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The Laboratory for Archaeometry and Not Destructive Analysis at the field season 2012 -Banbhore Sindh

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Laboratory for Archaeometry and not Destructive Analysis

ACTIVITY REPORT of
THE LABORATORY FOR ARCHAEOMETRY AND NOT DESTRUCTIVE ANALYSIS
at the FIELD SEASON 2012 - BANBHORE, SINDH, PAKISTAN
27 APRIL 2013

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The Department of Fundamental and Applied Science for Engineering (SBAI) of Sapienza, University of Rome, has signed an agreement with the Center of Research on the Southern System and Southern Mediterranean (CRiSSMA) of the Catholic University of the Sacred Heart (Milan) for supplying archaeometric support during the archaeological excavation/exploration at Banbhore (Sindh – Pakistan) during the field seasons of the Pakistani – Italian – French joint Archaeological – Historical – Research project. Thus, the team of the Laboratory for not Destructive Analysis and Archaeometry participated to the 2012 field season at Banbhore, Sindh, as part of the Italian Team and the Italian contribution to the Pakistani-French-Italian collaboration, carrying the transportable instruments from Sapienza, University of Rome, and installing a small laboratory for archaeometric analysis at the Banbhore site.

Figure 1 - The Banbhore site with the walls of the citadel in the background. In the foreground the remnants of a large number of big pitchers have been marked.

The opportunity of performing archaeometric analysis during the excavation field season directly on the archaeological site gives a new, strong, added value to the archaeological mission as well as to archaeometric investigations. In fact, usually archaeometric studies have been performed on musealized, restored artifacts. In the present case the studies are carried directly on unearthed artifacts from well defined stratigraphic contests. The aim of the analysis is to answering immediately simple questions, that normally arise during an excavation, such as: what is the material employed for a particular artifact? In addition, the analyses performed on several homogeneous materials (ceramics, coins, glasses, etc) found during the excavations give a first idea of their changes with time; finally questions like provenance of the artifacts or of the row materials can be addressed.

The results reported below are preliminary; in some cases the research requires more sophisticated techniques, available only at specialist laboratories, to reach final conclusions.

The archaeometry laboratory installed at the archaeological site of Banbhore is equipped with portable instruments brought from the Archaeometry and Non Destructive Analysis Laboratory of Sapienza, University of Rome:

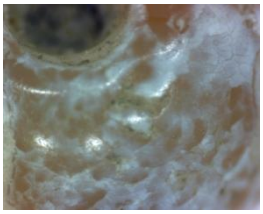
1. A small microscope to look at surfaces, drawings, marks left by the tools employed by the artisans, etc.
2. An X-ray fluorescence system for a qualitative compositional analysis, as well as for a semiquantitative chemical analysis (for a quantitative analysis it is necessary to have flat surfaces, homogeneous samples, remove all corrosion products etc.)
3. A portable Raman system for mineral and compound analyses.

We have studied several miscellaneous artifacts and addressed a few larger problems.

Figure 2 - The Laboratory

STUDIES ON MISCELLANEOUS MATERIALS – SELECTED EXAMPLES

- Small Orange bead found in the Pakistani trench.



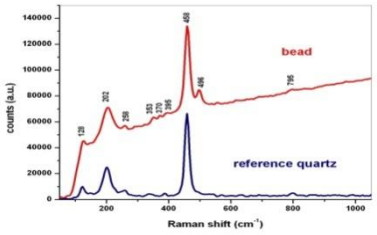


Figure 3 - The small orange bead; microscope view showing the cuts; the Raman spectrum compared with the quartz spectrum.

Cleaved for obtaining an almost round shape
XRF: glass (?) with rare earth elements as coloring agents (!!);
Raman: pink quartz!

- Stone with many small, dark-purple crystals:
  Raman: quartz; XRF: the coloring agent is iron

- Rusted iron nail

Figure 4 - Iron nail.

