



## Hands-on methodology in Alexandria using Non-Destructive Testing

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EDICULA: Educational Digital Innovative Cultural heritage related Learning Activities

Project Code: 2020-1-EL01-KA203-079108



# Non-Destructive Techniques (NDT) are used in the Field of Protection of Cultural Heritage because:

- ✓ *Destructive sampling is prohibited in the conservation of historic monuments*
- ✓ *They offer certain unique capabilities in a variety of applications*

## BUILT CH PROTECTION

DIAGNOSIS

PLANNING  
OF INTERVENTIONS

IMPLEMENTATION  
OF INTERVENTIONS

ASSESSMENT OF INTERVENTIONS

MONITORING

## USE OF NDTs

STATE OF PRESERVATION

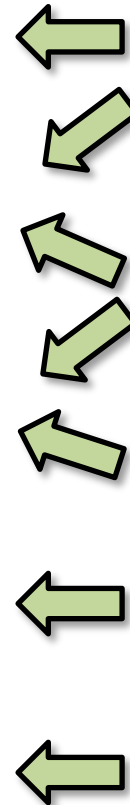
- ENVIRONMENTAL IMPACT ASSESSMENT
- STRUCTURAL & PHYSICO-CHEMICAL DATA
- MATERIALS & DECAY-DAMAGE MAPPING

MATERIALS QUALITY CONTROL

DECISSION MAKING

EFFECTIVENESS & COMPATIBILITY ASSESSMENT

MONITORING – MAINTENANCE



**Validation by laboratory testing**



**NATIONAL TECHNICAL UNIVERSITY OF ATHENS  
LABORATORY OF MATERIALS SCIENCE AND ENGINEERING**

**Portable Digital Microscopy**

**Digital Image Processing**

**Colorimetry**

**Ultrasonic Testing**

**Schmidt hammer**

**Endoscopy**

**Infrared Thermography**

**Ground Penetrating Radar**



**Advanced Spatial Data Management  
& Assessment Methods**

### **MONUMENT SCALE**

**Characterization of Materials**

**Evaluation of Materials & Interventions  
Compatibility**

**Environmental Impact Assessment**



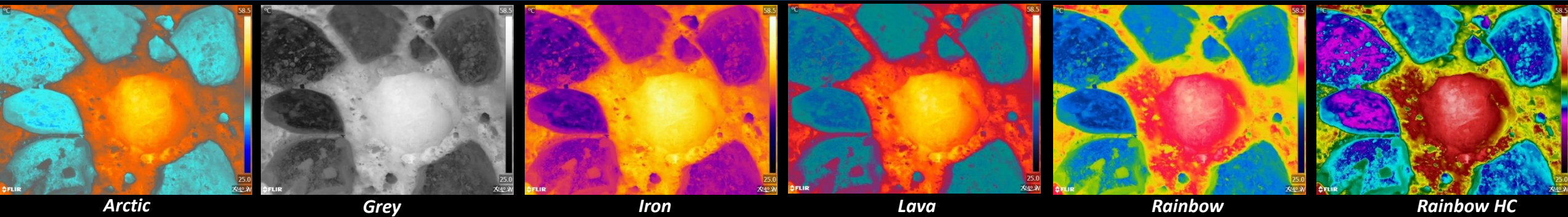
### **INTEGRATED PROJECTS**

**Strategic Planning of Conservation Interventions  
on Historic Buildings**

**Strategic Planning  
of Environmental Management as a Tool for a  
Sustainable Preservation of Historic Cities**

# Short description of the theory of Infra Red thermography (IRT)

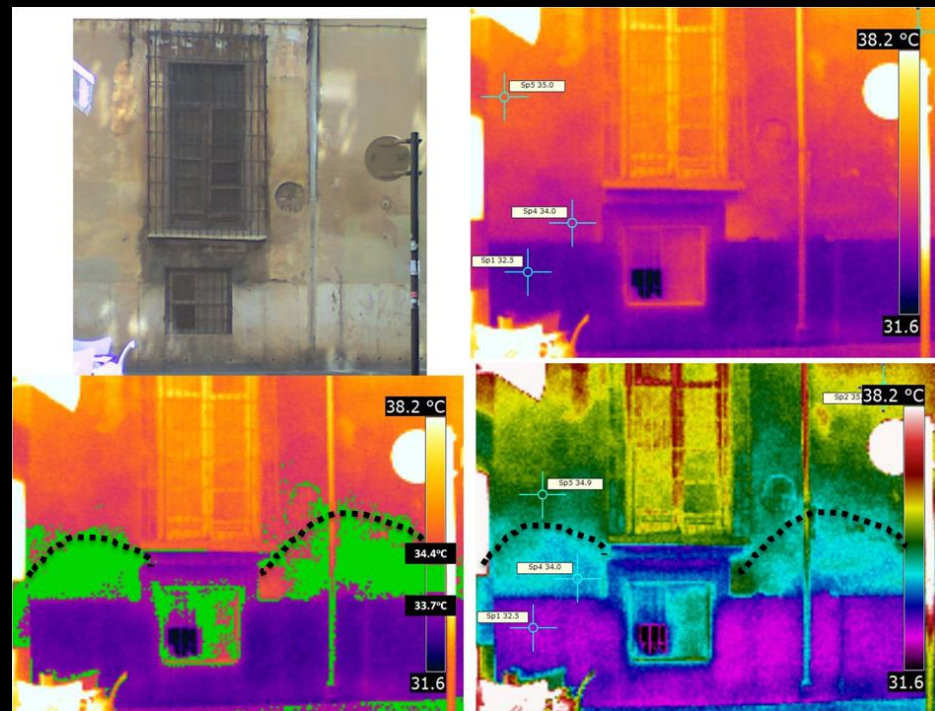
Infra Red Thermography (IRT): Every material emits infrared radiation above absolute zero temperature. IRT measures the thermal variations of the material under investigation and produces an image. The IRT image presents temperature readings and their distribution on the examined surface by the rendering of different colors.



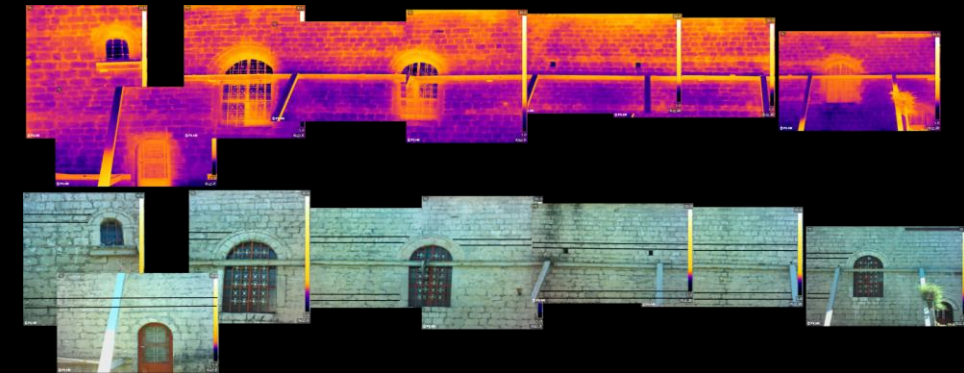
## Important tips

- ✓ Different colors depict different temperatures, depending on the color palette used,
- ✓ Always pay attention on the temperature scale to interpret an infra-red thermography image
- ✓ Iron color palette: the warm colors of red, orange, and yellow, as well as white represent higher temperatures
- ✓ Iron color palette: the cool color of purple, as well as black represent lower temperatures
- ✓ Atmospheric temperature, relative humidity, emissivity, and distance are parameters that need to be measured before each thermograph (emissivity values can be measured in situ or found in several reference tables in the literature)
  - ✓ Then, these parameters are imported in the thermal camera software
- ✓ During elaboration, selection of the appropriate temperature range is a key issue for the image interpretation, since it determines the contrast of a thermal image
  - ✓ Ultimate goal is to detect fine details in the false color IRT images, thus detecting temperature differences

