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Ravello

Territori della Cultura

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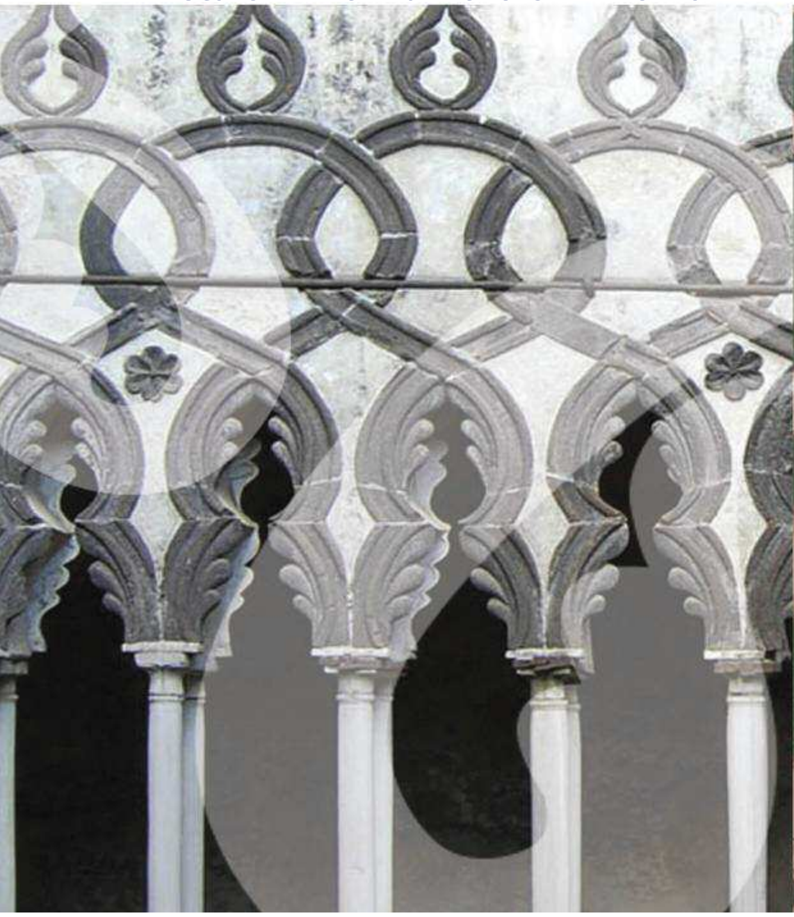

