Theme: Archaeometry approaches to pottery.

Provenance Analysis

Starting from the case study of Sumhuram (3rd - 2nd century BC – early 5th century AD) and Hamr al-Sharqiya 1 (HAS1) (1st millennium BC – 1st - 2nd century AD) (Dhofar Governorate, Oman), Daniele Zampierin, M.A. (PhD student, BerGSAS, Silk Road program) opened the first discussion about archaeometric and provenance analysis in archaeology.

Abstract:
The archaeological sites of Sumhuram (3rd -2nd century BC until the early 5th century AD) and Hamr al-Sharqiya 1 (HAS1) and Inqitat HAS1 (1st millennium BC until the 1st - 2nd century AD), are involved in one of the most important examples of large-scale trade network in the antiquity: the maritime trade network connecting the coasts of the Indian Ocean. The attention of this work is focused on the material characterization of both local and Indian pottery from both the previously mentioned settlements. A multi-analytical complementary approach was carried out in order to characterize the ceramics and validate the provenance identification resulting from the typological approach. The results led to the identification of 8 different fabric-compositional groups with very distinct geological signatures highlighting the enormous variability in the origin of raw materials, indicating the participation of several areas of the Indian subcontinent in the Indian Ocean trade network.

Aim of the analysis was to understand how the technologically, chemically, and mineralogically identified fabric groups related to the previous stylistically defined Indian subcontinent and Arabian Peninsula assemblages.

The study was conducted following a multi-analytical complementary approach, that allowed to characterise the fabric composition of the ceramics and focus on the provenance, as suggested by the typological attribution. Four different methods were used: X-Ray Diffraction (XRD), ceramic petrography, Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and Scanning Electron Microscope coupled to Energy Dispersive X-ray Spectroscopy (SEM-EDS).

The analysis of 35 samples led to the identification of 8 fabric-compositional groups: Shell-Temper (ST), Shale-rich Fabric (SF), Talc-rich Fabric (TF), Basalt-rich Fabric (BF), Rice Temper (RT), Fine Fabric (FF), Medium-Large temper grains in fine Fabric (MLF) and the Shell and Sand rich Fabric (SSF). The different fabrics could then be grouped within southwestern Arabian groups (ST, SF and TF), of which only ST is of Dhofar production, while SF and TF originates from Yemen. The Indian fabric-compositional groups identified underline the participation of several areas of the Indian subcontinent in the Indian Ocean trade network: the central-west region of the subcontinent corresponding to the Deccan Trap (BF and RT), south and south-east (MLF) and the alluvial plane of the north-east of the subcontinent (FF). The distinct geological signatures highlight the enormous variability of raw materials origin. BF and RT originate from modern days west India, as indicated by the presence of basalts (corresponding to the Deccan Trap geological formation) and rice husks (typical of the ceramic production from Gandhara and the neighbouring regions). However, not all the data obtained could be directly compared to exclusively geological formations, so, when possible, the direct comparison with archaeological materials of known origins was also considered to refine the definition of the provenances. Only for the SSF group it was not possible to establish a possible provenance.

The multi-analytical approach adopted was fundamental for the material characterisation of the ceramics and of the provenance of most of the samples. From an initial Arabic vs Indian typological division, the adopted methods highlighted the more complex classification of the archaeological material and, by extension, allowed to get a more detailed idea of the trade system network crossing the Indian Ocean, spotlighting the need for a new wave of multi-analytical studies focused on the materials found across the Indian Ocean in order to expand the understanding of Indian Ocean trade system.

METHODOLOGY

Q: How did you organise your study?

A: First, because of the invasive and partially destructive nature of the analysis conducted, all samples were first recorded through photography and some through 3D photogrammetry. The sampling was done by cutting two small fragments, which were rinsed with distilled water and ethanol before drying at 40°C for 24h. One fragment was then prepared for the creation of thin-sections for the Optical Microscopy (OM).The second fragment was powdered for mineralogical and chemical analysis. It was then powdered first by hand and then using the automatic mill Retsch PM100.