- Small yellow bead:
  Raman: several peaks to be identified
  (possibly lead oxide)
  XRF: lead, little amounts of iron and calcium

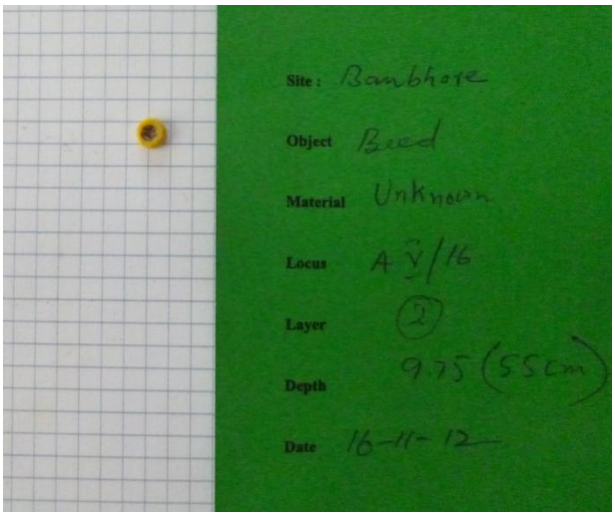


Figure 5 - Very small bead with its excavation card.

- Bed of sulphur, with fossil woven leafs

Figure 6 - Pieces of sulphur with a mat of woven leafs, found in the Pakistani trench.

- A small, nice metal work, showing a sophisticated craftsmanship. The XRF analysis shows that it is made by a copper – zinc – lead alloy, with a large amount of bromine.

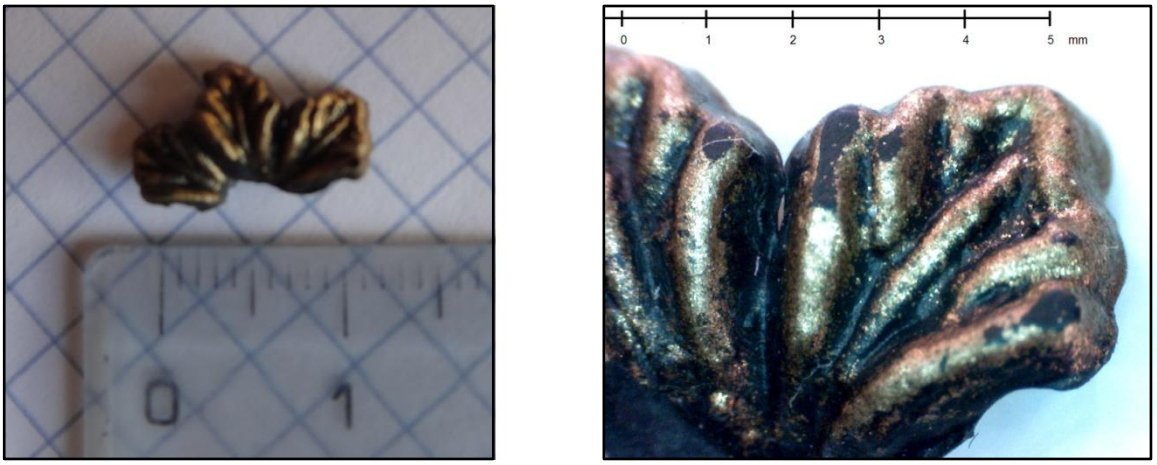


Figure 7 - Small sophisticated craftmanship found in the Pakistani trench.

- A fragment of the copper coin mould (see figure 8 – Φ ≈50 cm) with metal pieces. The corroded metal remains: copper and lead; the internal walls and the bottom of the holes: copper and lead; the holes present a thin, vitrified crust around; outside the holes: clay.

