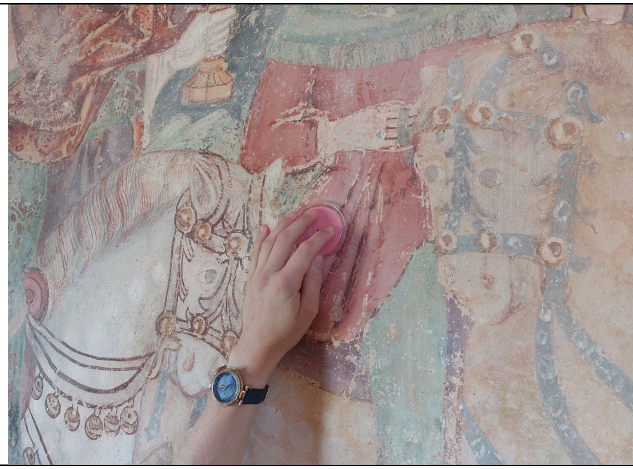
|  |  |
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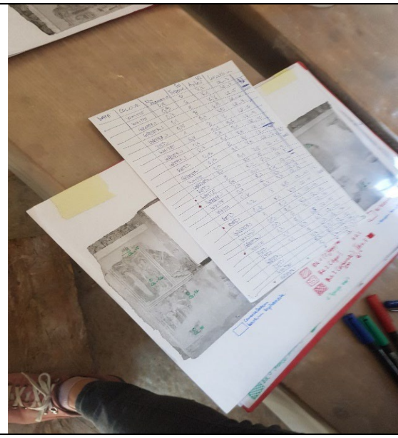
|  |  |
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# REPORT: SUMMER SCHOOL GRADIŠČE PRI DIVAČI (SLOVENIA)

2nd to 27th of August 2021

CHURCH OF ST. HELEN
CONSERVATION-RESTORATION OF WALL PAINTINGS

## ANNEX n. 7
## Cleaning and Consolidation trials


**Students/authors:** Katarina Bartolj.

**Mentors:** Alberto Felici, Neva Pološki, Suzana Damiani, Blaž Šeme, Anka Batič.


# Introduction

By Katarina Bartolj

When we finished all the examinations of the wall paintings and got a general idea of their current state, we began to perform different investigations and try-outs. We were interested to find out the reasons behind the current state of the paintings and especially, how do they behave under different treatments and with usage of different materials. It is of most importance to find this out to know, how we will treat the paintings in the future and which materials are the most effective and non-threatening for the artwork.

During examinations of the wall paintings we noticed visible impurities and stains all over the surface, that were clearly not meant to be there and were disrupting overall impression of paintings. It had been decided to try to remove them. Before any cleaning trial, we had to assess the state of cohesion of different colour areas. Therefore, we performed cohesion assessment trial by gently cleaning small areas of different colour surfaces with water-wetted cotton swabs. During this trial we were watchful of response of the surface on *water as a cleaning agent* and its overall cohesion. Most of the cleaned colour areas indicated, that they are generally stable, their response to water cleaning agent appeared to be satisfactory, with the exception of some red and yellow colour parts, where we will have to be careful in the future during cleaning procedures. After this promising results, we decided to proceed with more broad cleaning trials. First, we selected a few areas on different walls, where we performed our try-outs. All selected areas we cleaned with sponges and left to dry overnight. During the cleaning, we could see, that we removed some impurities off the surface, which seemed more colourful and overall cleaned after the procedure. After the drying process, we observed, that in some areas white veil has formed on the surface.

To treat the white veil and further clean the surface, we decided to try *ammonium bicarbonate solution*. We also tried different methods of application. The most efficient seemed to be application of the solution in form of poultice. In some cases, the white veil was easily cleaned off the surface after the bicarbonate treatment, in other the white veil seemed to grow even

further. To treat such areas, we tried different mechanical methods, which were all mostly efficient, and some chemical, such as *triammonium citrate*, which also gave sufficient results. After we got such good results with *ammonium bicarbonate* treatment, we decided to try cleaning the surface also with *ammonium carbonate*. The treatment was successful in removing the white veil and also some unidentified grey-ish stains on the upper side of the northern wall.
We also tried the treatment with *ionic exchange resins* to try to treat the sulfation of the surface. The results are quite minimal and negligible.