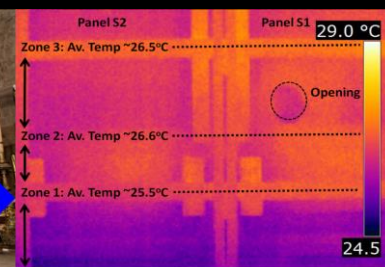
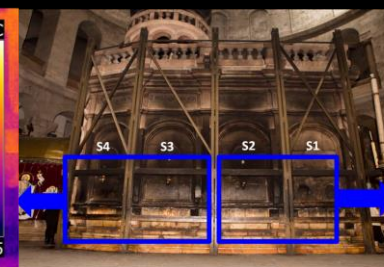
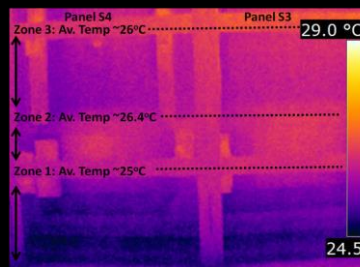
# Possible outcomes – representative results



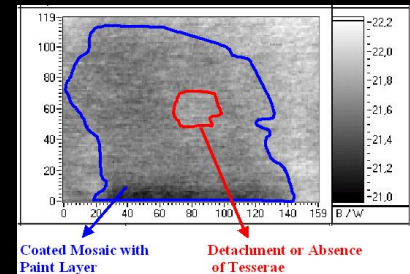
Detection of hidden structures  
*Colegio Arte Mayor de la Seda, Valencia*



Detection of hidden elements & materials mapping - Panagia Varnakova Monastery



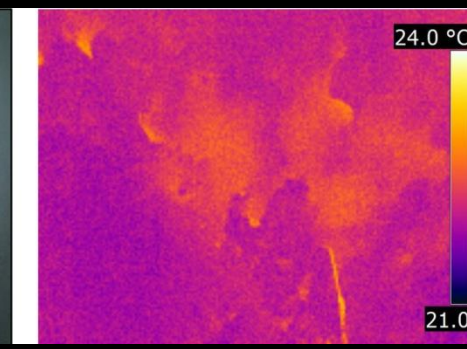
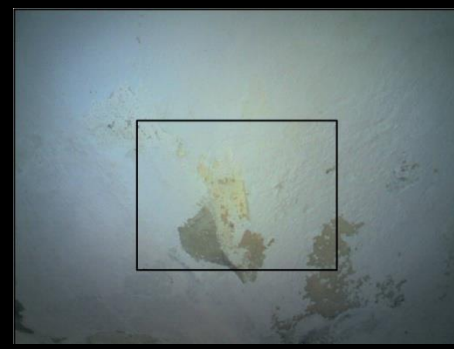
Thermo-hygric anisotropy – Holy Aedicule



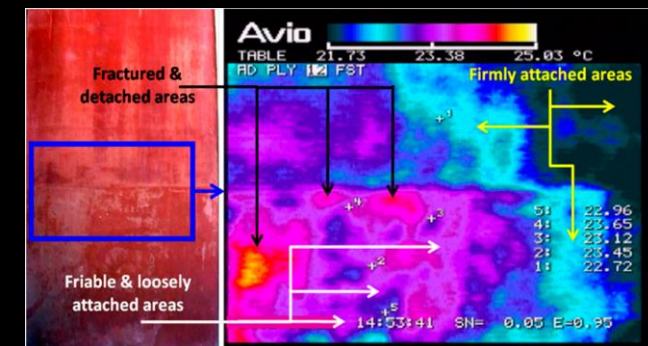
Detection of defect in coated mosaics – Hagia Sophia



Detection of the actual rising damp front  
Remaining dampness



Crack propagation – Medina, Tunis



Compatibility assessment of conservation works - National Museum of Athens

# IRT monitoring of the Shallalat Gardens in Alexandria



  
HELLENIC RESEARCH INSTITUTE  
OF THE ALEXANDRIAN CIVILIZATION

**THE ALEXANDRIA HANDS-ON WORKSHOP  
CONNECTING THE NTUA HOLY AEDICULE EXPERIENCE  
WITH THE HRIAC EXCAVATIONS AT THE SHALLALAT GARDENS**  
1-3 June 2022

The Alexandria Hands-on Workshop is organized by Hellenic Research Institute of Alexandrian Civilization (HRIAC), supported by the Patriarchate of Alexandria and all Africa, the Consulate General in Alexandria and the Hellenic Community of Alexandria. The event and the results of the workshop will be recorded and will be presented at the upcoming EDICULA "Educational Digital Innovative Cultural Heritage related Learning Alliance" Erasmus+ Multiplier Event in Athens.

**WEDNESDAY 1 JUNE 2022**  
09:00-13:00 | HRIAC Excavation at Shallalat Gardens  
**Hands on Workshop - Day 1**

**THURSDAY 2 JUNE 2022**  
09:00-13:00 | HRIAC Excavation at Shallalat Gardens  
**Hands on Workshop - Day 2**  
17:30-20:00 | HRIAC Library at the Greek District  
**Public Event**

- Introductory speech by Dr. K. Papakosta
- Inaugurations: Representatives from the Patriarchate of Alexandria and all Africa, the Consulate General in Alexandria and the Hellenic Community of Alexandria
- Prof. A. Moropoulou: The rehabilitation of the Holy Aedicule of the Holy Sepulchre in Jerusalem
- Prof. A. Georgopoulos, Dr. K. Lampropoulos: 3D dimensional geometric documentation of the Holy Aedicule and the RESPECT open access data platform: A challenge for EDICULA
- Dr. A. Deleqou: Hands-on methodology in Protection of Monuments using Non Destructive Techniques
- Dr. K. Papakosta: The excavation works at the Shallalat Gardens in Alexandria. Meeting the innovations of the Holy Aedicule rehabilitation within EDICULA: New perspectives in excavation strategies