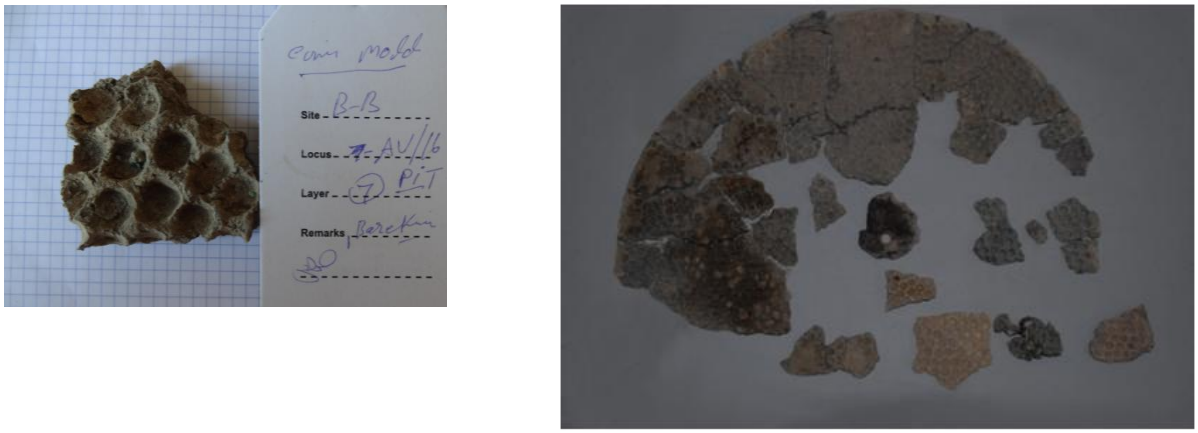


Figure 8 - The copper coin mould. Left: a small fragment with metal pieces, that we have analyzed.

SPECIFIC PROBLEMS

The partners of this joint project, in the course of their excavations, have submitted us some specific problems referring to the evidence which was brought to light.

1) **Soil samples:** we have been requested to checking the composition of the soil of some layers, in order to analyze the changes with depth and the salinity.

2) **Ceramic materials:** We analyzed with the microscope, XRF, and Raman spectroscopy about 60 fragments of ceramic material of different typologies, places and periods of production, chosen by the ceramologist of the team Dr. Agnese Fusaro. The results still need to be analyzed and small samples have been taken to Rome, with the permission of the Sindh Antiquities Department, for further work (thin sections, infrared spectroscopy, thermo gravimetric spectroscopy, etc.)

3) **Copper coins, found during the excavations**
At first we examined copper coins just as found, covered by a thick, green corrosion layer. These measurements could not give the coins composition; nevertheless we found that it was employed **bronze**, a copper – lead alloy. Then the coins were chemically cleaned by Mr. Saeed Domki, the Chemist of the Museum of the State Bank of Pakistan. Measurements performed on the cleaned coins have confirmed that they are made of a copper – lead – tin alloy, with small amounts of zinc and arsenic. Some coins and other metal pieces show a black area, rich of iron oxide.

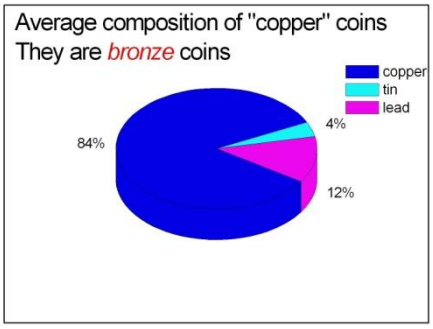


Figure 9 - Preliminary estimate of the average composition of the "copper" coins.

4) **Silver coins from the collection of the State Bank of Pakistan.**
With the XRF we analyzed 85 silver coins brought to our Laboratory from the collection of the Museum of the State Bank of Pakistan. The coins were related to Banbhore, but were obtained by the Museum from private donors. The coins are attributed to different rulers, but several of them are not identified.
The composition of the coins is: silver, copper and lead. We performed a rough estimate of their composition, obtaining approximately an average composition of 84% of silver, 14% of copper and 1.3% of lead. The remaining 0.7% includes several trace elements, such as iron, gold, platinum, etc. As shown in Figure 11, we found small 0.7% includes several trace elements, such as iron, gold, platinum, etc. As

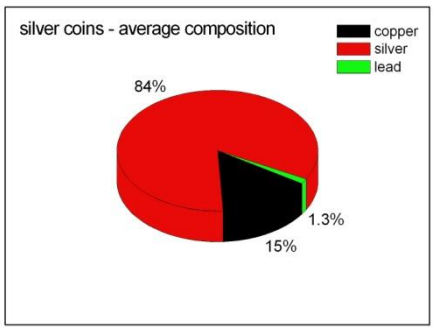


Figure 1010 - Preliminary estimate of the average composition of the silver coins.