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**Cohesion assessment**

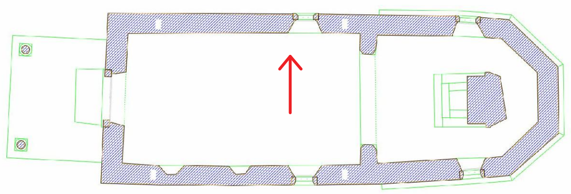


**Cleaning and consolidation trials**

Summer School Gradišče pri Divači, St. Helen, August 2021: **Mapping, Cohesion assessment, Northern wall.**


LEGENDA:

Cohesion assessment

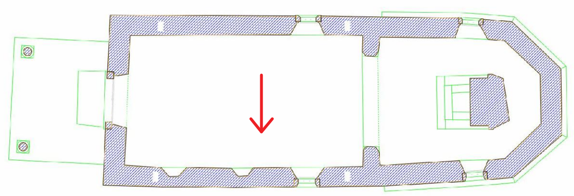


**Location:** Gradišče pri Divači
**Object:** Church of St. Helen
**Subject:** Wall paintings

**Cohesion assessment made by:** Alberto Felici, Marta Bensa, Andrej Jazbec, Blaž Šeme, Anka Batič, Neva Poloski.


LEGENDA:

Cohesion assessment



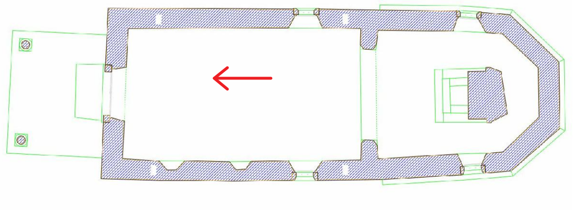
**Location:** Gradišče pri Divači
**Object:** Church of St. Helen
**Subject:** Wall paintings

**Cohesion assessment made by:** Alberto Felici, Marta Bensa, Andrej Jazbec, Blaž Šeme, Anka Batič, Neva Poloski.

Summer School Gradišče pri Divači, St. Helen, August 2021: **Mapping, Cohesion assessment, Western wall.**


LEGENDA:

Cohesion assessment



**Location:** Gradišče pri Divači
**Object:** Church of St. Helen
**Subject:** Wall paintings

**Cohesion assessment made by:** Alberto Felici, Marta Bensa, Andrej Jazbec, Blaž Šeme, Anka Batič, Neva Poloski.

Summer School Gradišče pri Divači, St. Helen, August 2021: **Mapping, Cleaning and consolidation trials, Northern wall.**

LEGENDA:

Cleaning with deionized water

Cleaning with ammonium carbonate - japanese paper

Cleaning with ammonium bicarbonate - japanese paper

Cleaning with ammonium bicarbonate - poultice with sepiolit

Cleaning with anionic resin

Cleaning with ammonium carbonate - poultice

Cleaning with ammonium bicarbonate - poultice

Consolidation with barrium hydroxide - poultice

**Location:** Gradišče pri Divači
**Object:** Church of St. Helen
**Subject:** Wall paintings

**Trials made by:** Alberto Felici, Marta Bensa, Andrej Jazbec, Anka Batič, Neva Poloski.

LEGENDA:

Cleaning with deionized water

Cleaning with ammonium carbonate - japanese paper

Cleaning with ammonium bicarbonate - japanese paper

Cleaning with ammonium bicarbonate - poultice with sepiolit

Cleaning with anionic resin

Cleaning with ammonium carbonate - poultice

Cleaning with ammonium bicarbonate - poultice

Consolidation with barrium hydroxide - poultice

**Location:** Gradišče pri Divači
**Object:** Church of St. Helen
**Subject:** Wall paintings

**Trials made by:** Alberto Felici, Marta Bensa, Andrej Jazbec, Anka Batič, Neva Poloski.

Summer School Gradišče pri Divači, St. Helen, August 2021: **Mapping, Cleaning and consolidation trials, Western wall.**