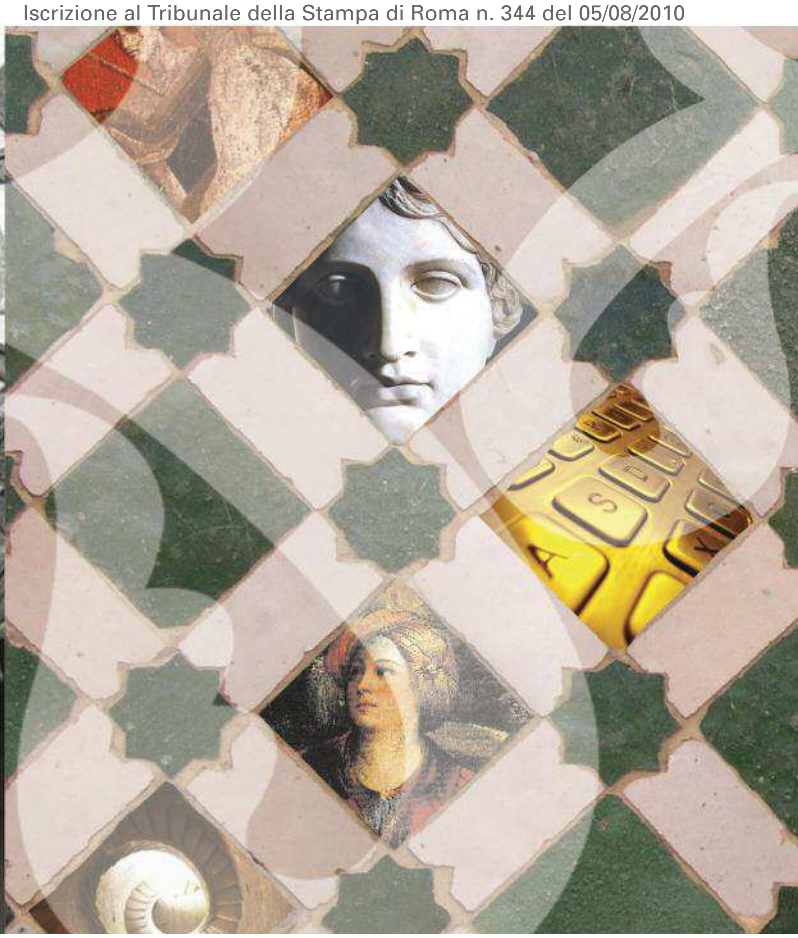

Sommario

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Archaeometry of ceramics as a scientific-humanistic discipline: in pursuit of the Ravello spirit - Part I. Methodological issues

To J.-P. Morel

Introduction

Since the Neolithic period, pottery sherds are one of the most common finds uncovered in archaeological excavations, mainly because once broken and deposited in the archaeological record they are practically indestructible. Its study allows important insights into the daily life of ancient populations. Thus the study of archaeological ceramics has become essential for the interpretation of ancient societies in general terms and a key material for dating sites. Of the many questions that can be asked, one of particular importance is **where the pottery was made**. Answering this question may help to study movements of people or trade and exchange but also patterns of consumption and use of the pottery and the products transported in them, as is the case for amphorae. In the determination of the provenance the application of physico-chemical and minero/petrographic techniques established by the experimental sciences have been fundamental. Chemical, mineralogical and petrographic characterisation, or better a combination of these, may indeed help to identify where a ceramic was produced.

Although the use of analytical techniques to study ancient objects may seem an innovative field, the first applications date back to the 17th and 18th centuries, even before Archaeology was established as a discipline (i.e. Trigger 1988; Pollard and Heron 2008; Henderson 2000; Pollard *et al.* 2007). Since then the relationship between Archaeology and Experimental Sciences has enormously evolved and Archaeometry could be considered now as a discipline on its own.

The original idea of this contribution was to present in detail the activities of the *Equip de Recerca Arqueològica i Arqueomètrica* of the University of Barcelona (ERAAUB) but this has already been made elsewhere. I intend therefore simply to outline the methodological approach that the ERAAUB have used in the archaeometric characterisation of archaeological ceramics. I shall clarify that the intention is not to provide a synthesis of the potential and limitations of the application of experimental techniques to ancient ceramics (see for instance Tite 2008). It is not either the aim to offer a deep and wide debate on the situation of archaeometry as a discipline. Other classical contributions with evocative titles such us *Why is Archaeometry so boring for archaeologists?* (Widemann 1982),

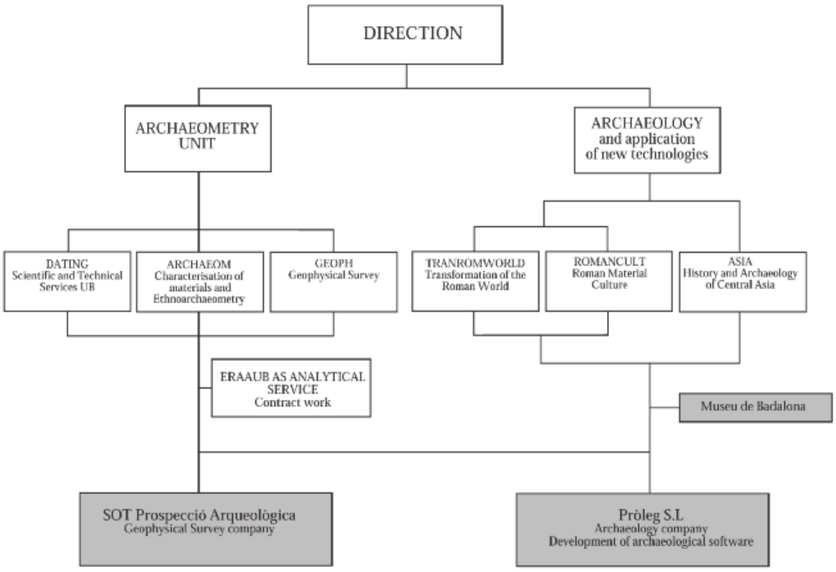


Fig. 1 Organisation and main research lines of the Equip de Recerca Arqueològica i Arqueomètrica, Universitat de Barcelona (ERAAUB).

