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Economic Space. On the Analysis and Interpretation of Pottery Production and Distribution

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Economic Space. On the Analysis and Interpretation of Pottery Production and Distribution

Ceramics are particularly well suited for investigating general patterns of the distribution of premodern products. Archaeometric methods, used to determine raw materials and production techniques, permit the identification of places of production. The work of the research group presented here pursues two objectives: (i) to investigate the usefulness of portable X-ray fluorescence equipment for the analysis of ceramics and (ii) to identify, interpret and study distribution areas of ceramic products in comparative perspective. The paper discusses key economic concepts, sets out the archaeometric methodology and presents initial results in the context of two examples.

Economy; production; exchange; value; infrastructure; archaeometry; archaeoceramology; distribution.

I Preliminary remarks

Given the dominance of post-processual approaches and materiality studies,¹ the issue of ‘economy’ lost the priority it was assigned since the advent of processual archaeologies.² Recent years have seen a further erosion of interest under the influence of symmetrical archaeology³ and post-anthropocentric approaches.⁴ Archaeologists interested in economy seem to be clinging to a dated paradigm. This necessarily contrasts with the relevance of the entire theoretical complex which has been highlighted by the continuing economic crises arising from the financial crisis of 2007/2008. This is best expressed in works such as anthropologist David Graeber’s *Debt: the first 5,000 years*.⁵ Contemporary work on the economies of the past tends to stress the emergence of value, where the archaeological discussion of “ritual economies”⁶ plays a significant role, along with the issue of “processes of appropriation” in the sense of a symbolic/cultural taking possession of things.⁷

These general tendencies marginalize two basic aspects of the economic: instrumental action and the provision of societies with the most basic material necessities. Today, both agricultural and industrial goods are manufactured in largely automated, immense factories or in the distant sweat-shops of a globalized world. This current state of the world has led to a vanishing familiarity with the production of goods, including and perhaps particularly in the ivory towers of academia. The result has been a collective shift of attention away from production and trade by scholars concerned with antiquity

1 E.g. Miller 2005.

2 Cf., e.g., Zimmermann 2001.

3 Olsen 2010.

4 Harris 2014.

5 Graeber 2011.

6 Wells and Davis-Salazar 2007; Spielmann 2002.

7 Hahn 2005; Stockhammer 2011; Schreiber 2013.

and culture. The production of basic durable goods and quotidian necessities no longer appears relevant as their provision is taken for granted today. Even exchange relations are pushed into the background when compared to archaeological studies of consumption.⁸

The orientation towards identity, consumption and materiality often appears cloaked in the terminology and conceptual framework developed by French sociologist Pierre Bourdieu who claims that various kinds of ‘capital’ (cultural, symbolic, economic, social) can be and are exchanged and converted.⁹ In this fashion, the assumption of a ubiquitous instrumentality enters culturally oriented interpretations via the backdoor.

We take this state of research as an admonition to reflect on the anchoring of instrumentality in cultural spheres of various kinds. Economic activity understood in the broadest sense of “instrumental reason” (based on Horkheimer’s criticism and further development of Weber’s *Zweckrationalität*, “instrumental rationality”)¹⁰ may not exist in practice, but Habermas argues that it exists as an ideology.¹¹ Certainly such reasoning existed in Neoclassical economics and in the minds of some archaeologists – and is always embedded in specific lifeworlds and ideologies, each leaving their own specific imprint. Investigations on the interface between instrumentality and culture have become the mainstay of several recently established research networks.¹² Our work is a contribution to these larger discussions. We have chosen to delve into one aspect of this research agenda, an element that is archaeologically easily accessible and ideally suited for comparative work based on the interaction of culture and economic activities: the production and distribution of pottery. In this paper, we detail our approach and present some preliminary results. Studying the production and distribution of pottery based on materials from some 10 projects (with different chronological and cultural contexts) offers a variety of different but comparable perspectives on past economic activity.

Pottery is uniquely suitable for the analysis of production processes and spaces of distribution. The required raw materials – clay, wood and other combustible materials, water – are widely available. This is one reason why pottery was produced in large quantities in the past. Found in increasing abundance on most archaeological sites beginning from around ten millennia ago, it can also be relatively easily dated and stylistically assigned to specific cultural groups, permitting the isolation of contemporaneous assemblages. Examining the component raw materials and the nature of the production process (clay, temper, shapes, firing procedures) often allows specific ceramic products to be assigned to specific workshops.