LEGENDA:

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| | Cleaning with anionic resin |
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**Location:** Gradišče pri Divači
**Object:** Church of St. Helen
**Subject:** Wall paintings

**Trials made by:** Alberto Felici, Marta Bensa, Andrej Jazbec, Anka Batič, Neva Poloski.


Zavod za varstvo kulturne dediščine Slovenije
*Institute for the Protection of Cultural Heritage of Slovenia*

Scuola universitaria professionale della Svizzera italiana
Dipartimento ambiente costruzioni e design
SUPSI

University *of Ljubljana*
Academy *of Fine Arts and Design*

Sveučilište u Zagrebu
Akademija likovnih umjetnosti


# REPORT: SUMMER SCHOOL GRADIŠČE PRI DIVAČI (SLOVENIA)

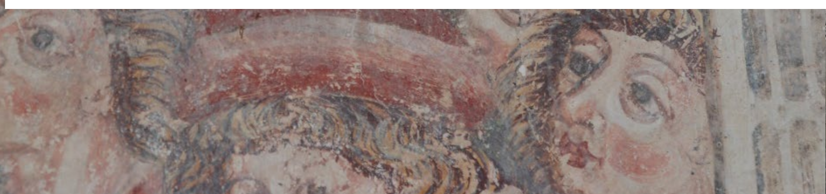
2nd to 27th of August 2021

CHURCH OF ST. HELEN
CONSERVATION-RESTORATION OF
WALL PAINTINGS

## ANNEX n. 8
## Programs of the 2021 Summer School


**Authors:** Marko Odič, Ajda Mladenović.

**Mentors:** Alberto Felici, Neva Pološki, Suzana Damiani, Blaž Šeme, Anka Batič.

Summary

by Marko Odič

The 2021 Summer School was divided into parts, two weeks online from home and two weeks of on site work. First week was a preliminary course to introduce these topics and issues:

- methodology and interdisciplinary approach towards conservation of wall paintings, techniques of intervention;
- data collection and management;
- presentation of wall paintings in Karst region;
- information about risk assessment, environmental monitoring and conditions;
- methodological and interdisciplinary approaches on conservation of wall paintings;
- and for the end of first week, theoretical reflections on preserving the cultural heritage.

After the preliminary week the second part started, the on site work, we began to assess the object of exploration and conservation, the Church of St. Helen. In two weeks of on site work we assessed and performed a myriad of operations, starting from individual and group observations, mapping and description of the technical executions and materials, described decay phenomena of the wall paintings, started work on visual glossary and executed a multitude of research activity, starting from non-invasive to invasive procedures.

For work optimisation the students were divided into two groups. In the first week, one group was performing a detailed indoor mapping of the conservation phenomena for visual glossary; original painting techniques, deterioration phenomena, previous treatments and later on, contemporary (ours) interventions. Second group was the outside group, which assembled mappings with the aid of computer technology into a cohesive unity, the visual glossary.
In the second week, as the second phase started, the students were more pro-active in research and investigations, where the experts and professors guided us, students, in performing technological research. Thus, we have performed eye assessments, UV light observations, multi spectral analyses, thermography, XRF, portable FT-IR, and of course, chose a selection of samples for observation on microscopic levels, optical and electronic, solubility tests and first trials; cleaning, consolidation tests and other interventions, typical for first trials. My tasks were combining mappings into the visual glossary, operating UV light and photographic equipment, assisting with other technological equipment and doing specific sampling testing; colour adhesion trials, wall humidity trials, etc.

