



## **Where did Roman Masons Get Their Material From? A DRIFTS/ MVA Investigation on Mortar Aggregates and Their Potential Sources in the X Regio**

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### **Abstract**

Preliminary results are presented of an investigation aiming to identify the possible material sources employed by the Romans in the construction of a building of Imperial Age located in Lio Piccolo, now partially submerged by the waters of the Venetian lagoon. Aggregates recovered from mortar fragments are studied by diffuse reflectance infrared Fourier transform spectroscopy and compared through principal component analysis to samples collected from potential sources.

### **Introduction**

In the study of the building technologies employed by the Romans, the identification of the possible material sources is increasingly receiving attention. Mortar aggregates are typically investigated through the comparison of their mineralogical characteristics to those of samples from the most likely sources, under the assumption that the approximately two thousand years intervened did not alter significantly the composition of the latter [e.g. 1-4]. Since these materials are inherently inhomogeneous, a different approach can be followed, searching resemblances among the different samples through chemometric tools to highlight overall affinity, instead of punctual similarities. This small research unit set up a combined spectroscopic/ chemometric procedure to evaluate by means of multivariate analysis (namely principal component analysis, PCA) the affinity of diffuse reflectance infrared Fourier transform (DRIFT) spectra of the aggregate fraction recovered from mortar fragments of Roman age buildings located in the X Regio (Venetia et Histria) with those of possible sand sources [5, 6]. The preliminary results presented here refer to materials found in the site of Lio Piccolo (the Roman Litus Minor), now a hamlet located in the Northern Venetian lagoon made up of a number of small isles separated by canals. Unlike the cases previously investigated in the Veneto and Friuli mainland where local rivers could easily be pinpointed as the most likely material sources, in this case both the particular site location and the considerable environmental changes occurred suggest a wider investigation involving samples from the lagoon bottom and the nearby sea-shore, as well as from the rivers known to have been flowing into the lagoon in ancient times.

### **Materials & Methods**

Five mortar fragments from the Lio Piccolo site 181 were considered for this exploratory work, along with fifteen sand samples from the lagoon bottom, the sea-shore and the Brenta and Piave riverbeds. For each archaeological sample a few grams of mortar were processed to separate the aggregate fraction from the binder: first they were gently crushed with a rubber stopper and then subjected to repeated cycles in ultrasonic bath [1,5,6]. Finally, all the sands were wet sieved between 63 and 420  $\mu\text{m}$ . For the natural specimens three different samplings were performed to enhance their representativeness. The DRIFTS measurement were performed on finally ground samples diluted in KBr powder employing a Vertex 70 spectrometer (Bruker Optik) equipped by a Pike DiffusIR measurement unit; all the spectra were recorded between 450 and 4000  $\text{cm}^{-1}$  with a resolution of 4  $\text{cm}^{-1}$  and converted to Kubelka-Munk units.

The DRIFT spectra of the potential sources were subjected to Principal Component Analysis (PCA, Simca-p software) in significant spectral ranges, identified resorting to the variance spectrum. Then the spectra of the mortar samples were checked in the scores plots found to provide the best differentiation among the sand sources to get information on possible similarities. As a last step the contributions of the spectral characteristics to the different PCs was inferred from the corresponding loading plots and highlighted through indexes descriptive of the samples composition obtained from the spectral intensities of suitable absorption bands.

## Results

The PC4 vs PC1 scores plot in the 690-900  $\text{cm}^{-1}$  spectral range is presented as an example in Fig. 1 a, where the points representative of the mortar samples (in red) can also be found. The position of the representative points of the natural sand is roughly distinctive of the different sources; the points corresponding to mortar aggregates fall close to sea-shore samples but do not suggest a marked affinity to any of the tested sources. Comparing the trend of the PCs loading plots (Fig. 1 b) to the main spectral absorptions it is possible to recognize positive PC1 values as mainly due to carbonates contributions, whereas PC4 negative values can be partially related to silicates contributions, so that samples with an increasing carbonates content should be approximately found along the diagonal connecting the upper right corner to the lower left one of the diagram. This is confirmed in Fig 1 c where sample labels have been replaced by the ICS index obtained from the integrated intensities of two related absorption bands (898-1230  $\text{cm}^{-1}$  for silicates and 1325-1575  $\text{cm}^{-1}$  for carbonates).

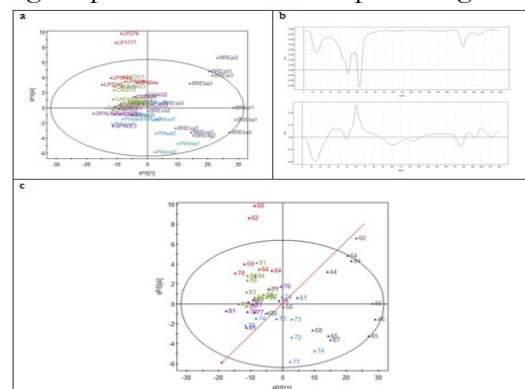


Fig. 1; (a) PC4 vs PC1 scores plot in the 690-900  $\text{cm}^{-1}$  spectral range; (b) loading plots of PC1 (upper curve) and PC4 (lower curve); (c) ICS descriptive index in the PC4 vs PC1 scores plot (the red arrow indicates increasing values of the ICS index)

## Conclusions

This exploratory combined spectroscopic/ chemometric analysis performed on the aggregate fraction of five mortars fragments from a Roman building in Lio Piccolo and on a few sediment samples collected from potential sources did not show any close resemblance between the archaeological and the natural samples. Widening the set of the investigated samples, adding in particular more data from both the lagoon bottom and the relevant rivers (e.g. the yet untested Sile), are needed to shed more light on the identification of the possible building material sources.

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