Although in theory pottery could be produced virtually anywhere, archaeologists frequently find complex patterns of spatial distribution suggesting elaborate networks of stylistically and typologically distinct vessels. Specific production workshops, and even individuals distinguished by particular abilities produced pots of more or less distinct types. On the other hand, not all communities have been and are equally receptive to adopting products from outside. Differences between production characteristics and user preferences lead to historically changing distribution spaces of pottery classes. One should not simply assume that such networks reflect the straightforward impact of market supply and demand mechanisms as we know them from neoclassical economics. This may have been the case in a few state economies, but we start from the premise that we cannot assume the degree to which such mechanisms were at work.

8 Cf. Wengrow 2008; Mullins 2011.

9 Bourdieu 1979.

10 Horkheimer 1947; Horkheimer 1967.

11 Habermas 1985.

12 Cf. in Germany, e.g., the Graduate Schools *Rohstoffe, Innovation, Technologie alter Kulturen* (Universität Bochum), *Wert und Äquivalent* (Universität Frankfurt/Main), *Archäologie vormoderner Wirtschaftsräume* (Universität Köln) and the Special Research Area 1070 *RessourcenKulturen. Soziokulturelle Dynamiken im Umgang mit Ressourcen* (Universität Tübingen).

In order to interpret distributional spaces, we must take a close look at the regularities in the production and consumption of pottery. The type and organisation of production is closely related to the exchange mechanisms as well as the distribution and use of pottery which together reflect taste, basic requirements and political or social conditions (for instance when vessels are used for feasting). Under ideal conditions of preservation, excavation or survey finds should convey an image reflecting these social and economic contexts.

2 Basic concepts

2.1 Space and knowledge

Our projects are derived from a specific approach systematically drawing on ‘space’ and ‘knowledge’ in order to analyse production and distribution. Physical space and the knowledge of its specific potential plays a special role in the exploitation of raw materials and understanding the infrastructural possibilities of the landscape, which offers or restricts routes and means of communication.

The underlying technical knowledge incorporated in pottery production can be investigated; the origins of this knowledge are as interesting as its practical execution. To understand the workshops, the scope, and organisation of production we need to investigate the functions and the value of specific kinds of pottery: who used and appreciated such vessels, and which quantities were involved.

Regardless of by whom and in which fashion the distribution of pottery was organized (and even how many people were involved), knowledge about the spatial extent of the social, political and ritual context is extremely important: where is there an interest in specific products, and with whom can one engage in trade or exchange and under what circumstances can this be carried out? And where and with whom is this not possible?¹³ In one and the same space, different types of exchange systems could have coexisted. The usage of different kinds of pottery had a role in structuring productive and distributive spaces. And purely practical issues of access to raw materials and users could have had an impact on human behaviour that is spatially structured and structuring spaces.

2.2 Production

Archaeological traces of pottery production come to us in two fundamentally different ways. First, evidence can be direct, in the form of excavated pottery kilns with pottery installations (such as pits to levigate clay), or as combustible materials, moulds, stamps, potters’ tools, perhaps even potters’ wheels, raw materials (clay, temper), and production debris (wasters: unfired, deformed or overfired vessels).¹⁴ Second, when such primary evidence is lacking, it is more difficult to demonstrate specific production locations. A concentration of specific pottery in a single place is initially but a hint about distribution

13 So e.g., Calvo et al. 2011, 16: “We must also consider that social relationships play a major structuring role in the formation of exchange types, organizational systems and scale of pottery distribution. Within the same territory, therefore, there may be different, overlapping and constantly changing distribution patterns”

14 There are various possibilities to be considered, e.g., (a) some overfired pottery could have resulted from exposure to heat during ordinary fires (i.e., after the original firing in a kiln) and (b) a vessel with cracks formed during the original firing can be found far from its original place of manufacture (Daszkiewicz and Bobryk 1998). If the heat of the ‘secondary firing’ is greater than that of the original firing, it is impossible to be certain about the original firing.

and consumption patterns and not necessarily informative about a specific locality of production.

