## COPERNICUS & ME

# Safeguarding cultural heritage in Rhodes



THE EPHORATE OF ANTIQUITIES OF THE DODECANESE NEEDED TO MONITOR SOIL MOVEMENTS NEARBY ARCHAEOLOGICAL REMAINS.



DATA FROM SENTINEL-1 ALLOWED FOR THE CREATION OF SOIL DEFORMATION MAPS OF THE AREA.

THE EPHORATE CAN FORESEE THE EFFECTS OF SOIL MOVEMENTS AND TAKE MEASURES TO SECURE AND RESTORE MONUMENTS.



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## COPERNICUS



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#### CLIMATE CHANGE AND GEOHAZARDS HAVE BEEN RECOGNISED AS VERY SERIOUS THREATS TO CULTURAL HERITAGE.

The increase in temperatures, with consequent phenomena such as floods and sea-level rise, erode our archaeological remains, endangering the physical materials with which they were built.

Also geological movements, in particular earthquakes and continuous soil subsidence, threaten the structural stability of the archaeological remains and historical buildings on which our societies and economies rely for social identity and cohesion and for sustainable growth.

Indeed, culture has a crucial role to play to achieve sustainable development and it is explicitly mentioned in the targets of the SDG N° 11 "Make cities inclusive, safe, resilient and sustainable". Target 11.4 calls for strengthening efforts to protect and safeguard the world's cultural and natural heritage. At the same time, the SDG N° 13 compels us to take urgent action to combat climate change and its impacts.

TO IMPLEMENT EFFECTIVE CONSERVATION MEASURES, GOVERNMENTS NEED RELIABLE, SHAREABLE, AND UP-TO-DATE INFORMATION ON THE STATUS OF OUR HERITAGE AND ON CLIMATE CHANGE PHENOMENA AND GEOLOGICAL MOVEMENTS AFFECTING IT.

Such information is vital to conceive and implement structural responses, preventive measures, and restoration, resilience and adaptation strategies.

According to the UNESCO, "World Heritage properties are affected by the impacts of climate change at present and in the future. Their continued preservation requires understanding these impacts to their Outstanding Universal Value and responding to them effectively" [1].



Today, methodologies to understand and quantify the effects of climate change and geological phenomena on cultural heritage are still under development. Without such methodologies, it will be very challenging for our governments and cultural authorities to deploy effective and sustainable mitigation and reconstruction plans to safeguard cultural heritage [2].



Rhodes is the historical capital and the largest of the twelve islands of the Dodecanese, in Greece.

The island is also called the Island of the Knights, after the Knights of Saint John of Jerusalem, who occupied it from 1310 to 1522.

The city of Rhodes was founded in 408 B.C., and it has a rich and fascinating history.

Known worldwide for having hosted one of the Seven Wonders of the Ancient World, the legendary Colossus of Rhodes, its medieval town is today a World Heritage site, and the island has become one of main tourist destination in Europe.

The city is located at the northern tip of the island. In addition to the mediaeval town, it also includes numerous archaeological sites, among which the area of Rodini.

Rodini was part of the necropolis of the ancient city of Rhodes, much larger than what we can see today, including monumental graves and cave sanctuaries, within a valley crossed by a torrent. IN RODINI, ARCHAEOLOGICAL REMAINS ARE EMBEDDED IN THE NATURAL BEDROCK. WE CAN SEE HERE TRACES OF A MONUMENTAL GRAVE COMPLEX, WITH FALSE DOORS AND COLUMNS SCULPTED IN THE ROCK, AS FORMING A THEATRICAL SCENE, AND A VERY BIG GRAVE IN THE FORM OF A MAUSOLEUM.

Due to the beauty of the landscape, Rodini has been also used, since ancient times, as a park and a place for recreation.