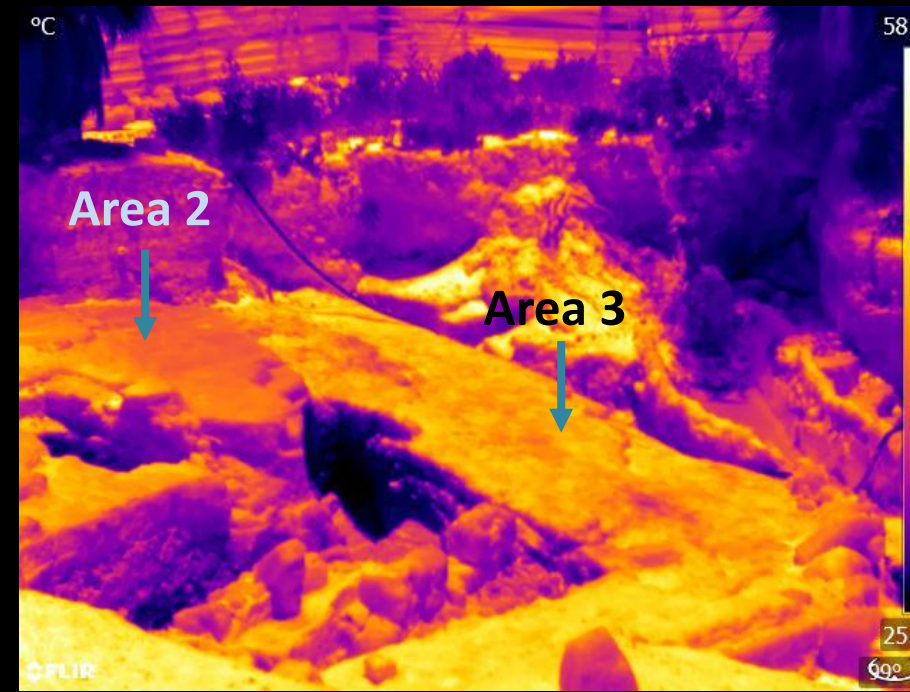
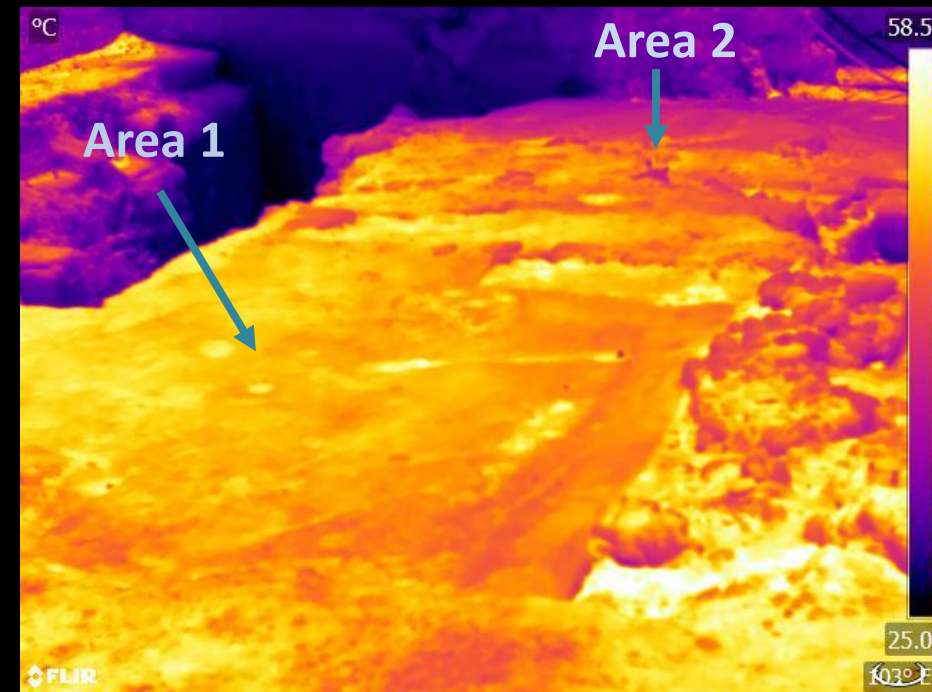
**WEDNESDAY 3 JUNE 2022**  
09:00-13:00 | Patriarchate of Alexandria and all Africa  
**Hands on Workshop & Evaluation**

Note: In this workshop outcomes from RESPECT "An exemplary information system and methodology for the integrated management, analysis and dissemination of digital cultural heritage data coming from the rehabilitation of the Holy Aedicule" Research Program funded by PA 2014-2020, and the Research Program "Exhibition and dissemination events of the results of the rehabilitation works and the research of the Holy Sepulchre in Jerusalem"(Code: 62365900), both coordinated by the National Technical University of Athens (NTUA), are presented.



with the permission of chief archaeologist K. Papakosta

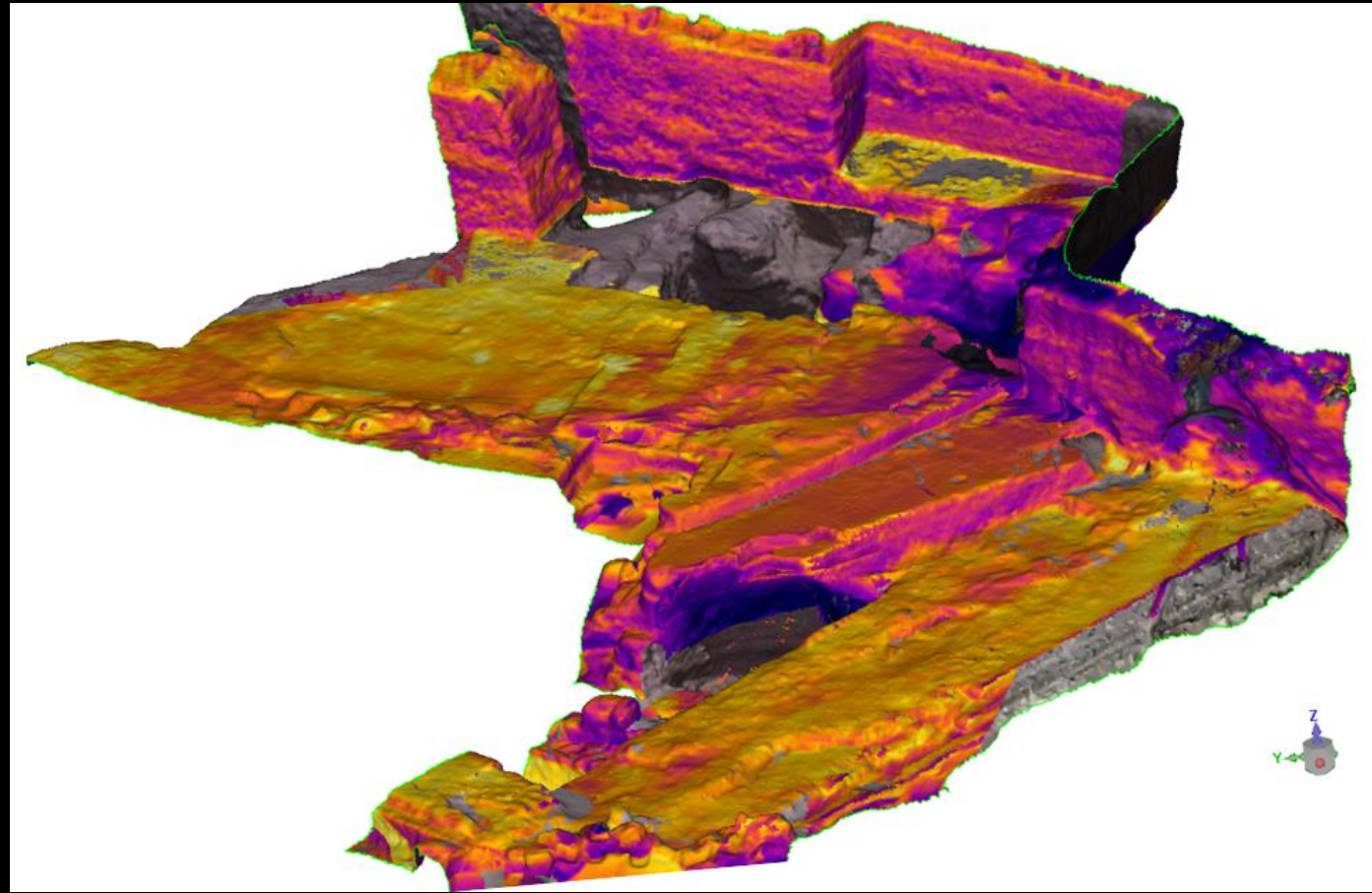
# The IRT investigation of the Royal Road of Alexandria (R1)



- ✓ The 3 distinct parts of the Royal road present high temperature variations
- ✓ Area 2 presents a lower temperature of  $\sim 5^{\circ}\text{C}$  comparing to the temperatures of areas 1 & 3
- ✓ This can be attributed to the different surface textures, indicating that area 2 holds a better preservation state

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# Developing an IRT textured 3D point cloud