Although archaeometrical methods offer good data about where materials may have come from geologically (as for example the early ‘Germanic’ pottery from Auerberg),¹⁵ only exceptionally do archaeometrical methods allow the indisputable identification of deposits from which raw materials for certain products were extracted.¹⁶ The presence of kilns (e.g., Rheinzabern¹⁷ or Nürtingen¹⁸) suggests that the clay will have come from deposits in the vicinity. In contrast, archaeometrical methods are ideal for distinguishing workshops without actually locating them precisely. The raw materials – clay and temper – play a significant role in identification, along with shaping methods, treatment of the clay, and firing procedures. Such methods can be supplemented by stylistic analyses of form and decoration.

All this must be taken into consideration when attempting to reconstruct the organisation of production archaeologically. Costin’s¹⁹ influential study of production with her elaborate system of classifying possible types of pottery production makes it clear that particular steps in pottery production processes do not all have the same potential of being recognized in the archaeological record. The complexity of a technology used, with the implied necessary knowledge, and the scope of production offer clues about the organisation of production for workshops with known products but of unknown locality. Certain types of pottery can be investigated according to the length and complexity of *chaînes opératoires*, but also by trying to record the density of sherd distributions on a site and in a region. Together, the data produced by estimating these types of variables offers relatively clear information about the forms of production without knowledge of the actual place of production. Finding actual workshops enables statements about the “concentration” of production (i.e. its internal spatial organisation). Costin distinguishes “nucleated” and “dispersed” production; assigning workshops a role in relation to a settlement’s layout allows statements about production contexts (i.e., “independent” or “attached” production). In the absence of accompanying textual material, only exceptional cases could potentially lead to distinctions between kin-based, wage- or slave labour production. The same applies to determining whether producers were ‘working’ full-time or part-time on the manufacture of pots.

2.3 Exchange and trade

There are different means of distinguishing pottery exchange and trade. The potential diversity of forms of exchange compiled by Renfrew und Bahn²⁰ offers a survey of the possibilities, but the value of their version is restricted. On the one hand, the role of markets and middlemen is oversimplified, while on the other, the potential variety of forms of non-instrumental (or ‘asymmetrical’) exchange is almost entirely neglected. The question to be posed here is just how and if such forms can be archaeologically demonstrated. Of central importance is the potential to identify the production of a specific site and its relation to a particular form of distribution. Regional systems of *ad hoc* exchange lead to distribution patterns that differ fundamentally from consciously directed long-distance trade mechanisms or the use of marketplaces. Transfer and gift-giving as non-reciprocal forms of exchange render the reconstruction of distribution practices even

15 Flügel 2000.

16 On the rare cases of the import of raw materials, cf., e.g., Levi and Williams 2003.

17 Schneider 1978.

18 Daszkiewicz and Schneider 2012.

19 Costin 1991, esp. Tab. 1.1.

20 Renfrew and Bahn 2004, 376.

more difficult. However, when it is possible to identify an actual place of production, the geographic dispersion of objects exchanged can be integrated into the interpretation as an important variable.

Since many vessels served as containers for a more important content, in exchange contexts one should distinguish primary (vessel) and secondary (container) wares. Ordinarily, this distinction is rather problematic, but the wine amphorae from Amarna (Fig. 1) are a case in point because of their labels. The same is true of transport vessels found in shipwrecks. In contrast to such self-evident cases, the analysis of residues in pottery vessels is a further avenue for such a distinction, but remains ambiguous insofar as one must differentiate between the potentially intended content and contents placed secondarily in such vessels.²¹