For conclusion of the on site operations, we have presented our results to all involved in the project, sponsors, contributors, and the local community. In these two weeks on site, we have visited many cultural-historic sites with the aim of deeper understanding of its surroundings. The Hrastovlje wall paintings have shown us the horizons, painting techniques and technologies of the John of Kastav's workshop, the detail and wholeness of major architectural object on example of Piran's Church of St. George we explored many other natural and historical landmarks, the Škocjan caves. In addition to the cultural visits, we had some relaxing moments such as the boat trip to Piran or the excursion along the river Reka which made our stay in this region pleasant as well as interesting.
After the on site work the last week of joint operations followed. The analytics and

concluding works, where we prepared complete graphical documentation and individually written final reports, condition assessment of the wall paintings and a proposal for a conservation treatment.

**Daily plan**

| 2-6 August<br>**WEEK 1 online: Zoom** | |
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| **DAY 1**<br>**Monday, 2. 8.**<br>**9.00-17.00** | 9.00–10.30<br>- Introduction of the partners and participants<br>- Presentation of the summer school (short PPT of each institution): Ajda Mladenovič (IPCHS); Giacinta Jean (SUPSI); Blaž Šeme (ALUO); Jonas Roters (HKB); Suzana Damiani or Neva Pološki (ALU)<br>10.45–12.30<br>- Presentation and introduction about the site and history of the church (Marta Bensa IPCHS, Minka Osojnik IPCHS)<br>- Available documentation (Marta Bensa IPCHS, Minka Osojnik IPCHS)<br>- Group forming<br>12.30–13.30 Lunch Break<br>13.30–14.00<br>- **Lecture**: *Examples of mapping: Materials and techniques, previous interventions, decay phenomena* (Alberto Felici, Giulia Russo, Stefania Luppichini SUPSI)<br>15.30–16.15<br>- Group work: Prepare a base line graphic documentation on the base of the professional rectify photos to be used for future mapping (AutoCad)<br>16.30–17.00<br>- Feed back – groups exchange information |
| **DAY 2**<br>**Tuesday, 3. 8.**<br>**9.00-17.00** | 9.00–10.00<br>- **Lecture**: *The methodological and interdisciplinary approach for the conservation of wall paintings* (Alberto Felici, SUPSI)<br>10.15–12.30<br>- Group work: Prepare a base line graphic documentation<br>12.30–13.30 Lunch Break<br>13.30–14.30<br>- **Lecture**: *Data collection and data management* (Giulia Russo, Stefania Luppichini, SUPSI)<br>14.30–16.15<br>- Group work: Prepare a base line graphic documentation<br>16.30–17.00<br>- Feed back – groups exchange information |

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| **DAY 3 Wednesday, 4. 8.** | 9.00–10.00<br>- **Lecture**: *Techniques and materials of Slovene wall paintings* (Martina L. Kikelj, IPCHS)<br>10.15–12.30<br>- Group work: Prepare a base line graphic documentation<br>12.30–13.30 Lunch Break<br>13.30–14.30<br>- **Lecture**: *Wall painting monuments of the Karst region* (Minka Osojnik, Andrej Jazbec, IPCHS)<br>14.30–16.15<br>- Group work: Prepare a base line graphic documentation<br>16.30–17.00<br>- Feed back – groups exchange information |
| **DAY 4 Thursday, 5. 8.** | 9.00–10.00<br>- **Lecture**: *Regular condition monitoring and risk assessment as a basis for preventive and planned conservation: the case of medieval wall paintings in Slovenia* (Blaž Šeme, ALUO)<br>10.15–12.30<br>- Group work: Prepare a base line graphic documentation<br>12.30–13.30 Lunch Break<br>13.30–14.30<br>- **Lecture**: Scientific investigation for the study of wall paintings (Francesca Piquè, Patrizia Moretti, SUPSI)<br>14.30–16.15<br>- Group work: Prepare a base line graphic documentation<br>16.30–17.00<br>- Feed back – groups exchange information |
| **DAY 5 Friday, 6. 8.** | 9.00–10.00<br>- **Lecture**: *Environmental monitoring and conditions of the Gradisce church* (Katja Kavkler, IPCHS)<br>10.15–12.30<br>- Group work: Prepare a base line graphic documentation<br>12.30–13.30 Lunch Break<br>13.30–14.30<br>- **Lecture and discussion:** *Preserving the authentic - basic principle or empty phrase?* (Jonas Roters, HKB)<br>14.30–16.00<br>- Group work: Prepare a base line graphic documentation<br>16.15–17.00<br>- Feed back – groups exchange information (finished mapping and fist ideas about visual glossary) |

