



## **A methodology for the in-situ chemical analysis and monitoring of environmental and climatic deterioration products on monuments using advanced, non-contact, laser-based technologies**

Paraskevi Pouli (1), Philippidis Aggelos (1), Kalokairinou Eleni (1), Melessanaki Krystalia (1), Kokkinaki Olga (1), Siozos Panagiotis (1), Hatzigiannakis Kostas (1), Kavoulaki Elissavet (2), Politaki Elpida (2), and Psaroudaki Angeliki (2)

(1) Institute of Electronic Structure and Laser, Foundation for Research and Technology-Hellas (IESL-FORTH), Heraklion, Crete, Greece (ppouli@iesl.forth.gr), (2) Ephorate of Antiquities of Heraklion, Heraklion, Crete, Greece

Every single monument, historical center and archaeological landscape is continuously threatened by climatic change, extreme meteorological phenomena and natural hazards. The HERACLES project (“HERitage Resilience Against CLimate Events on Site”, GA 700395) aims to design, validate and promote responsive systems, methodologies and techniques in order to mitigate the impact of climate change and natural hazards on Cultural Heritage sites, structures and artefacts.

Towards this end the continuous inspection for deterioration features and their correlation to climatic changes is essential. In this work, a methodology for the chemical analysis and monitoring of decay products due to environmental impact, such as efflorescence and salt accumulations on monuments and Cultural Heritage sites, is presented. The objective is to determine the nature and the conditions that trigger the presence and the evolution of degradation products and define the factors responsible for their expansion, especially the ones related to the climate change. In this respect the determination of their chemical composition and spatial distribution on the monument along the year is of vital importance. Data obtained through regular measurements recorded from portable instruments (Multispectral Imaging, portable Raman and Laser Induced Breakdown spectroscopy) are investigated and cross-correlated to produce maps that will indicate expansion trends and risks.

The methodology consists of the following actions-steps: 1) selection of indoor and outdoor areas where intense and expanded surface degradation and decay products, are present 2) sampling of raw material from the selected areas and analysis in the laboratory using Raman and LIBS spectroscopies in order to determine their chemical composition and develop a data-base of reference analytical information, 3) in-situ measurements on the selected areas using portable Raman and LIBS instruments, 4) validation of the in-situ results to the ones acquired in the laboratory and correlation with the data obtained from multispectral imaging in-situ measurements in order to define areas of high risk, 5) repetitive in-situ measurements aiming to monitor the formation and the extension/evolution of decay products at the areas of interest over the year and under various weather conditions.

The methodology is developed on the two test-beds of HERACLES in Heraklion, Crete, Greece; namely the Archaeological site of Knossos and the Venetian sea-fortress of Koules. Both monuments of different historical eras and construction materials, are subject to variable climatic conditions and their study is expected to enlighten the influence of climatic change to the safeguarding of CH assets.