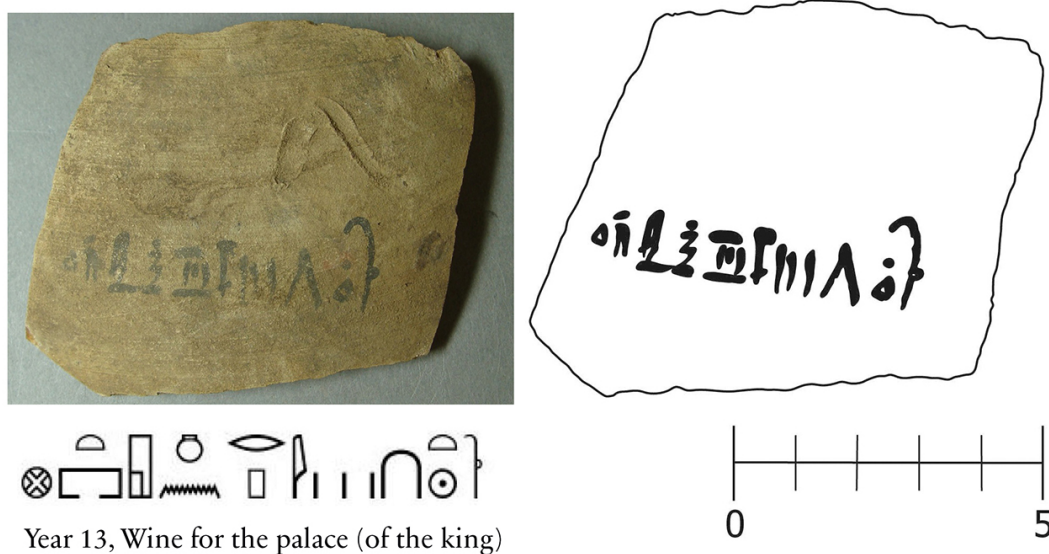


Fig. 1 | Tell el-Amarna. Amphora shard with hieratic inscription.

2.4 Value and equivalency

Without access to written sources it is difficult to determine the values of ancient objects.²² Use value plays a particularly important role in household production. Understanding the exchange value of pottery is a perilous project, for there is little hard data; potential transport costs will probably have influenced dispersed production of ordinary wares; while access to clay, water and fuel may have been more important than labour and transport costs in cases of more valuable pottery. In such cases we can only indirectly gain an idea of value that is largely restricted to inferences about the ranking of different wares. Indirect indications of high value occur:

21 For practices of recycling and reuse of amphorae as storage container for foodstuff see Peña 2007, 61–118 and 124–131.

22 Cf., e.g., Peña 2007, 27 for pottery prices in Diocletian's price edict.

- in extraordinary find contexts; for example, wheel-thrown pottery in Germanic “princely tombs”;²³
- in elaborate techniques which are difficult to imitate, for instance in the early Medieval *Tatinger Kannen* (wine pitchers) with tin worked into the ceramic fabric;²⁴
- in rare materials such as the ‘metallic’ or ‘stone’ ware of 3rd millennium BCE northern Mesopotamia made from a special (non-calcareous) clay²⁵ or the ‘golden’ ware of 2nd millennium BCE Nubia with its micaceous slip;²⁶
- in imitations, e.g., of Roman pottery in *germania magna*, beyond the limes;²⁷
- in a massive overkill of pottery products and production centres, as in south and central Iran of the 5th millennium BCE;
- in repairs as, e.g., with the Neolithic grey on grey ware of Thessaly;²⁸
- on vessels which were evidently perceived to be valuable, and the reworking of fragments as bits of jewellery; examples being Roman Terra Sigillata in *germania libera*.²⁹

Ultimately, the issue of ‘value’ can only be approached in approximate terms as far as the production and distribution of ordinary objects of daily life is concerned. Comparative studies can only succeed if in comparative cases, the items to be valued are more or less identical.

3 Archaeometrical methodology

Common to all the projects united here – regardless of spatial, temporal and cultural contexts – is the uniform application of archaeometrical methods of analysis, understanding the archaeometrical results as proxies or markers offering information about value in socio-economic terms. The basic assumption regarding economic spaces studied through pottery is that workshops are characterized by style, by technology and by the material used for production (provenance). Determining provenance and technology requires archaeological knowledge as well as laboratory analyses. Traditional methods are based on the analysis of small samples taken from the objects and on analysis of the chemical composition of the powder, the mineralogy of the temper and aspects of forming and firing techniques. They may be replaced to some extent by non-destructive chemical analysis using a portable (or handheld) energy-dispersive X-ray fluorescence analyser (pXRF, p-ED-XRF, HHpXRF). The two strategies, however, are not comparable. Extensive experience with conventional methods has revealed their limitations and possibilities. Analysis by pXRF however, without extracting a (destructive) material sample, enables the analysis of only a limited part of the chemical composition of a thin surface layer of a sherd, preferably on a fresh break. This constrains the potential for representative and accurate data concerning the whole body of a sherd or vessel. However, a quick chemical screening in the field offers the potential of acquiring large data-sets. This is valuable in situations where destructive interventions are impossible and/or exporting samples is not

23 Bemmman 2001.

24 Hupka 2012.

25 Schneider and Daszkiewicz 2001.

26 Knoblauch 2011.

27 Hegewisch 2005.

28 Schneider, Knoll, et al. 1994.

29 Meyer and Hegewisch 2014.

easy. Our research agenda aims at developing a reasonable workflow for the integration of pXRF into archaeoceramological projects.