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| **Sunday, 8. 8.** | Travel and arrival<br>See **Practical Information** |
| 9-15 August<br>**WEEK 2 on site** | |
| **DAY 1**<br>**Monday, 9. 8.**<br>**9.00-17.00**<br>12.30 -13.30<br>Lunch Break | **On site:**<br>**LECTURE 1:** *Short presentation of all partners – introduction of participants*<br><br>**Practical work on site**:<br>• Individual observation of the church exterior and of the wall painting inside.<br>• Feedback on individual observations, Group forming<br>• Observation, description and mapping of the technical executions and materials and decay phenomena of the wall paintings<br>• Visual glossary: definition and organization<br>• Feedback – groups exchange information |
| **DAY 2**<br>**Tuesday, 10. 8.**<br>**9.00-17.00**<br>12.30 -13.30<br>Lunch Break | **Conference room:**<br>**LECTURE 2:** *Non-invasive and invasive analyses of paint layers, mortars and degradation products of originals and former interventions in the Church of St. Helen* (Katja Kavkler, IPCHS)<br>**LECTURE 3**: *Presentation of restoration works at church of Virgin Mary in Dolenja vas* (Minka Osojnik, Andrej Jazbec, IPCHS)<br><br>**Practical work on site:**<br>• Discussion on the results of the diagnostic investigations<br>• UV light observation<br>• Observation, description and mapping of the technical executions and materials and decay phenomena of the wall paintings<br>• Feed back – groups exchange information on the on the daily activities carried out |
| **DAY 3**<br>**Wednesday, 11.8.**<br>**9.00-17.00**<br>12.30 -13.30<br>Lunch Break | **Practical work on site:**<br>• Thermography (Katja Kavkler IPCHS) – depends on the weather (flexible activity)<br>• Observation, description and mapping of the technical executions and materials and decay phenomena of the wall paintings<br>• Feed back – groups exchange information on the on the daily activities carried out<br><br>**Conference room:**<br>**LECTURE 4:** *Case Study: Medieval Wall Paintings in the Church of St. Mary of Pond in Gologorica; Researches and treatments* (Neva Pološki, ALU) |

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| | **LECTURE 5:** *Microorganisms: mechanisms of biodeterioration, but not only!* (Cristina Corti, SUPSI) + practical exercises |
| **DAY 4**<br>**Thursday, 12. 8.**<br>**9.00-17.00**<br>12.30 -13.30<br>Lunch Break | **Practical work on site:**<br>• Observation, description and mapping of the technical executions and materials and decay phenomena of the wall paintings<br>• Discussion: the conservation needs, concept of the intervention and criteria for the choice of materials and techniques<br><br>*Afternoon excursion (2 hrs)*: *church of Virgin Mary in Dolenja vas* (Andrej Jazbec, IPCHS) |
| **DAY 5**<br>**Friday, 13. 8.**<br>**9.00-17.00**<br>12.30 -13.30<br>Lunch Break | **Practical work on site:**<br>• First trials: cleaning, fixing, first intervention treatments<br>• Assessment and documenting the trials carried out<br>• Feed back – groups exchange information on the on the weekly activities carried out |
| **WEEKEND**<br>**14. 8. and 15. 8.** | *All day excursions*:<br>SATURDAY<br>**Holy Trinity Church, Hrastovlje** (Marta Bensa, Anita Kavčič Klančar, IPCHS)<br>The church is painted with Gothic frescoes by Johannes de Castua from 1490.The most famous is the Dance of Death or "Danse Macabre"; approx. 2 hrs + time for lunch<br>**Lipica Stud Farm**<br>Lipica is the oldest European stud farm continuously breeding one of the oldest cultural horse breeds. As such it has a remarkable significance as a cultural, historical and natural heritage for Slovenia and Europe; approx. 2 hrs<br><br>SUNDAY<br>**Piran** (Minka Osojnik, IPCHS)<br>Visit of the medieval town, its town walls, church of Saint George, the bell tower, boat trip…+ time for lunch |
| 16-21 August<br>**WEEK 3 on site** | |
| **DAY 1**<br>**Monday, 16. 8.**<br>**9.00-17.00**<br>12.30 -13.30<br>Lunch Break | **Practical work on site:**<br>• Assessment of the trials carried out (Katja Kavkler, IPCHS)<br>• First trials: cleaning, fixing, first intervention treatments<br>• Planning diagnostic insights |
| **DAY 2**<br>**Tuesday, 17. 8.**<br>**9.00-17.00**<br>12.30 -13.30<br>Lunch Break | **Practical work on site:**<br>• Non-invasive: multispectral images, XRF, Portable FT-IR, portable Raman; |

