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New insights about the consolidation of archaeological mortars located in underwater environment: the case study of the apsidal fishpond of Castrum Novum (Santa Marinella, Rome, Italy)

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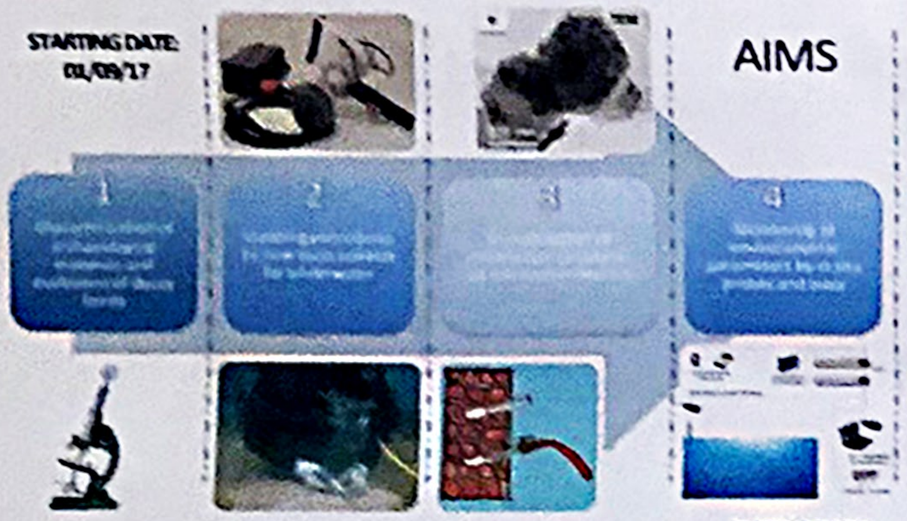
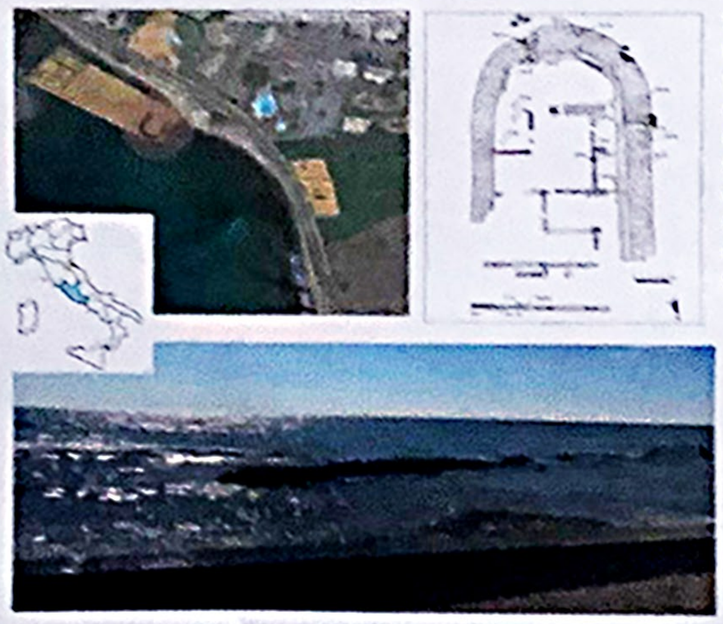
INTRODUCTION