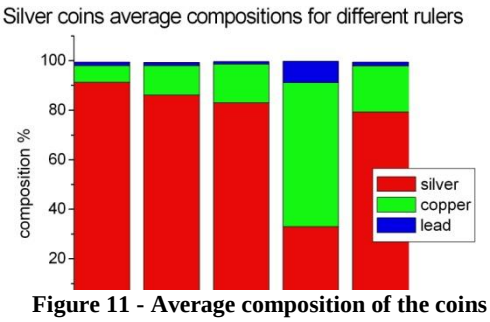


Figure 11 - Average composition of the coins assigned to different rulers.

shown in Figure 11, we found small differences between the coins mint under the three rulers Abdallah, Alì and Umar, whereas the coins labeled as "Arabic" are totally different and have not been included in calculating the average composition of Figure 10.

5) **Glasses found during the excavation. Comparison with modern glasses**
We analyzed with XRF, Raman spectroscopy and the microscope 20 pieces of glassware found in the excavations and 7 pieces of modern, colored glass. We found several differences between the two groups. Many ancient fragments have potassium and calcium, with the exception of a transparent piece, that does not have potassium and has mostly calcium. In general the colors are obtained using different coloring agents with respect to modern glasses, except for the very dark glasses, obtained with manganese. The fragments found in the excavations show a thick layer of corrosion products.The study of the Raman spectra and their interpretation is still in progress.

TRAINING

During our visit we trained Mr. Saeed Domki, the Chemist of the Museum of the State Bank of Pakistan, to archaeometric investigations, in particular the use of the microscope and of the XRF set-up.

WORK IN PROGRESS

The archaeometric study of the excavated materials is still in progress. As already reported above, the analysis of the **ceramic** as well as of the **glass** artifacts still needs further work. The measurements performed on the **silver coins** have been reanalyzed carefully with different methods and a software that takes into account the sensitivity of the set-up to the different elements and the matrix effects in order to obtain a semi-quantitative composition of the coins. The statistical analysis of the data is in progress.

Figure 12- Pieces of materials hard as stone, but not well identified.

In both the French and the Pakistani trenches at Banbhore large amounts of bones and similar materials have been found, many of them partially worked, indicating a lively craftsmanship activity. A small fragment (encircled in Figure 12) have been taken to Rome. Prof. Maria Rita Palombo, Professor at the Earth Sciences Department, examined the fragment, at first with visual inspection, then with the SEM-EDS. The fragment cleaves easily in layers, alike ancient ivory, albeit the Schreger lines, typical of proboscidean ivory, cannot be detected. The composition determined with the SEM-EDS locally shows a large amount of fluorine in addition to calcium, which is a marker of **ivory**. However the SEM-EDS images did not show the characteristic structure present in elephant tusks, neither the granular aspect typical of artifacts made of ivory powder. Further studies are in progress for identifying the big mammal from which the ivory was taken.

Several discussions have been taken with Prof. Luciana Orlando, Professor at the Department of Civil, Constructional and Environmental Engineering, for non-destructive tests of the site in order to detect earthed structures before excavating or looking for mural structures near/inside the river, that could be assigned to the ancient harbor. From the discussion, we obtained that an improvement in the activity will be obtained from non-destructive surveys. We planned to collect speedy large-scale surveys including geomagnetic and low-frequency electromagnetic (EM) surveys and small-scale surveys collected with geo-radar. The large-scale surveys will aim to

confine the areas of greatest archaeological interest which will be subject to detailed investigation with multi-frequency ground-penetrating radar. The data will be processing with dedicated algorithms with the goal of increasing the signal to noise ratio and the interpretation will be made focusing the attention on the integration of results. In this way we would eliminate the ambiguities in the interpretation of anomalies inherent in each indirect method.

CONCLUSION

The importance of an in-situ laboratory for archaeometric research has been proved. The results obtained so far from the analyses are still preliminary and require further work as shown above and more inter-disciplinary contacts. Many queries have been opened and investigations with other techniques are strongly recommended in order to reach a thorough understanding of the materials used, their production and their provenance. It is fundamental to relate the analysis results with the historical-archaeological context of the artifacts.

For the next season fields we plan to continue going on the site for archaeometric analysis on excavated artifacts. We recommend to bring other specialists with their instrumentations for doing a full survey of the archaeological site: questions such as: which was the Indus river bed when the place was flourishing? which was its level, since many refined ceramic shreds and masonry have been found in a deep trench below the present water level? Where are the harbor structures? What about the "industrial" area?