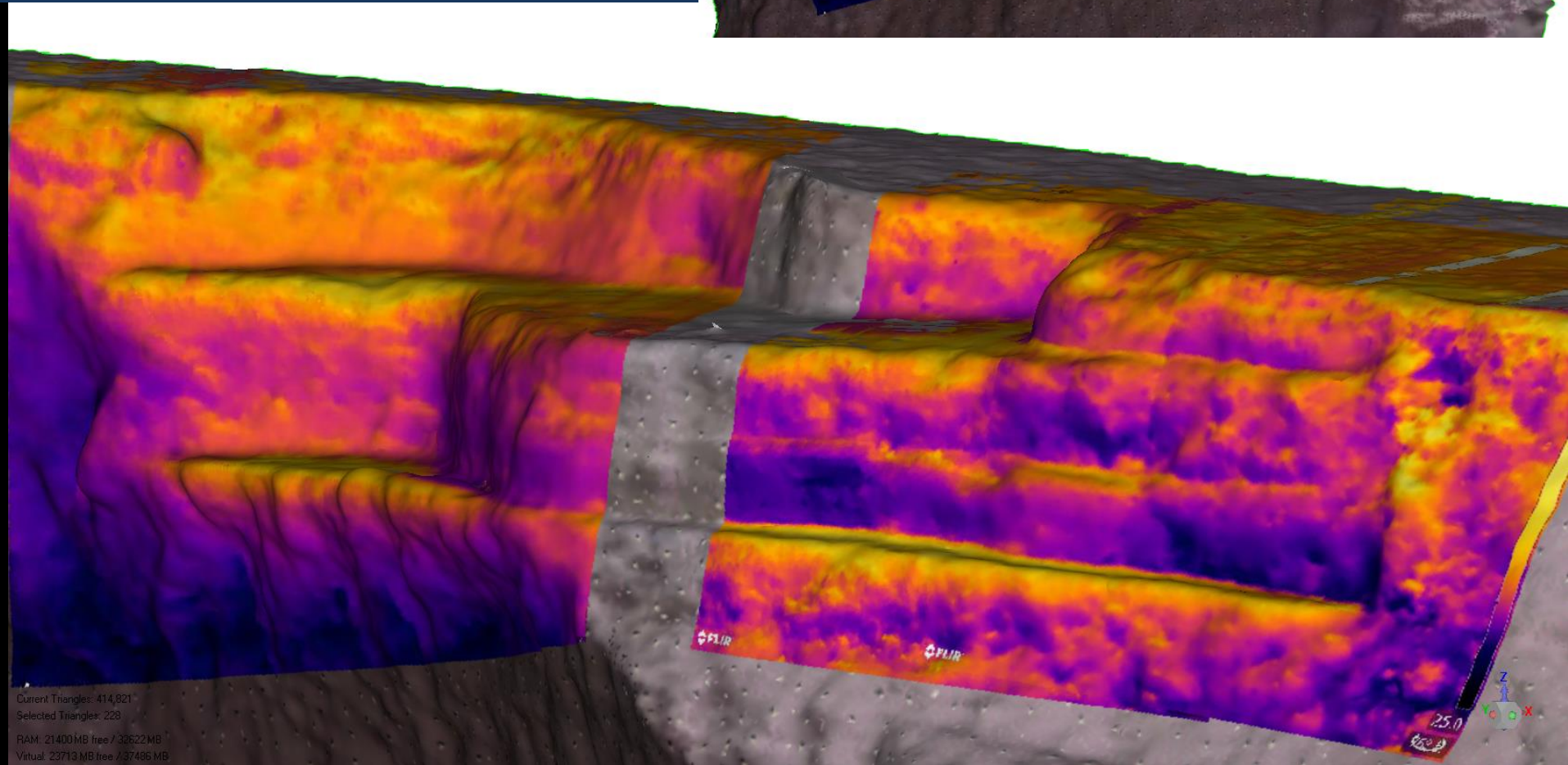
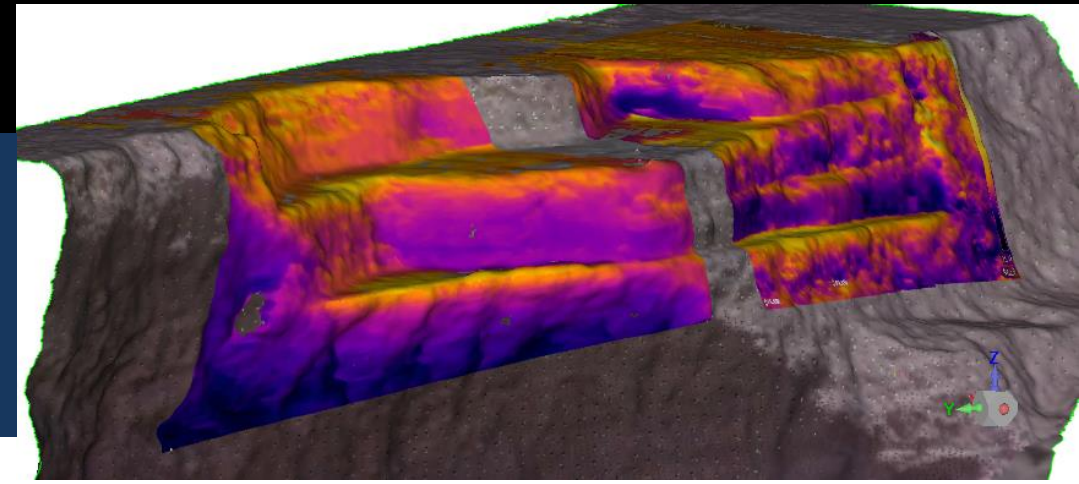


- ✓ Integration of thermal variations into the 3D point cloud
- ✓ Geo-location of the thermal variations of the Royal Road (R1)
  - ✓ Classification of building materials texture
  - ✓ Improved assessment of preservation state