The system for traditional laboratory analysis of archaeological ceramics to determine their provenance and technology applied in the Topoi A-6 research group is the so called DBS package (from: Daszkiewicz & Bobryk & Schneider, whence the designation 'DBS package'³⁰), the result of many years' experience (model analyses, ethnographic studies and analysis of around 30,000 fragments of ancient pottery) by the international archaeometric research team DBS. Where technological analysis is concerned, the choice of methods used is inextricably linked to the questions posed by archaeologists. For investigations of the provenance of ceramic bodies, the DBS standard package consists of MGR-analysis (Matrix Group by Refiring)³¹, chemical analysis by WD-XRF (wavelength-dispersive X-ray fluorescence) and thin-section studies. This integrated approach combines methods and experiences from three fields of science and technology: ceramology, analytical chemistry and mineralogy-petrography. Optimally, every sherd should be studied with all three methods.³² MGR analysis yields information on the plastic quality of the ceramic body regarding the thermal behaviour by refiring small fragments of the sherds at defined temperatures under laboratory conditions. Chemical analysis by WD-XRF of powdered samples of one gram (melted with lithiumborate flux) determines the ten major, and about fifteen trace, elements. Thin sections are studied under a polarizing microscope to get information on texture, structure and composition mainly of the non-plastic inclusions which may give clues to technology and provenance. It becomes clear that reducing archaeoceramological projects to the use of chemical analysis by pXRF simply cannot replace such a multifaceted approach. Nevertheless, pXRF can be a valuable tool if it is integrated into a broader methodological approach.

As outlined above, chemical analysis in general is an important but limited part of the analysis of archaeological pottery. Comparison of chemical data shows if two samples are identical (i.e. the differences are within the limits of precision) for at least approximately fifteen significant elements (not including elements such as phosphorus which is strongly influenced by post-depositional alteration effects³³). This is the basis of provenance studies and is done using WD-XRF, NAA (neutron activation analysis) or ICP-MS (inductively coupled plasma mass spectrometry) yielding data on up to thirty elements with sufficient precision.³⁴ In each case, a small powdered sample of 0.1 to 1 gram after cleaning is needed. To represent the composition of the body it should be taken from the core of the sherd after removing any surface layers. The amount to be powdered depends on the grain size and should be as large as possible. It should also be kept in mind that using only chemical data may be misleading, regardless of the analytical technique used. For example, two pottery vessels made from the same clay could belong to two different chemical groups because of added temper and/or salt.³⁵ If only the chemical composition is analysed and the subsequent report is written up relying even on precise data obtained by WD-XRF and on sophisticated statistic methods, the resultant cultural and historic conclusions could be erroneous. This necessarily applies even more so to the limited quality of analytical data from pXRF. A combination with other methods is therefore necessary, including traditional archaeometrical methodology such as MGR-analysis, WD-XRF, and thin-section studies.

30 www.archaeometry.pl, (visited on 04/05/2016).

31 Schneider and Daszkiewicz 2001; Daszkiewicz 2016.

32 Daszkiewicz 2014.

33 Schneider 2016.

34 E.g. Daszkiewicz and Schneider 2014.

35 Daszkiewicz 2014.

For some years now, portable equipment for ED-XRF (pXRF) has been available allowing the analysis of sherds without taking samples.³⁶ It must be borne in mind that (a) because of the limited depth of information provided by the X-rays representing the chemical composition (only between 0.005 and 0.5 mm), (b) because the samples measured are not homogenous and may feature large inclusions of more than one millimetre grain size, and (c) because measurement is not carried out under optimal geometric conditions, the data cannot be as precise as when a powdered sample is analysed, for example by WD-XRF. In experiments, the coefficients of variation proved to be two to ten times larger for the roughly twenty elements which can be measured (pXRF does not determine the important element sodium and, even with the use of Helium flow, the usually low concentrations of magnesium cannot be detected with sufficient precision). This is even true when four measurements taken at different spots on one and the same break of a sherd, each for two minutes, are averaged.³⁷ Measurement was tested on fresh breaks, cut sections and slipped and unslipped surfaces of fine and coarse pottery.³⁸

The principal advantage of pXRF is that it provides a non-destructive method of pottery analysis. This, however, only concerns the analysis of a surface. It must be clearly stated that, if reliable information about the chemical composition of the body of a sherd is to be obtained, ideally measurements should be taken from fresh breaks, or from areas which have been scratched and cleaned. Yet such procedures are not absolutely non-destructive. The composition of the original surface may also differ significantly from the composition of the body because of applied slips, contamination or post-depositional alterations.