Shortly before the torrent meets the sea, a bridge built in Roman times is still in use today. The Roman Bridge (1st century B.C.) is one of the few ancient bridges preserved in Greece and the only one still in use today. Indeed, the bridge is one of the main entry points to the modern city of Rhodes. In Rhodes, excavations started after the reunification with Greece, in 1948. The ancients performed successive works to allow the population to enjoy the area of Rodini, and during the Italian occupation of the Dodecanese (1912 – 1947), a modern park was arranged there.

Today, the construction of new buildings in the area is forbidden and the park is still stunning. Nevertheless, few tourists know about Rodini, which seems today neglected [3].

THROUGHOUT THE CENTURIES, SUMMER FIRES, STORMS AND FLOODS ERODED THE ARCHAEOLOGICAL REMAINS, WHICH ARE ALSO SEVERELY THREATENED BY LAND DISPLACEMENTS. Indeed, Rhodes is situated in a seismic area, and it has been struck by numerous earthquakes. Notorious earthquakes in the island include the 226 B.C. earthquake that destroyed the Colossus of Rhodes, the one of 1481, which devastated big parts of the city of Rhodes, the earthquake of 1926, and a 6.3 magnitude earthquake in 2008.

Due to the earthquakes, part of the Mausoleum complex in Rodini has collapsed. Another nearby grave complex presents a cracked rock façade, which could cause the crumbling of the grave monuments cut in it.

Also the roman bridge, even though it is statically stable, is presenting fissures on the inner sides of the arches, which make its monitoring necessary.





#### THE EPHORATE OF ANTIQUITIES OF THE DODECANESE

Type of organisation: Public regional administration Country: Greece Annual budget in 2020: €1m - €1.5m Previous experience with Earth Observation data: No

The Ephorate of Antiquities of the Dodecanese is responsible for protecting, preserving and studying all antiquities in the islands of the Dodecanese.

Under the authority of the Greek Ministry of Culture, the Ephorate has a staff of around 100 people distributed around the islands. Most of them are based in Rhodes and in Kos.

The Ephorate performs excavations, and supervises conservation and restoration works of the antiquities in the islands, including sites, monuments and artifacts dating from prehistoric until Byzantine times. Moreover, it is in charge of authorising and controlling public and private works in the areas of heritage sites. In the last three decades, it carried out important conservation and restoration works, created new museums, organised exhibitions in the islands, and participated in periodical exhibitions of Rhodian artifacts in Greece and abroad.

The Ephorate is in charge of securing the excavations that started shortly after the reunification of the Dodecanese with Greece, and that have brought to light the ancient city of Rhodes, lying underneath the modern city.

A large number of monuments and entire parts of the ancient city were revealed. Studying them, the staff of the Ephorate realised that the island of Rhodes is subject to intense land deformation. In particular, Rodini is affected by intense ground deformation.



TO PREVENT FURTHER DAMAGE TO THE MONUMENTS IN RODINI, AND TO ADOPT EFFECTIVE CONSERVATION MEASURES, THE EPHORATE NEEDED ACCURATE AND UP-TO-DATE INFORMATION ON LAND DEFORMATION IN THE AREA. The Ephorate of Antiquities has a wellestablished collaboration with the National Technical University of Athens, which proposed their participation in the Hyperion project.

Launched in June 2019 with a duration of four years, the project is funded by the European Union's Horizon 2020 research and innovation programme, and it involves 18 partners from eight European countries.

The goal of the HYPERION project is to leverage existing tools and services and new technologies to deliver an integrated resilience assessment platform for multi-hazard risk understanding, better preparedness, faster, adapted and efficient response, and sustainable reconstruction of historical areas [2].

The project identified four test sites in Greece (Rhodes), Spain (Granada), Norway (Tønsberg) and Italy (Venice). Prior to the technical implementation of the project, a report was issued collecting needs and practices of the bodies responsible for managing cultural heritage in these sites.

In Rhodes, HYPERION aimed at recording the damage to the monuments in Rodini that is directly related to the natural environment and the microclimate of the area, at assessing their degree of risk and the rate of their deterioration over time, and at building tools to plan for conservation and restoration measures.