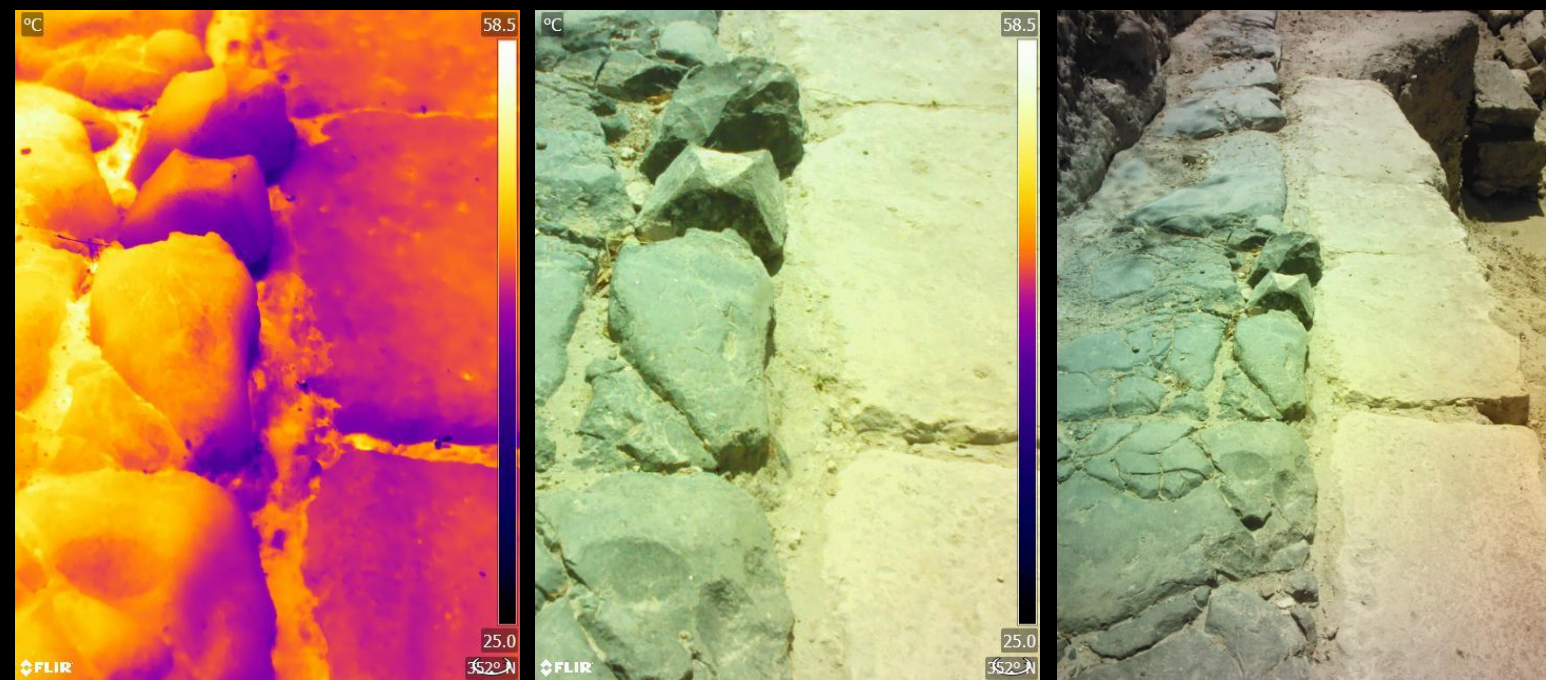


# Developing an IRT textured 3D point cloud

- ✓ Integration of thermal variations into the 3D point cloud
- ✓ Geo-location of the thermal variations of the stairs at the Royal Road (R1)
- ✓ Improved classification of building materials texture
- ✓ Improved assessment of preservation state



# The IRT investigation of the Roman road – close view



*The exact area of the thermogram*

- ✓ Black Aswan stones are depicted by higher temperatures compared to the white stones ( ~10°C difference ). This is due to:
- ✓ Different chemical/mineralogical composition, different emissivity, thermal conductivity & heat capacity



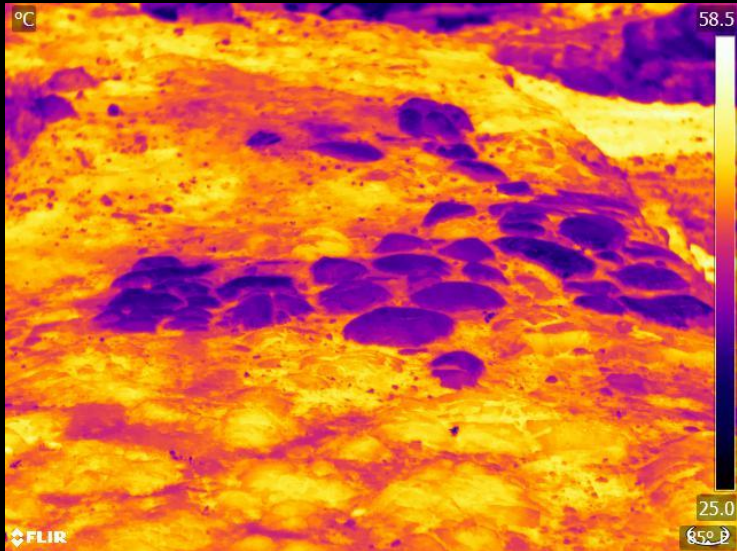
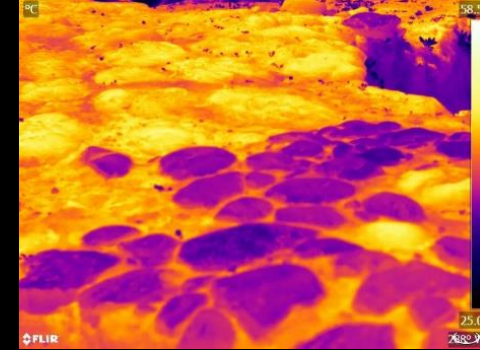
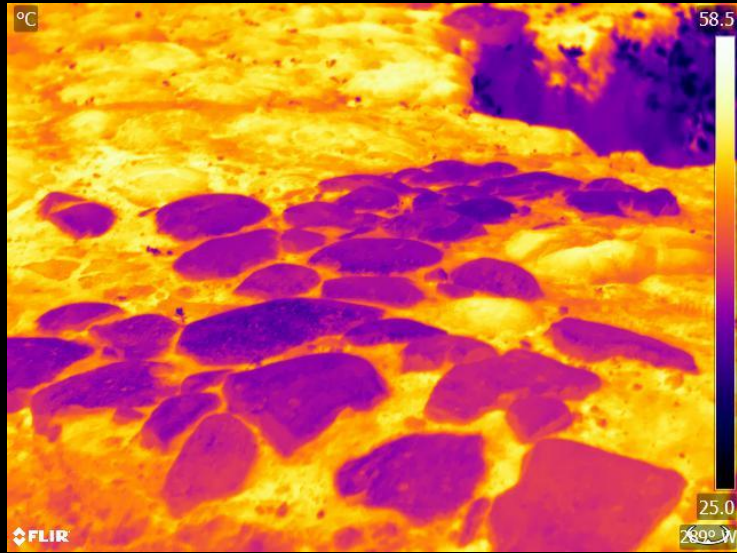
Contribution to materials mapping



*The exact area of the thermogram*

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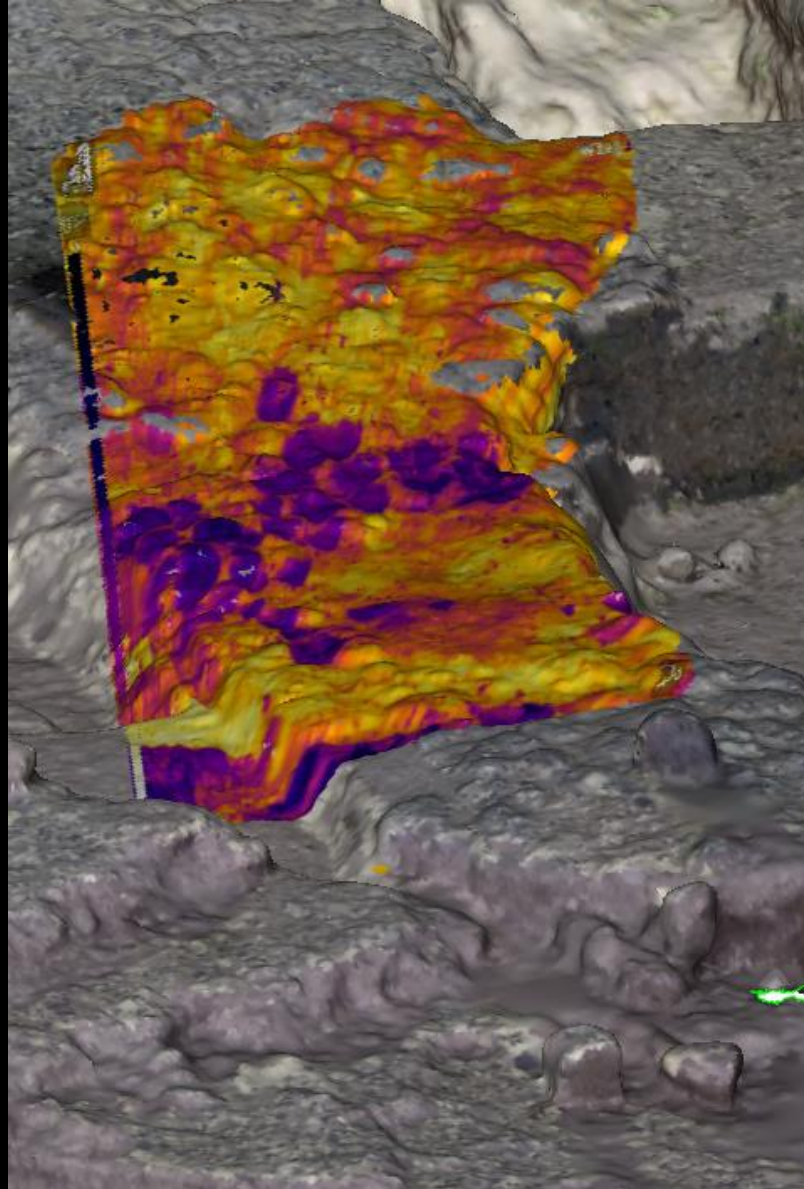
# The IRT investigation of the Roman road – distant view