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| | • Invasive: samples for observations with optical and electronic microscope, cross sections and thin sections, FTIR and Raman microscopes, dissolving tests First trials: cleaning, fixing, first intervention treatments (Katja Kavkler, IPCHS)<br>• First trials: cleaning, fixing, first intervention treatments<br><br>*Afternoon excursion (3 hrs)*: *Visit to the Škocjan caves – the UNESCO world heritage site (optional)* |
| **DAY 3**<br>**Wednesday, 18. 8.**<br>**9.00-17.00**<br>12.30 -13.30<br>Lunch Break | **Practical work on site**:<br>• First trials: cleaning, fixing, first intervention treatments |
| **DAY 4**<br>**Thursday, 19. 8.**<br>**9.00-17.00**<br>12.30 -13.30<br>Lunch Break | **Practical work on site**:<br>• First trials: cleaning, fixing, first intervention treatments<br>• Feedback on the non-invasive diagnostic insights<br>• Feedback on the finalization of the documentation collected<br><br>*Afternoon excursion (2 hrs)*: *church of Holy Lady of Assumption, Vremski Britof* (Andrej Jazbec, Minka Osojnik, IPCHS) |
| **DAY 5**<br>**Friday, 20. 8.** | Presentation of the results by the students to the local community, representatives of the Ministry of Culture of Slovenia and interested professional and laic public<br>**Conference room:**<br>10.00-10.15<br>Welcome speeches (representative of the Ministry of Culture of Slovenia, representative of IPCHS, mayor of Municipality of Divača)<br>10.15-11.00<br>Presentation of the Summer school and its results<br>**Church of St. Helen:**<br>11.30-13.00<br>Presentation on site – discussion, questions...<br>Refreshment |
| **Saturday, 21. 8.** | Return home |
| 23-27 August<br>**WEEK 4 online** | |
| **DAY 1**<br>**Monday, 23. 8.**<br>**9.00-17.00** | Follow-up week<br>- Discussion of analytical results and further steps to be taken.<br>- Writing up the final report “Condition assessment of the wall paintings and proposal for a conservation treatment” and complete documentation of the activities carried out. |
| **DAY 2**<br>**Tuesday, 24. 8.**<br>**9.00-17.00** | Follow-up<br>Feedback – groups exchange information |

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| **DAY 3**<br>**Wednesday,**<br>**25. 8.**<br>**9.00-17.00** | Follow-up<br>Feedback – groups exchange information |
| **DAY 4**<br>**Thursday, 26. 8.**<br>**9.00-17.00** | Follow-up<br>Feedback – groups exchange information |
| **DAY 5**<br>**Friday, 27. 8.**<br>**9.00-17.00** | Follow-up<br>Feedback – groups exchange information |