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Ancient gypsum mortars from Cyprus: characterization and reinvention

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Mortars with various binding materials have been used across different pre-historic and historic periods to meet several construction applications, such as jointing masonry blocks, finishing walls and isolating water bearing structures. In the framework of an ongoing research programme (NEA ΥΠΟΔΟΜΗ/ΝΕΚΥΠ/0308/17) funded by the Cyprus Research Promotion Foundation, the Republic of Cyprus and the European Union Regional Development Fund, 25 samples of gypsum mortars from different archaeological sites in Cyprus were collected and characterized following a systematic analytical approach. Petrographic observations of thin sections were carried out using polarizing optical microscope. Scanning electron microscopy equipped with energy dispersive X-ray microanalyser (SEM-EDX) was used to examine the microstructure and texture of the mortar samples and to determine semi-quantitatively the chemical composition and interface of their binders. X-ray diffraction (XRD) was performed to identify the main mineral crystalline phases of the specimens' binder and aggregates. Thermal analyses (TG/DTA) were used as a further confirmation of the material composition. The pore structure and volume of the ancient mortars were also determined by mercury intrusion porosimetry (MIP) analysis. Last but not least, a portable drilling resistance measurement system (DRMS) was used for micro-destructive assessment of the mechanical state of the samples.

The results confirmed the predominant presence of hydrous calcium sulphate in all samples. Calcite was also found both in the binder and aggregates. Small proportions of SiO_2 were also detected. The common ratio of binder to aggregates was 1:2.5. MIP showed porosity values between 14-48% and real densities between 1-1.7 g/cm^3. The average pore diameters were smaller in the case of mortars with lower porosity. The use of DRMS indicated lower resistance to drilling for the case of joint mortars (as opposed to analysed gypsum plasters). This confirms the phenomena of crystallisation and recrystallisation closed to the exposed surfaces due to long-term weathering.

As anticipated, the results of this study have proven useful in reinventing gypsum-based materials based on the production technology of the past and the use of local raw materials. It is worth noting that gypsum is a widely available mineral in Cyprus due to the extensive evaporite deposits on the island. In the mortars designed and produced in the laboratory, ratios of binder to aggregates were based on the results of the analysed ancient samples. Gypsum and lime based materials were used in different proportions both as binder and aggregates. The new mixtures were tested in fresh and dry conditions at 7, 28, 56 and 90 days after their production. The results indicated higher mechanical strengths (7.6-9.6 MPa) when only gypsum based materials were used both as binder and aggregates. Porosity and average pore diameter tended to increase as the percentage of calcite increased in the mixtures. The variability of the results enhances the possibility of selecting the appropriate repair mortar depending on the nature of the material which may demand a conservation treatment.