© HYPERION

#### THE SENTINEL-1 SATELLITES OF THE COPERNICUS PROGRAMME PROVIDED THE DATA NEEDED TO UNDERSTAND HOW LAND MOVES IN RODINI.

The Laboratory of Remote Sensing of the Technical University of Athens collected more than 100 Sentinel images from 2016 to 2019, which allowed them to assess the level of ground deformation in the area.

The images captured by Sentinel-1 satellites are particularly useful for this kind of assessment, since these satellites have a short revisit time, ranging from 6 to 12 days. This means that researchers are able to capture up-to-date information on land movements for each date in which satellite images are acquired.

Moreover, Sentinel-1 images also have a high spatiotemporal resolution, which enables for the identification of deformation patterns even on large size monuments.

The Sentinel-1 images allowed for the creation of a land deformation map of the area of Rodini.

The map shows a 10mm uplift around the area between 2016 and 2019, which clearly affects the structural integrity of the monuments there.

To ensure sustainability, after the end of HYPERION, the project partners committed to continue updating the ground deformation map once a year.



#### Hyperion



#### **Rhodes-Greece** Ground Deformation and Velocity Map



opernicus

The Ephorate of Antiquities of the Dodecanese will have access to the information on land movements in Rodini through the holistic resilience assessment platform (HRAP) that will be developed within the framework of the HYPERION project.

Through the platform, they can consult ground deformation maps which classify the level of ground deformation with different colours, and can zoom on specific locations to know how the ground is moving there.

The movements are assessed with millimetre accuracy, providing the Ephorate with extremely precise information on the structural stress affecting the monuments.

This information can be consulted for a specific day or as an annual average.

The short revisit time of the Sentinel-1 satellites allows for the updating of this map every 2 or 3 months, hence ensuring the high reliability of the information provided to the Ephorate on soil movements.

#### THE MAP FACILITATES THE EARLY RECOGNITION OF POTENTIAL RISKS TO THE MONUMENTS AND SUPPORTS THE REGULAR MONITORING OF LAND DEFORMATION PERFORMED BY THE EPHORATE IN RODINI.

The map serves as a non-invasive tool to collect the information needed to preserve cultural heritage in Rhodes. The Ephorate can identify the structures that need more urgent action and propose measures to secure and restore the monuments.

For example, they will take action to stabilise the monuments that are more affected by land deformation in the ancient necropolis in Rodini and will ask the Municipality to stop or lighten the traffic on the Roman bridge.



## REFERENCES

[1] UNESCO World Heritage Centre, Climate Change. Consulted on the 4th of February 2022.

[2] HYPERION project, Our vision.Consulted on the 4th of February 2022.

[3] HYPERION project,

Demonstration case in the Municipality of Rhodes, Greece. Consulted on the 4th of February 2022.



## LINKS

Ministry of Culture and Sports of the Hellenic Republic:

www.culture.gov.gr/en/SitePages/default.aspx Ephorate of Antiquities of the Dodecanese: www.culture.gov.gr/en/ministry/SitePages/viewyphresi a.aspx?iID=1705

Remote Sensing Laboratory of the National Technical University of Athens: www.youtube.com/watch? v=rJoUs3bHWcI

Hyperion project: www.hyperion-project.eu Labadi, S., Giliberto, F., Rosetti, I., Shetabi, L., Yildirim, E. (2021). Heritage and the Sustainable

Development Goals: Policy Guidance for Heritage and Development Actors. Paris, ICOMOS:

www.icomos.org/images/DOCUMENTS/Secretariat/20 21/SDC/ICOMOS\_SDGs\_Policy\_Guidance\_2021.pdf The Global Goals for Sustainable Development, Goal 11 Make cities and human settlements inclusive, safe, resilient and sustainable: www.globalgoals.org/11sustainable-cities-and-communities

Coal 13 Take urgent action to combat climate change and its impacts: www.globalgoals.org/13-climateaction

UNESCO World Heritage Centre (2008) Policy Document on the Impacts of Climate Change on World Heritage Properties: https://whc.unesco.org/en/news/441

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