- ✓ Materials mapping
- ✓ Easy & better classification of materials from a long distance

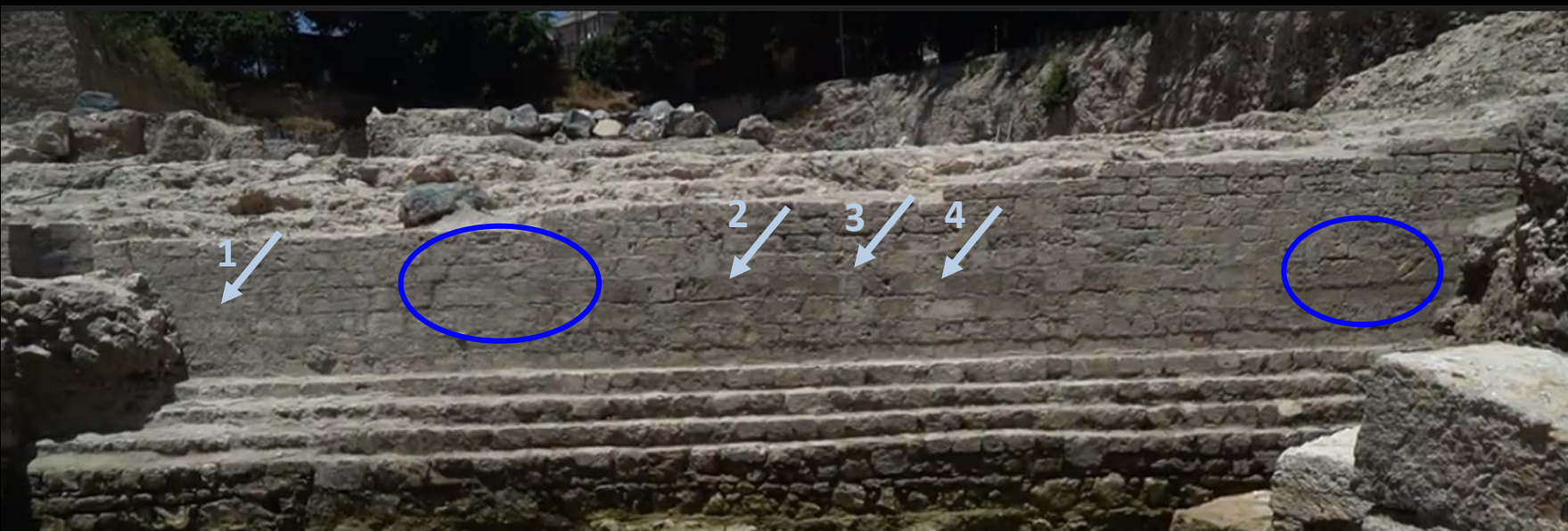
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# Developing an IRT textured 3D point cloud

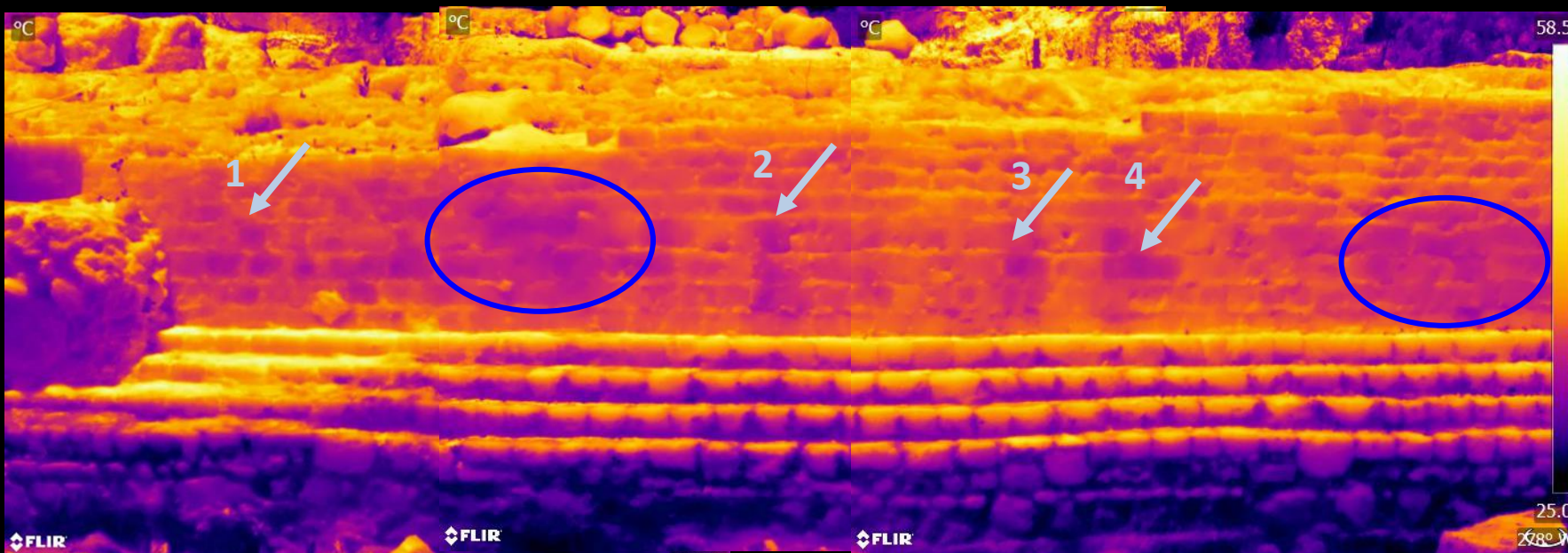


- ✓ Integration of thermal variations into the 3D point cloud
- ✓ Geo-location of the thermal variations of the Roman road
- ✓ Improved classification of building materials – materials mapping
- ✓ Improved assessment of preservation state

# The IRT investigation of the Ottoman wall



- ✓ Temperature distribution width of  $\sim 6\text{ }^{\circ}\text{C}$
- ✓ lower temperatures ( $36.2\text{ }^{\circ}\text{C}$  -  $37.6\text{ }^{\circ}\text{C}$ ) can be attributed to:

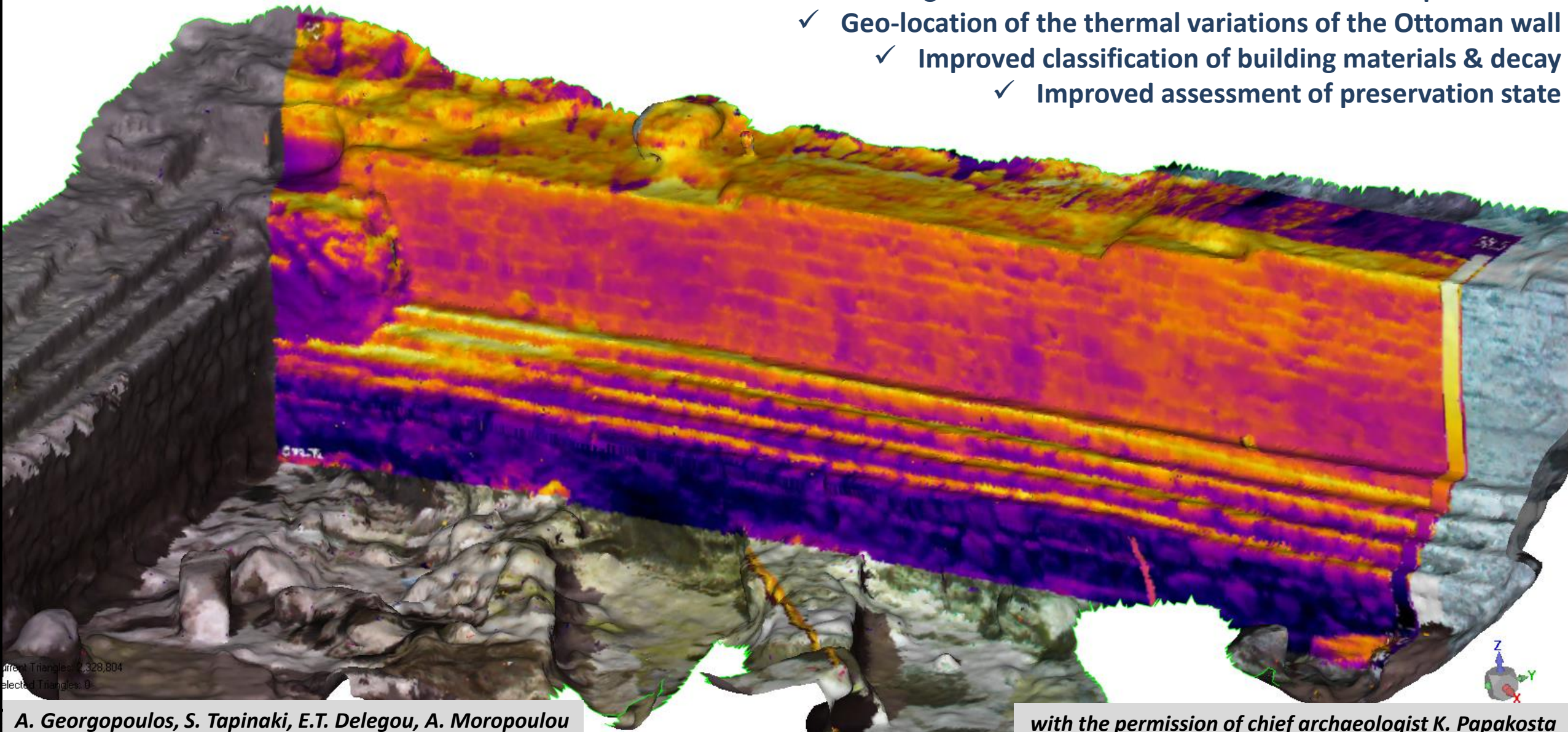


- ✓ the effect of rising damp
- ✓ different lithotypes – materials mapping

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# Developing an IRT textured 3D point cloud

- ✓ Integration of thermal variations into the 3D point cloud
- ✓ Geo-location of the thermal variations of the Ottoman wall
  - ✓ Improved classification of building materials & decay
  - ✓ Improved assessment of preservation state



A. Georgopoulos, S. Tapinaki, E.T. Delegou, A. Moropoulou

with the permission of chief archaeologist K. Papakosta

# IRT monitoring in the Museum of the Greek Orthodox Patriarchate of Alexandria and all Africa



*After invitation and with the permission of the Greek Orthodox Patriarchate of Alexandria and all Africa*

# IRT monitoring in the Museum of the Greek Orthodox Patriarchate of Alexandria and all Africa



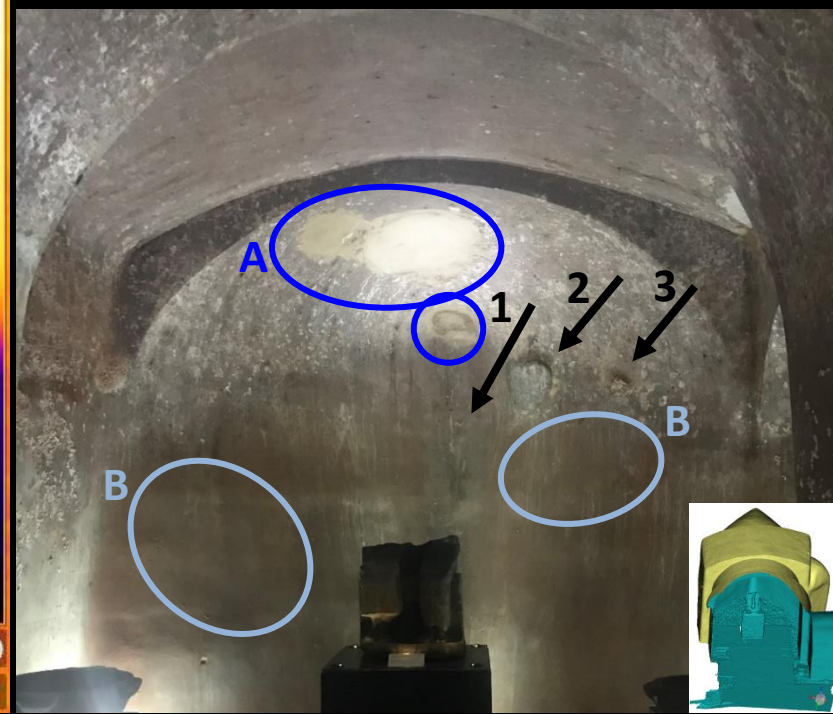
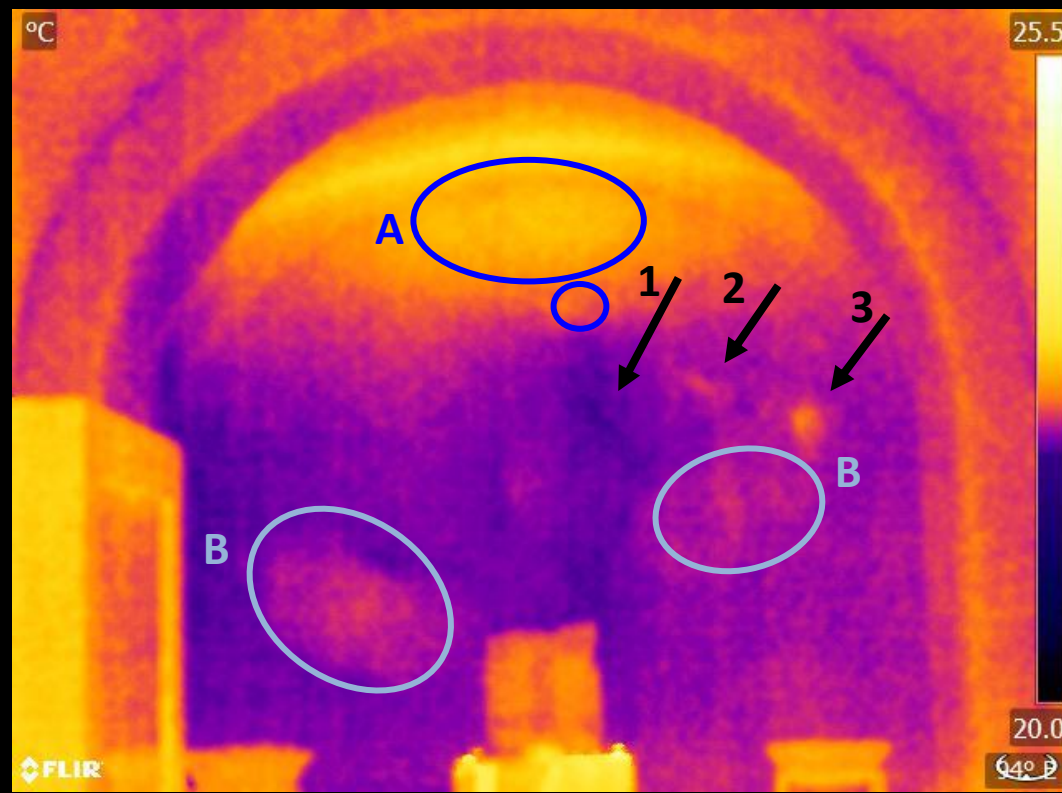
- ✓ **Underground construction**
- ✓ **Intense phenomena of rising damp**
- ✓ **Atmosphere of high relative humidity (RH= 75%)**