The thin-sections were first analysed by Optical Microscopy (OM) with the aim of observing and recognizing the minerals, rock fragments and all the other inclusions within the clay fabric, as well as study the matrix characteristics, the porosity and the sorting of the inclusions.

Powder X-rays Diffraction (PXRD) was conducted on the powdered samples, allowing mineralogical bulk analysis using the International Centre for Diffraction Data databases. The mineral characterising the powdered sample can be recognised based on the diffraction angle.

Inductively Coupled Plasma Mass Spectrometry (ICP-MS) was conducted on the powdered samples. ICP-MS is a technique able to vaporize the previously digested sample and ionize the small particles of gas by means of the plasma flow. The ionized atoms of the elements composing the sample are then moving along a tube with four different magnets, which are forcing a spiral movement into the ionized atoms. Such movement is responsible for the separation of the ions in accordance with the atomic mass allowing the detectors located at the end of the path to identify the elements in accordance to the atomic mass. Due to the digestion process conducted previous to the analysis, it was not possible to study the concentration of Si within the samples, but it was possible to indirectly measuring it by means of combining ICP-MS and LOI data.

Scanning Electron Microscopy with Energy Dispersive Spectroscopy (SEM-EDS) was finally performed on the thin-sections already used for the OM. Microanalysis are a fundamental step for the development of a complete dataset of ceramic samples. With such technique it was possible to observe the structure of the fabric to the order of the µm, but it was also possible to study the elemental composition of specific formations within the fabric to a µm level of precision. With this technique it is then possible to have a very specific picture of the fabric components, a very detailed mapping of the distribution of the chemical elements in accordance to the components and study the nature of each component by means of the identification of their chemical composition.

The whole process can take from 3 to 4 months and involves considerable costs and the investment of long hours in collaboration with expert technicians in order to avoid mistakes that can cause completely unreliable results. Thus, it is not always possible to use all the different methods above presented. (The analysis for this study were conducted at the University of Evora, Portugal)

Q: How should a sample ideally be selected?

A: The sample should be selected according to the research question you want to answer, keeping in mind archaeological and statistical considerations. The sample should not be contaminated and samples collected from surface surveys can be used, but the researcher has to bear in mind the lack of context and the possibility of having contaminations connected to salt depositions and similar phenomena. Since the procedure is destructive, it would be advisable to use non-diagnostic wall fragments instead of diagnostic part of the vessel or, worse, complete vessels. Moreover, it is important to make sure that the sample is big enough to provide enough material to perform all the analysis.

Q&A:

Q: You have presented a huge amount of data, obtained by different methods. However, you have showed only 4 parameters in your analysis. Is it possible to apply multivariate analysis within archaeometric results?

A: The analysis here presented are the most effective and understandable ones. Moreover, a multivariate statistical approach cannot always be explained archaeologically. For example, there could be no geological explanation of the reason why the variables are grouped in a specific way. Petrographic analyses are even more complicated, since by looking at a very specific point of the ceramic and since the observations are of subjective nature, no real statistical analysis is possible.

Q: How is the sample analysed (35 sherds) distributed across the site?

A: The sample was given (without the possibility of selection) by the DHOMIAP project team. 18 sherds are from HAS1 and 17 from Sumhuram. The sherds from HAS1 date from the second half of the 1st millennium BC to the 2nd century AD, while the samples from Sumhuram date from the 3rd century BC to the 5th century CE. The samples selected tries to express the best way possible the variety of Indian and southwestern Arabian fabric and vessel types recorded within the two sites.

Q: Which is the most common archaeometric analysis for provenance analysis?

A: Petrography is the most common and, I would say, the one to go for in case of having to choose only one technique, but the combination of different methods improves the final understanding of the fabric.

Q: Is it possible to perform archaeometric analysis on painted pottery?