Archaeometry: Quo Vadis? (Maggetti, 2006), or *A bicycle made for two? The Integration of Scientific Techniques into Archaeological Interpretation* (Pollard and Bray 2007) have addressed some of the problems. The main aim is simply to offer a few ideas regarding the methodological approach, introducing some of the problems that archaeometry/archaeology may be facing nowadays.

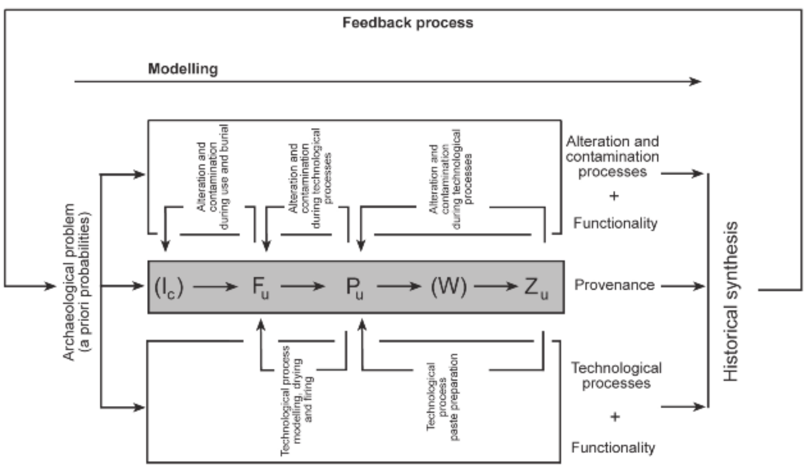
Methodological issues and techniques

The structure of ERAAUB can be summarised in Figure 1 where the organisation and the main research lines are outlined. In Figure 2, the flow diagram represents the methodological and theoretical framework in which our team has worked on the archaeometry of ceramics over the last decades (Buxeda *et al.*, 1995; Cau 2003, 2009). Of course, there is no space here nor is it the scope of this contribution to explain this approach in detail, but there are few aspects that I would like to highlight concerning the methodological approach to ancient ceramics, considering that the team is both an archaeological and archaeometrical team, applying analytical techniques from an archaeology department.

First, a fundamental aspect to the whole process (Fig. 2) is the existence of an '**archaeological problem**' to be solved and the definition of what we call 'a priori probabilities'. Unless a problem has been defined, it is not worth initiating any archaeometric work, and time, effort and money can be saved.

A second important aspect is that the approach of archaeometrists is the opposite of the procedure followed by potters (or the *chaîne opératoire*). In pottery making, the potter selects raw

Fig. 2 Diagram showing the methodological approach of the Equip de Recerca Arqueològica and Arqueomètrica of the Universitat de Barcelona (ERAAUB) to the archaeometry of ceramics.



material(s) and then prepares a paste(s) from which a vessel(s) is formed, dried and fired to create the pottery. The pot is then used and discarded, and deposited in the archaeological record. An archaeologist uncovers the object and, after specific treatment, it reaches the laboratory. In archaeometry, the work on provenance starts the other way around. The sample in a 'received state' is analysed to make inferences about the fabric and the paste and subsequently the raw materials used, which can be related to specific geological areas. It is therefore the opposite process to pottery making and this has implications.

