Modern shelters and limestone decay in archaeological sites - a study from Malta

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Background

The UNESCO World Heritage Sites of Ħaġar Qim and Mnajdra were constructed between the mid-4th and mid-3rd millennia BC. Three of these prehistoric Megalithic Temples were covered with a temporary open-sided shelter between 2009 and 2014. This was to protect the Temples from environmental factors causing deterioration of the Temple materials and the structures. The sheltering was preceded by intense environmental monitoring which lasted for 1 year and which is continuing, albeit not without operational problems, until today.

Figure 1. The sheltered prehistoric site of Mnajdra in Malta – the first site being studied in a holistic manner to determine the effects of the shelter on the limestone megaliths.

Problems over the years

The Temples consist of free-standing megaliths which are up to 6.4 m long and weigh up to 20 tonnes, made of two types of locally available limestone (Globigerina Limestone and Coralline Limestone) of which the Globigerina Limestone is particularly subject to salt decay, usually manifest as advanced powdering, flaking and granular disintegration. In addition, the now roofless double wall construction of the Temples with a rubble and soil infill has for centuries been vulnerable to the external environment, including direct rainfall, which has gradually depleted this infill, destabilizing the mortar-free structure. Consequently, instead of behaving as a homogeneous structure, these Temples can over time behave as a series of freestanding megaliths moving independently of each other, leading to a series of collapses over the years before sheltering.

The sheltering

A number of studies on the Temples have been carried out over the years. Besides an existing rich archaeological bibliography dating from the 19th century to today, over the last 40 years there have also been many other studies, albeit sporadic, aiming to understand the structures and how they were built, the materials themselves, and their deterioration and the surrounding environment. These have all contributed to the current understanding of the sites and their problems, and also led to the decision to shelter the sites, a venture which was made possible through EU (ERDF) funds. These reversible open-sided structures (Figure 1) are covered with a PTFE membrane which has a life expectancy of 25 years.

It was therefore being urgently felt that a concerted efforted had to be made to understand precisely the behaviour of the shelters, and more importantly the prehistoric materials beneath the shelters, and how the changed environment beneath the shelters is contributing to the preservation, or otherwise, of the fragile megalithic surfaces. This led to the launch of a three-year research project to understand exactly what is happening beneath these shelters, also as compared to the environment before the sheltering took place.

Current study

The current project, which includes a team of conservation and natural scientists, engineers, and archaeologists, has two main thrusts:

- Environmental monitoring and the modelling of data (past and present) to understand how the climate has changed in the Temple sites since the erection of the shelters. This is being based on a vast array of data collected at the sites, and includes air and surface temperature, RH, insolation, wind and soil moisture data in particular.
- Study of the effects of salt weathering on the limestone, and its modelling, to define precisely how the salts present within the megaliths are bringing about their deterioration, also related to the above-mentioned data.

The ultimate aim is to ensure the continued preservation of the sites in the future, with or without a shelter.

Concluding remarks

The study has now entered its second year (with a hiatus due to the pandemic) where more and better *in situ* data are being collected. These includes the analysis of the megaliths themselves (deterioration materials, deposited salts, dust, etc) with newly acquired portable equipment (portable XRD-XRF, portable XRF, portable Raman, portable FTIR, thermal imaging equipment) and supporting lab equipment (ESEM). The monitoring and modelling of wind flow over and under the shelters, and around the megaliths, is now at an advanced stage. It is hoped that within the next six months we will be able to start integrating all the data within the models being produced. These data will also be amalgamated with the yearly mapping of the megaliths (deterioration phenomena, biological patinas) so as to then eventually produce a true picture of what is happening beneath the shelters, and to qualify and record the effects of the shelters on the covered limestone megaliths, for their future preservation.