A: Yes, it is, but it presents some challenges. For example, glazed ceramic might be problematic. There are different methods that can be used, based on the analysis of the components of which the paint is made. However, the paint layer must be thick enough to be able to sample it (if researching on paint composition) without taking the fabric underneath as part of your sample.

Q: How does it work with archaeometric analysis on small regions?

A: It depends on your research questions, but if the aim is that of identifying the provenance of the ceramics, working on small areas can be more difficult than working on large-scale areas. For an effective identification of the provenance of a ceramic, it is necessary to have characteristics that can point to an area with specific geological formations. The basic principle is that, to identify different production centres, the production centres must have different characteristics. If the region in consideration, weather large or small, has no remarkable geological variability, it might be extremely hard to identify the provenance of the ceramic (even if not impossible).

DISCUSSION: HOW TO USE THE RESULTS FOR THE ARCHAEOMETRIC INTERPRETATION

1) How is it possible to prove that the pottery analysed actually was produced in India and was not produced on spot or somewhere else?

   Minerals as talc and other inclusions like rice husks are characteristic only of specific areas. Rice husks in that period are found only in ceramics from NW India. Talc, on the other hand, is quite specific of Oman mountain range and of Yemenite Mountain range, but the comparison with some archaeological finds from Oman exclude the omanite mountain rang as source of the raw material. It is difficult to imagine that the clay for pottery production was transported across the Ocean or across long distances in desertic lands. It is more likely that the pots were produced in India and then traded or used for containers for the trade of goods. However, it is not always possible to rely on geological data, as for Yemen, for example. In this case, an approach that combine different sources – e.g. archaeological finds, is the best solution to gain the most complete picture possible. The pottery locally produced in the Dhofar region tends to be of a lower quality than the Indian and the Yemenite ones, characterised by distinct shapes.

2) Why is pottery moving?

   In the context of the Indian Ocean trade in Antiquity, pottery stands most probably as a "left-over" of trade. The articulated exchange of goods from the Mediterranean to the Indian Ocean and to the Persian Gulf is not only well attested by the Roman sources, but also by the ceramic found at several sites in the Arabic peninsula as well as in India. Garum and wine were some of the products travelling towards the east, while pepper, gemstones, silk, and pearls were among the goods moving towards the west, stored in specific vessels. If on the one hand the remains of such goods are only rarely preserved and thus it is difficult to work with them, ceramic can be used as a valid proxy for the trade and archaeometric analysis can help to identify the location of the production centre. However, the pots involved in the economic exchange do not reveal anything about the social status of the people involved in the trade, which is most likely related to the goods transported. It is possible, however, that among the ceramics transported along the trade routes were not only pots used for the exchange, but also common ware used by the crews of the ships and the merchants while travelling. In the case of the Sumhuram, however, it is believed that Indian travellers were staying at the colony for longer periods waiting for the right moment to take advantage of the monsoon season to leave the Omani coast.
   It is also possible that foreign trading pots were reaching the village of the locals (HAS1) as gifts, as containers of goods or simply taken by the local nomads, who might have used them as common ware in their households or for their own trades. This is however only an assumption with no solid basis since the traces of nomadic populations are extremely difficult to detect archaeologically.

3) Is it possible to estimate the proportion between Indian and local wares based on archaeometric analysis?

   Yes, if you have a complete dataset from both the assemblages. Due to the lack of pottery analysis so far published from HAS1, however, it is not possible to give an estimate at current point.

4) Macroanalysis typology and archaeometric analysis: dismantling false comparisons.

The multi-analytical approach was demonstrated to be determinant for the material characterisation of the ceramics and of the provenance of most of the samples. From an initial Arabic vs Indian typological division, the adopted multi-analytical approach highlighted the more complex classification of the archaeological material and, by extension, allows to get a more detailed idea of the trade system network crossing the Indian Ocean.
The importance of archaeometric analysis is better highlighted when the results are compared with typology established based on macroanalysis and can be effectively used to avoid the risk for false comparisons.

Suggested bibliography:

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