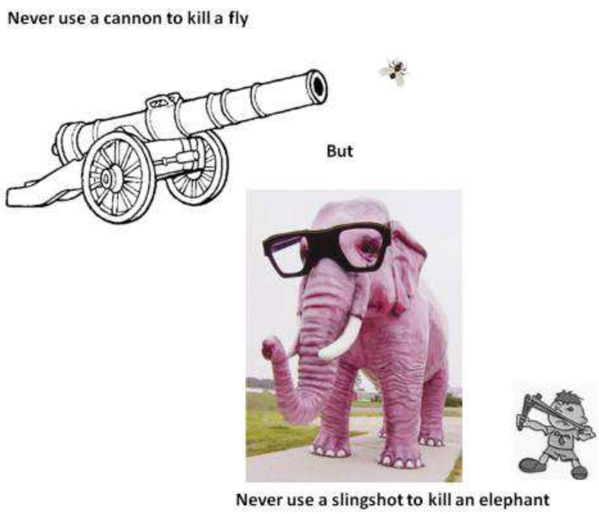
Provenance studies are based on the provenance postulate, '... *namely, that there exist differences in chemical composition between different natural sources that exceed, in some recognizable way, the differences observed within a given source*' (Weigand *et al*. 1977, 24). In short and in simple words, the provenance postulate says that it is possible to distinguish artefacts produced at the same source because the compositional variability between them should be always less than any of them compared with artefacts made in a different area. This postulate was made in the framework of a study of turquoise and therefore on a natural material where the anthropic action to create the object had no influence on its composition. In pottery studies, this principle needs to take into account the fact that the relationship between final products and original raw materials may not be direct, blurring the link between objects and source, due to technological reasons. The use of temper, clay mixing, levigation and other practices need to be addressed because they may have an important influence. The relationship will be direct between final products and the paste prepared by the potter, but the relationship between the paste and the raw materials may be direct sometimes if there is no alteration due to the technological process, or be rather obscure if technological processes had a great effect. Pottery is an anthropic product, with both natural and cultural information and its compositional variability includes natural variability and that introduced by the potter due to technological and/or cultural issues. As the technological process may affect the compositional characteristics of the original raw materials, it is clear that a provenance study has to take always into account technological aspects. While a technological study without provenance is possible (for instance to study the technology of a glaze), a provenance study needs to verify whether the technological processes may have had an effect on the compositional characteristics of the raw materials or not.

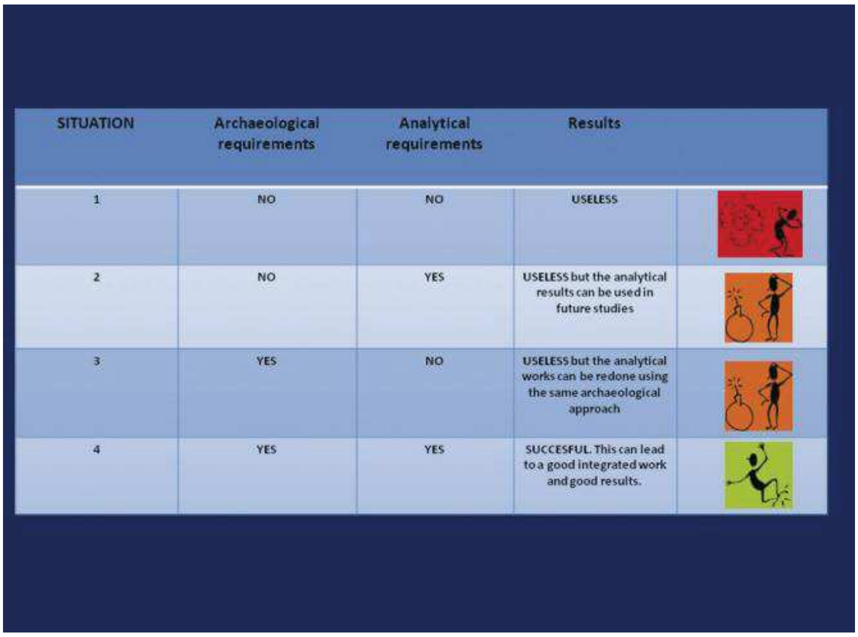
It is also necessary to stress **the need of a combination of different techniques** in order to understand pottery complexity. In our case, the team has always worked with X-ray fluorescence (XRF) to determine the chemical composition; X-ray diffraction to determine the main crystalline phases, particularly important in our case to recognised firing minerals and secondary phases; and optical microscopy by thin-section analysis for the petrographic characterisation as the only way to recognised main and accessory minerals, as well as rock fragments. Re-firing experiments and scanning electron microscopy to study microstructure and sintering state and for the microanalyses of minerals, glass, slips, glazes, decorations, etc. are also used, as well as other techniques in a non-routine basis.