This work is part of a research project titled MaTaCoS (Advanced materials and technologies applied to the conservation of underwater cultural heritage) funded by the Italian Ministry of Economic Development (MISE), concerning development of innovative tools and methods for the protection of Underwater Cultural Heritage, with particular regard to cleaning and consolidating procedures to be carry out directly in situ. The fishpond of the archaeological site of Castrum Novum (Santa Marinella, Rome, Italy) was chosen as a pilot site for experimentation. Castrum Novum was a Roman colony whose ruins are located between Torre Chiaruccia and Casale Alibrandi. The archaeological site lies on a wide area facing the sea, at the 64.4 km of the Aurelia State Road, in the Province of Rome, in a territory corresponding to today's Santa Marinella, which, during the Roman ages, belonged to Caere, now Cerveteri. During the first half of the third century BC, it was one of the most important cities found along the ancient Etruscan coast as Alsium (now Palo Laziale) and Pyrgi (Santa Severa). Other significant remains, concerning the ancient city and the ancient harbour, lie close to the beach where now some modern stilts stand. The apsidal fishpond is one of these structures on the coastline. It is composed of only one tank, with an average immersion of 0.37 m below the sea level, and it develops with an NE/SW orientation. The masonry structures reach the maximum thickness at the apex of the fishpond (4.70 m) and consist of a concrete conglomerate composed of slightly rough stones of medium size bound with non-hydraulic mortar. After sampling, for a complete characterization of selected archaeological fragments, different and complementary techniques (stereomicroscopy, polarising optical microscopy and X-ray powder diffraction analysis) were carried out in order to: a) define the minero-petrographic features; b) investigate their state of conservation. The obtained data allow defining the main constituents of mortars from a compositional point of view. The raw materials, in fact, are quite homogeneous, as well as the ratio in which they were mixed, confirming the typical "recipe" used in Roman times to manufacture hydraulic-type mortars by adding pozzolana [1]. At the same time, it was possible to identify the various degradation processes they are interested in, mainly, biological colonization (bio-fouling) that develops differently according to environmental conditions. From the applicative point of view, the textural, mineralogical and chemical information might represent the first step both for the definition of restoration interventions and for the planning of maintenance protocols.

THE PROJECT

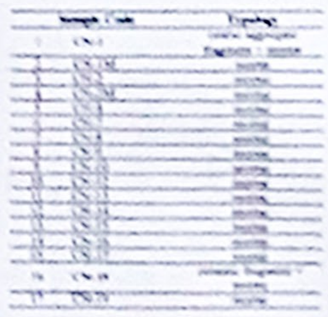


THE PILOT SITE



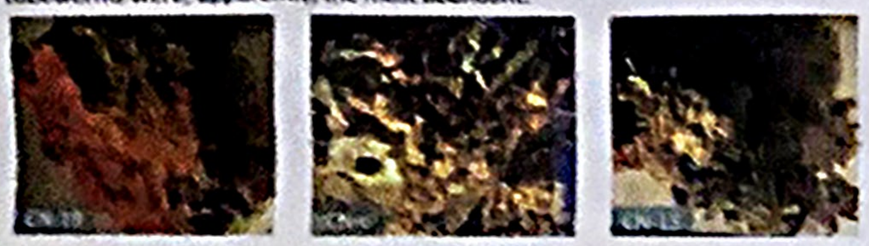
MATERIALS AND METHODS

Selected archaeological fragments were analysed by different and complementary techniques, i.e. observations under a stereomicroscope, polarising optical microscopy (POM) on thin and stratigraphic sections, X-ray powder diffraction analysis (XRPD) and Electron microprobe analysis (EMPA) in order to: a) define the minero-petrographic features; b) investigate their state of conservation. In a second analytical step, mortar test-pieces will be produced in laboratory by using different raw materials and by adding nanomaterials. They will be anchored to a sample holder and immersed in the archaeological area of S. Marinella in order to monitor the biological growth at increasing time intervals of permanence in seawater.

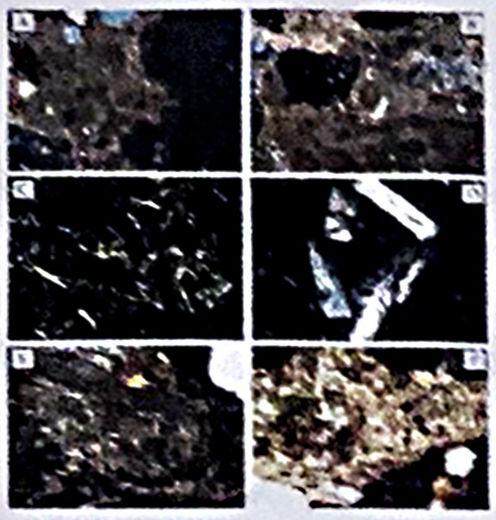


PRELIMINARY STEREOMICROSCOPY OBSERVATION

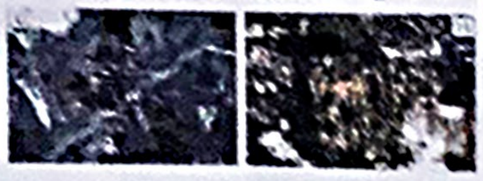
Mortar's surfaces were colonized by different groups of encrusted organisms such us barnacles, tubeworms, bryozoans, molluscs and coralline algae. Barnacles and tubeworms were, apparently, the most abundant.