result to

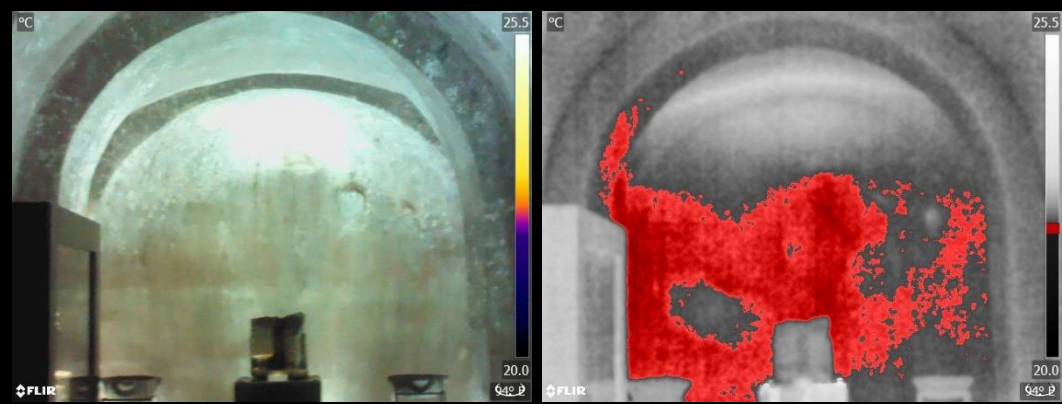
- ✓ **Intense salt efflorescence**
- ✓ **Exfoliation of older and newer restoration plasters**



# IRT monitoring in the Museum of the Greek Orthodox Patriarchate of Alexandria and all Africa



- ✓ Low Temperature distribution width (1°C)
- ✓ Area A: higher T, due to spot light stimulation, special geometry (apse), patches of newer restoration plasters & salt efflorescence
- ✓ Higher T of Area B indicates the presence of a defect area, non observable visually
- ✓ The lower T of Spot 1 can be attributed to a geometrical thermal bridge (niche). However, the thermal bridge is deviating from the vertical, due to salt efflorescence
- ✓ The higher T of Spot 2 is attributed to geometrical effects (shallow cavity), and to salt efflorescence
- ✓ The higher T of Spot 3 is attributed to salt efflorescence and surface exfoliation

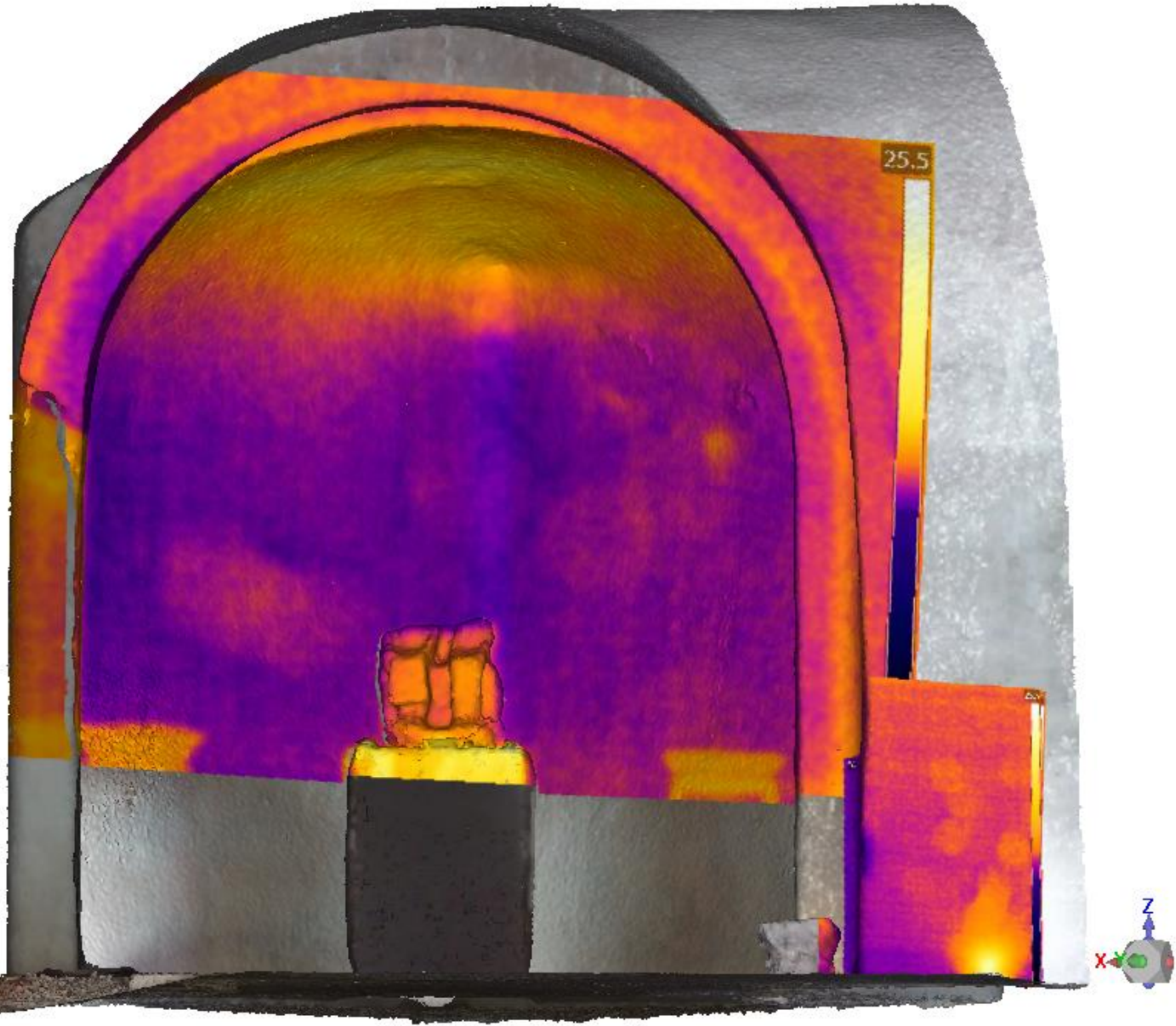


## masonry below the arch:

- ✓ The masonry's part designated by the red color can reach temperatures below the dew point
- ✓ In this case, condensation occurs and liquid water is withheld inside the masonry

The exact area of the thermogram

# Developing an IRT textured 3D point cloud



- ✓ Integration of thermal variations into the 3D point cloud
- ✓ Geo-location of the thermal variations of the Museum masonries
- ✓ Improved classification of building materials & decay
- ✓ Improved assessment of preservation state

*A. Georgopoulos, S. Tapinaki, E.T. Delegou, A. Moropoulou*

*After invitation and with the permission of the Greek Orthodox Patriarchate of Alexandria and all Africa*

# Conclusions

IRT monitoring in the excavation of the Shallalat Gardens & in the Museum of the Greek Orthodox Patriarchate of Alexandria and all Africa demonstrated significant information about the preservation state of the monuments under investigation. In particular:

- Different materials
- Materials of different textures
- Areas of rising damp , as well as areas at the risk of condensation
- Defect areas not visible by naked eye

Were detected and displayed.

Finally, the interdisciplinary approach of integrating the IRT results into the 3D model can enhance our interpretation capabilities about the preservation state of a monument, since the temperature readings are attributed to space, allowing the quantitative classification of building materials and decay, in terms of thermal properties variations.

The image shows the interior of a large, domed church. The dome is covered in intricate mosaics, including several figures of saints and angels. The walls are also decorated with mosaics and frescoes. Light streams in from several arched windows, creating a bright, hazy atmosphere. The text "THANK YOU" is overlaid in the center of the image in a large, white, sans-serif font. The overall scene is one of a grand, historic religious space.

**THANK YOU**