Confucius stated one of his famous proverbs 'never use a cannon to kill a fly'. This can apply perfectly to analytical techniques and archaeometric approach. It is important to adjust the techniques and the methodological approach to the question being asked. Sometimes the question to be answered is easy and requires simple methods; other times it is not possible to do so and more advanced techniques are necessarily required. This applies also to the routine techniques that we apply, now that new methods are available. For much of the work on Mediterranean pottery, routine techniques, even when relatively old, have still a role to play. Of course, the potential and applications of synchrotron radiation to archaeometry, for instance, is of great interest, and I see that using it some complex problems could be solved. However, I do not see, due to the number of synchrotron facilities available and the cost of these, that this will be applied as a routine technique in many case studies within the Mediterranean. There are also economic reasons to use most of the techniques that we already have available. Having said that, it is obvious that even if we will not use a cannon to kill a fly, 'we cannot pretend to kill an elephant with a slingshot and less if this is a weird pink elephant wearing glasses' (Fig. 3).

More important than the techniques (and their limitations), the general methodological framework of the archaeometry of pottery is fundamental. It is important to remember that the role of archaeologists is essential, even in the initial stages of the work. It is important to stress that the definition of the 'archae-

Fig. 3 'Flies' and 'elephants' in the archaeometric approach. The original images are from the internet.





SITUATION	Archaeological requirements	Analytical requirements	Results
1	NO	NO	USELESS
2	NO	YES	USELESS but the analytical results can be used in future studies
3	YES	NO	USELESS but the analytical works can be redone using the same archaeological approach
4	YES	YES	SUCCESFUL. This can lead to a good integrated work and good results.

Fig. 4 Possible situations in the archaeometric approach to archaeological ceramics according to the degree of accomplishment of the archaeological and archaeometrical requirements.

ological problem', the 'a priori probabilities', and the definition of the 'individuals' to be studied are provided exclusively by archaeology and therefore are the responsibility of the archaeologist. It is essential to understand that **an archaeometric study begins with an 'archaeological question' that needs to be solved.** This is the starting point of the archaeometric approach. Without this, we can apply analytical techniques to ancient objects, but I am not sure that this could be called archaeometry. It is important also to bear in mind that **for an archaeometric approach to be useful it has to accomplish both the requirements of archaeology as a humanistic discipline and of experimental procedures as natural sciences** (Fig. 4).

A different general consideration that we may need to remember is that, in archaeometric studies for archaeological ceramics, **there is an initial difference between working in production centres or in consumption centres.** When a kiln site is available, the provenance of the pottery is already known from archaeological considerations. In this case, an archaeometric study of production is essential to characterise the reference group (RG) (Picon 1973), that is, to establish the chemical, mineralogical and/or petrographic fingerprint characteristic of that production (or better a combination of those). Establishment of the reference group is an ideal step towards studying the distribution of the material, as any other sherds that are thought to belong to the same production centre can be analysed and compared with it. This, complemented with a survey of the raw materials around the kiln site, can produce excellent results for defining the site's production and investigating the raw materials and technological processes used in pottery manufacture. For those responsible of excavations of kiln sites, there is a real need to define the reference group(s) (RG[s]), as these open up new possibilities for many other studies.