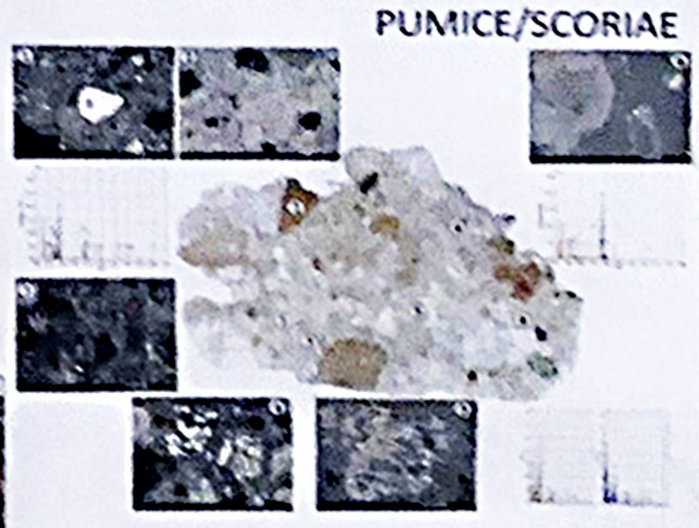
THIN-SECTION PETROGRAPHY (OM)



Mortars samples show as distinctive 'marker' the presence of trachyte, pumice and glassy scoriae fragments (with a variable relative abundance ratio), predominating over all the other constituents.
A-B) cryptocrystalline and recrystallized aspect of the binder
C) crystals of sanidine in a trachytic fragment;
D) tabular crystals of sanidine;
E - H glassy scoriae and pumice fragments



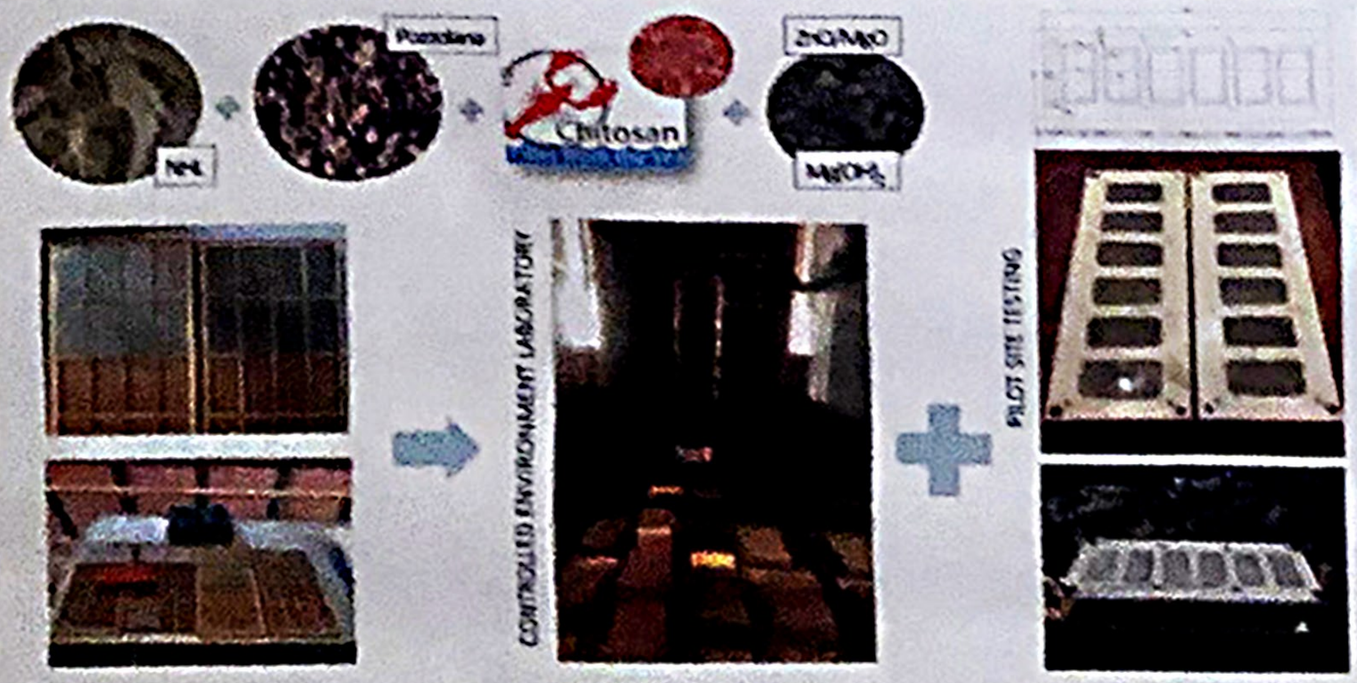
EPMA OF CLINOPYROXENE AND PUMICE/SCORIAE