Rome, 27th April 2013

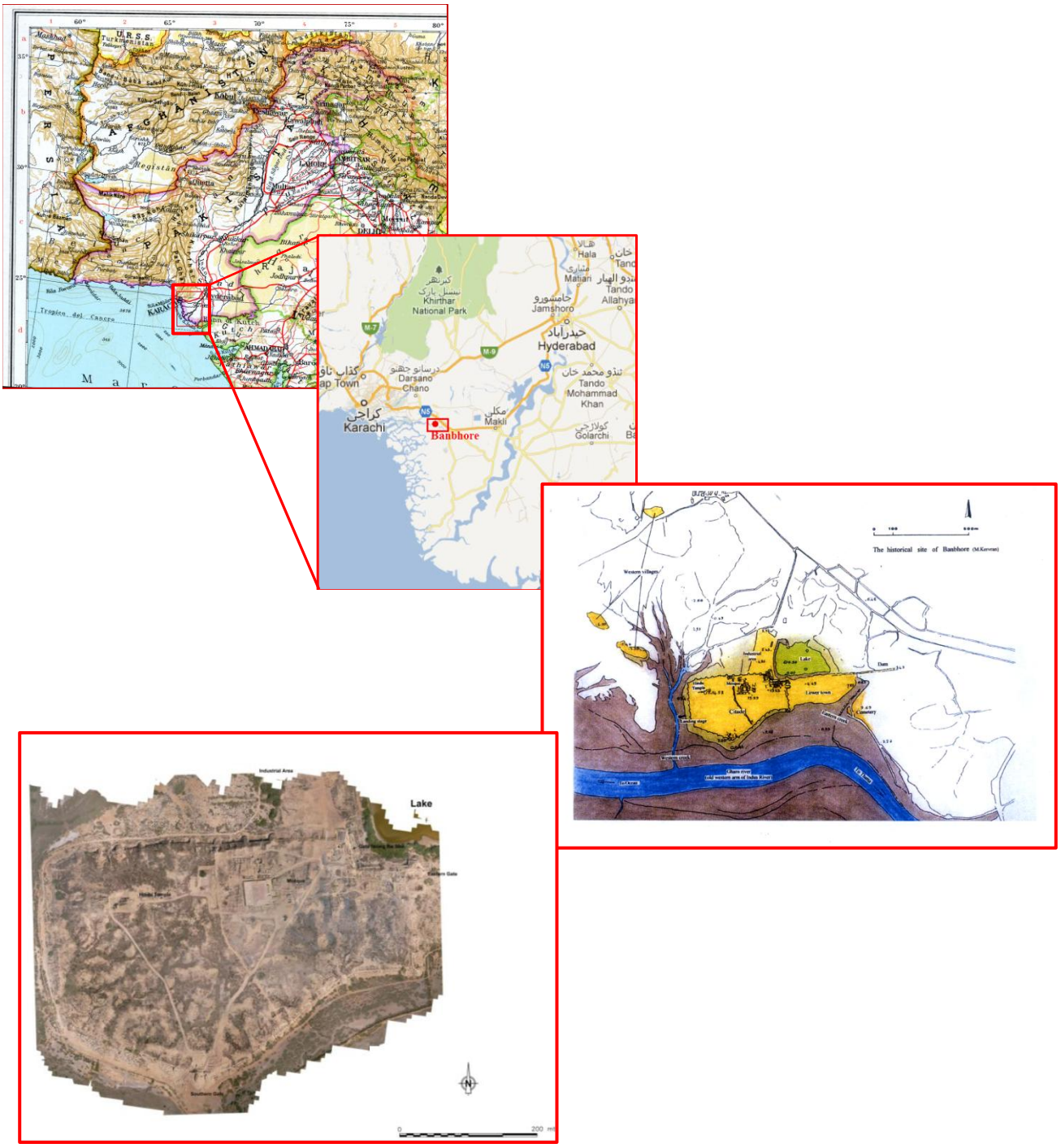


Figure 13 – from top to bottom: Map of Pakistan; map of Sindh; the archaeological site of Banbhore (in yellow); kite photo of the citadel.