Title: Archaeometric study of amphorae

Tutor: Vincenzo Morra

Co-tutor: Alberto De Bonis

Research program

In ancient times most of the foodstuff was transported and stored in amphorae. These ceramic containers, in use since the Neolithic period, were characterised by different shapes and manufactures, varying according to the ages and contents. In Greek and Roman times, huge amounts of foodstuffs, both solid and liquid, such as oil and wine, were produced in rural area of the Mediterranean and then transported in amphorae to different places, even very far away.

For this reason, amphorae were the main cargo found in numerous shipwrecks in the Mediterranean sea. Very often, transport amphorae were reused as containers or recycled either as fragments, for example for masonry works, or intact, to lighten the vaults. Amphorae were also re-used in the funeral sphere, to contain ashes or for burial of very young children (enchytrismos).

Amphorae are, therefore, very important finds from an archaeological point of view as, even more than other ceramic materials, they allow for retracing commercial and cultural connections between the various cultures, by identifying their production areas and circulation. Archaeological morpho-typological analysis for identifying different styles attributable to the various production centers and cultures, or the study of the stamps of the manufacturer, are fundamental to date and classify amphoric finds. However, this approach does not always provide exhaustive answers on the origin and production sites of the amphorae. As with other ceramic finds, archaeometric investigation based on mineralogical and petrographic methods can provide crucial clues in this regard. Ceramic materials are produced from raw materials of geological origin, of which clay is the main component. Therefore, the comparison of the composition of the end-products with that of the raw materials from the hypothetical production site or with that of production indicators and well-defined reference groups, provides important information for provenancing amphorae.

From a technological point of view, amphorae are considered high-performance objects because, in addition to better preserve the contents, they had to endure the stresses they were subject to during transport. Production techniques for making the best products included the right type and mix-design of raw materials (clays and temper), as well as a firing performed at high temperatures for triggering a series of mineralogical and structural transformations that hardened the ceramic body.

The finishing of the surfaces (smoothing, slip, pseudo-engobe) and the various closure systems were intended to isolate these containers and improve the preservation of the food.

Minero-petrographic techniques also have the potential to investigate the technological features of ceramics, starting from the processing techniques of the raw materials and tempering, mixing of different clays or levigation, up to the firing dynamics, such as temperatures and redox conditions of the atmosphere inside the kiln. An additional and significant contribution to the study of the technological features is also provided by experimental approach via preparation and petrophysical analyses of ceramic replicas.

The research team at the DiSTAR has decades of experience in the studies of provenance and technology of archaeological ceramics, publishing several papers on the most important

international journals and volumes in close cooperation with archaeologists of universities and institutions from Italy and from abroad. The research program was mainly focused on the identification of raw materials and on the study of different ceramic classes produced in settlements of the Campania region of Italy from Protohistory to the Middle Ages, for the reconstruction of circulation and trade of ceramics and ancient production technologies. Thanks to a sound geological knowledge, the research team at the DiSTAR has carried out provenance studies of ceramics found in different Italian archaeological sites, but also in Africa and Asia. This latter is an essential aspect for the study of transport amphorae, which can come from the most disparate settlements in the Mediterranean area. In this case, a knowledge of the different geological features of the territory and a correct interpretation of cartographic data and scientific literature are definitely necessary.

The analytical approach adopted for the study of amphorae is based on the main techniques used for the archaeometric study of ancient pottery. Mineralogical and petrographic techniques will be applied, such as: polarized light microscopy for the examination in thin section of the components of the ceramic body (matrix and inclusions), X-ray diffractometry for the analysis of minerals - also submicroscopic - and the identification of phase changes due to firing process, scanning electron microscopy for the observation of microstructural characteristics as a function of firing temperatures, micro-chemical analysis to examine the composition of points and areas of specific phases of the investigated material, X-ray fluorescence for bulk chemical analysis of samples. In addition to these techniques, Sr-Nd isotope analysis can also be applied, as it already provided interesting results for provenancing selected archaeological pottery and local raw materials from the Campania region in comparison with experimental ceramic replicas. This pioneering study has demonstrated that isotopes represent an effective fingerprint of pottery that strictly depends on the geochemical affinity of the raw materials. Further analyses in this sense are expected to provide a valid contribution to the definition of provenance of transport amphorae and to test the method on materials from different sites.

A further aspect to consider is the possibility of investigating the organic residues contained in the amphorae with the help of analytical methodologies from other scientific disciplines.

Proposal for a PhD position

A doctoral position will be applied for a candidate who can carry out research on a specific topic of archaeometric interest. The project will be focused on a topic selected among the most intriguing questions about production and circulation of transport amphorae in the Mediterranean area and should be completed within three years. The work programme will include the study of the available literature and a selection of pottery following a strategy carefully planned with the expert archaeologist(s) responsible for the materials. The analytical programme will be performed by using the instrumental facilities at the DiSTAR of the Federico II University of Naples (Italy), where the PhD student will have the possibility to acquire technical skills in mineralogical, petrographic and physical methods, such as chemical analysis (XRF), mineralogical analysis (XRPD), polarised light and scanning electron microscopy with microanalysis (EDS/WDS), spectroscopic techniques (Raman, FT-IR) and Sr-Nd isotope analysis. Training courses of the "Scuola di Dottorato" will be also available for the student at the host University for improving its knowledge on different topics.

A period of at least five months for a visiting fellowship abroad is also included in the work programme in order for the PhD student to learn different analytical methods and to make useful discussion with other scholars, in order to have the possibility to develop further its career.