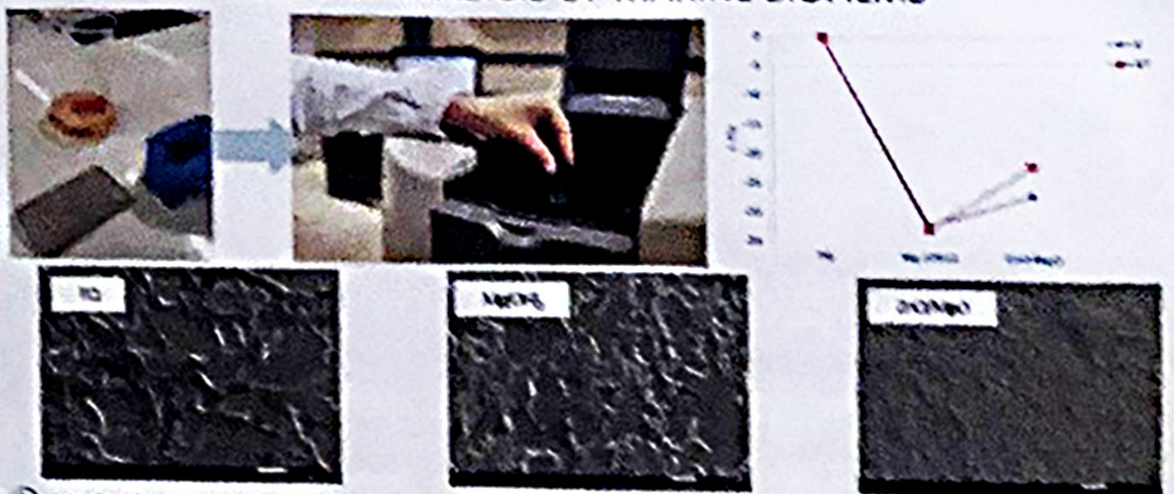
PRELIMINARY OUTCOMES

This archaeometric study has provided interesting information on the mortars used in the archaeological site of Santa Marinella as well as on their production technology:
① identification of the main constituents of historic mortars;
② identification of the various degradation processes they are concerned in.

CONSOLIDATION OF UNDERWATER STRUCTURES BY INNOVATIVE MORTARS



RESULTS: ANALYSIS OF MARINE BIOFILMS



① Marine biofilms are organized in mixed communities of microorganisms
② Bacteria are the initial colonizers of surfaces
③ Biocide effects of $Mg(OH)_2$ and ZnO/MgO

CONCLUSION

Formulations with best performances will be selected for consolidating underwater structures.

REFERENCE

[1] Randazzo L., Ricca M., Ruffolo S., Aquino M., Davidde Petriaggi B., Enei F., La Russa M.F. (2018). An Integrated Analytical Approach to Define the Compositional and Textural Features of Mortars Used in the Underwater Archaeological Site of Castrum Novum (Santa Marinella, Rome, Italy). Minerals 2018, 8, 268; doi:10.3390/min8060268

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NEW INSIGHTS ABOUT THE CONSOLIDATION OF ARCHAEOLOGICAL MORTARS LOCATED IN UNDERWATER ENVIRONMENT: THE CASE STUDY OF THE APSIDAL FISHPOND OF CASTRUM NOVUM (SANTA MARINELLA, ROME, ITALY)

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