A different approach is to work on consumption centres in which the application of analytical techniques may help in the first instance to establish groups of sherds of the same composition and therefore presumably the same provenance, even if this is unknown or just suspected. In this case, the archaeometric approach cannot establish the 'reference group', but rather what has been called 'paste compositional reference units' (PCRUs) (Bishop *et al.* 1982). These are in fact coherent compositional groups that probably had the same 'provenance'. If the groups that are defined can be compared with established reference groups through a pattern association process, then it could be possible to ascribe a particular PCRU to a particular RG, that is to say, to a known production centre. This is especially true for a chemical approach to provenance. If petrography is also applied, then the groups that are defined can be compared with the regional geology to determine lithological compatibility with the geological environment and therefore to decide whether the material could have been produced locally, made regionally or imported. When the materials are imported, a comparison with the geology or with other reference collections can lead to the ascription of a particular provenance or the rejection of some possible sources and the proposal of others. The case of Pantellerian Ware in Late Antiquity is paradigmatic, as a very specific paragenesis derived from peralkaline volcanic rocks indicates that a group of cooking wares that were widely distributed in the Mediterranean were produced in Pantelleria, a small island between Sicily and Carthage (see for a review Montana *et al*. 2007). Of course, this is an exception, and in many cases the area of production can only be approached in relative terms according to the regional geology. It is important to remember that while lithological incompatibility between the composition of the ceramic material and the regional geology of a particular site means necessarily that the pot was imported, lithological compatibility does not demonstrate automatically a local origin, because other areas with similar composition could be found in other regions.

In archaeometric terms, whether we are defining a reference group or trying to group ceramic samples in a consumption centre, **the analytical results can be affected by the history of the object**. The ceramic sample that is analysed in the laboratory is a sample in a 'received state', meaning that it reaches the laboratory after its production, use, discard, burial, recovery and treatment in the archaeological excavation and/or museum.

When a sherd is analysed in the laboratory, the original composition of the object may have changed essentially through use and post-depositional processes during its burial or manipulation. One could say that pottery (like other porous materials) 'has a memory'. Thus, its composition can contain information on its use or burial and other post-depositional conditions that can alter the original composition. This can have a considerable effect, particularly on the chemical approach to ceramic provenance, as chemical elements may be affected by contamination or alteration, which makes it more difficult to interpret the results and to determine the provenance.

Consequently, archaeometric analysis has to take into account the fact that the composition of the sherds may have been altered, especially because these processes are more common than previously thought. Alterations and/or contamination processes that affect pottery are frequently related to secondary mineral formation. In archaeological pottery, they can be due to use or reuse, burial conditions or manipulation of the artefacts. The use of overfired kiln wasters to establish the reference group of a production can be problematic, as they can be strongly altered. The analysis of materials from underwater environments is also complex, as they have normally been altered and/or contaminated. Therefore, it is essential to take these processes into account in the interpretation of results and to apply robust methodologies, including a combination of analytical techniques, to overcome the problems that they may cause (see for instance Buxeda 1999).

Regarding the interpretation of the data we cannot get in detail in this issue, but it is necessary to remember that for chemical data, for instance, statistical analyses are a way of exploring our data and helping in their interpretation, but cannot stand alone. Our approach has been linked to the particularities of the compositional data (Aitchison 1986). In particular, during the GEOPRO European project the team adopted the use of the Statistical Package S-Plus from Mathsoft with several routines created *ad hoc* for the archaeometrical approach to ceramics according to the theoretical assumptions of the team. In general univariant, bivariant and multivariate statistics are applied. One useful instrument to explore the variability of a compositional data set has been the Compositional Variation Matrix (CVM) (Buxeda and Kilikoglou, 2003). In multivariate statistics we normally used Cluster Analysis with centroid method and squared Euclidean Distance. Automatic classifications for petrographic

data (Cau *et al*. 2004) or mixed-mode analysis to treat petrographic and chemical data in equal-footing (Baxter *et al*. 2008) have also been explored. A real understanding of the raw data and by a multiplicity of techniques is really needed. **I claim for a back to the roots** and to have a careful look to our results and to use simple tools to explore and to represent the data in the first instance before entering in more sophisticated methods. An 'excel table' and a pencil and a careful qualitative observation of the data are as important as any 'fancy' statistical treatment. Do not forget, that chemistry is somehow blind and two samples that are in fact different may fall into the same 'group' after certain statistical treatment. So this has to be 'cross-checked' with other information, petrographic for instance, and including of course the archaeological one. However, chemistry can be also more discriminant than petrography revealing aspects that a petrographic study alone would probably not have revealed. Again **a combination of techniques is the key.**
Analysed samples are not the problem: we can find out many things from them. I tend to say that the problem an archaeologist has is not the 100 samples he/she sends to the laboratory but the thousands of sherds (or tons) waiting to be classified in the storerooms. Therefore, it is important that after the analysis we try to provide easy keys, whenever possible, so that the archaeologist can identify at macroscopical level the groups (or fabrics and/or the evolution of temperature if this implies physical changes in colour or texture for instance) defined by the archaeometric study. There are two dangers here. The first is that this stage is often missing (what I call **the missing link**) or not even considered. A second problem that I have witnessed a few times is that someone may know everything about the 'sample' in analytical terms, but is not able to transfer these observations to a macroscopical level useful 'in the field'.

Archaeometry of ceramics as a humanistic-scientific discipline
Archaeometry is a playground in which both 'humanistic' and 'natural' sciences share space. Archaeometry is by definition a field in which interdisciplinary work is needed and where we need to construct a new frontier of knowledge and capabilities. In fact as Jones (2004) has expressed, 'sciences study the behaviour and properties of objects, while the arts and humanities are concerned with the study of subjects'. In ceramics, as material culture, both the natural and the cultural factors are intrinsic to its nature and therefore both have to be equally ad-

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dressed if we really want to understand pottery production, technology, consumption, function, use, discard and many other aspects. This is why **I personally defend archaeometry as a humanistic-scientific discipline on its own right** (and humanistic-scientific does not suggest that humanistic disciplines are not scientific; the terms are complementary). In this field, the requirements of archaeology as a humanistic discipline and those of experimental sciences (and this is not to say that archaeology is not experimental) have to be accomplished to obtain results that help us to interpret the materials under study and thus to understand the society that produced, used, and discarded them. By extension, these results contribute to the understanding of the transformation of societies throughout history. Only in doing so will archaeometry come to solve problems that are in the first instance of an archaeological and/or historical nature. Understood in this way, archaeometry is closer to the vast majority of archaeologists who unfortunately still think that it is something only for a minority. If we bring archaeometry closer to them (to us), as it should be, it will not evolve separately and without real interplay with archaeology. Seeing in this way, archaeometry fits in the *Spirit of Ravello* that years ago stated among other aspects that:

'*cette conception de la science englobant la connaissance de l'homme et de la nature optimise le développement de toutes les potentialités créatrices et notamment artistiques'* (Déclaration de Ravello, 6-7 juin 1984).

There are still problems with achieving real and integrated collaboration, and misunderstandings between archaeologists and archaeometrists still arise quite often. There is also a dangerous derivation of archaeometry into two different trends: one that is more closely related to the 'hard sciences', and one that involves more 'archaeologically orientated' archaeometric research, which Capelli (2011) calls *archeometria per archeologi*. Although I might agree on the essence of his message, in terms of terminology this is one of the few aspects where I do not concur with my colleague, simply because I believe that it should not be an 'archaeometry for archaeologists' as opposed to an archaeometry that is not. I believe that all archaeometry should be for archaeologists (as I consider that the aim is to solve problems of an archaeological nature, and therefore should be accessible to archaeologists). Perhaps what we are facing is a deeper problem with the definition of archaeometry. Some studies that are now called archaeometry may be materials sciences

applied to ancient objects, rather than real archaeometry, if we define the term as the application of methods and techniques from experimental sciences to solve archaeological questions. Perhaps the problem is not the definition of archaeometry, but the definition of what we understand as an archaeological problem, but this would be a long discussion.
Archaeometry has enormously evolved and advances in the relationship between archaeology and 'hard sciences' are more than evident, particularly in certain European countries. There are still problems to be solved and challenges to be faced but we have advanced a lot so far. So, the view should be overall positive. Of course, an analysis of the main problems and future challenges needs to be addressed and I shall do this shortly in this journal.

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