However, there may be cases where the composition of clean slipped surfaces can be used to classify sherds according to their provenance (e.g. for *Terra Sigillata*³⁹). Limitations such as the limited number of about ten significant elements, poor precision and limited comparability with analytical data available e.g. from databases, must be considered. The experiences of Behrendt⁴⁰ using pXRF showed erroneous provenance classification of 10–45% of samples (up to 20% in the case of fine wares). This means that in the worst case almost half of the samples can be misclassified. Combining this technique with more precise laboratory methods is, therefore, recommended. Secure lab data might be used to determine the necessary reference groups as a basis for the attribution of the pXRF data thus enabling, even with limited certainty, the screening of a large number of sherds or the inclusion of sherds from which samples could not be taken.

It must be emphasized that using pXRF does not eliminate the need for precise macroscopic descriptions of fabrics or typological analysis. And once chemical composition analysis by pXRF has been completed and multivariate clustering has been carried out, samples for MGR-analysis and/or additional WD-XRF analysis should be selected from each individual pXRF cluster. The sampling within the clusters should be based on the results of typological and macroscopic fabric analysis and not be based on random sampling (Fig. 2). This scheme is an abridged version of down-up sampling classification.⁴¹

36 Here, the archaeological ceramologist's dream of being liberated from the expensive help of scientists and the restricted capacities of laboratories seems to have become a reality. However, experience gained from forty years of archaeometric study of ancient pottery in Europe and the USA has highlighted multiple problems involved in the interpretation of ceramic chemical composition data. Even precise and accurate data can only yield meaningful results in archaeological terms if the scientific implications and correlations of the data are adequately analysed and understood.

37 Schneider and Daszkiewicz 2010.

38 These measurements were carried out with a Niton RF-Analyser (details see in chapter Pottery at the Late Bronze Age mega-site of Cornești-Iarcuri).

39 Daszkiewicz and Schneider 2012.

40 Behrendt, Mielke, and Mecking 2012.

41 Daszkiewicz 1998; Daszkiewicz, Bobryk, and Schneider 2010.

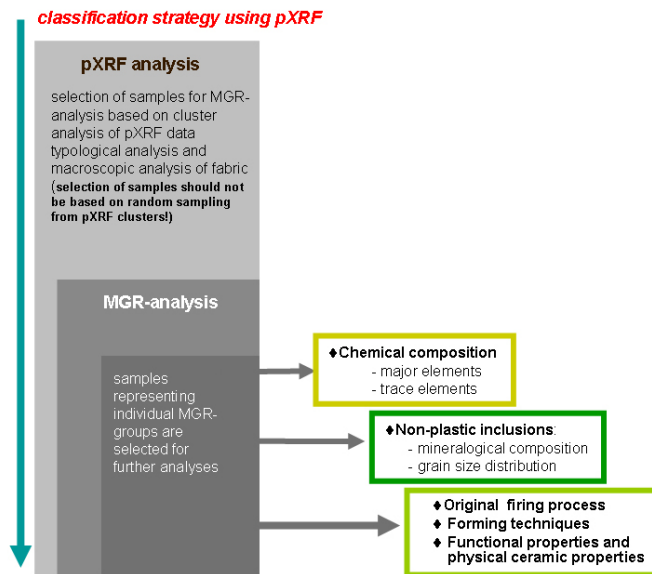


Fig. 2 | Classification strategy using pXRF and conventional methods for Topoi projects.

4 The application

Tests were conducted to assess the possibilities and limitations of pXRF methods to classify ceramic materials from the various projects carried out by the research group: wheel-thrown pottery from Olbia (South Ukraine, see below), fine ware from Petra (Jordan),⁴² and different wares from Cornesti (Western Romania, see below). The methodology described in this paper has been used in all of these projects as a preliminary form of classification. Technological analyses have only been carried out for some projects.⁴³ Additionally, a pilot series of fine ware pottery from Musawwarat es-Sufra (Sudan) has been analysed by WD-XRF. First results have already been published.⁴⁴

We also assessed the possibilities and limitations of applying pXRF in the non-destructive/semi-destructive analysis of various kinds of archaeological samples:

- in the analysis of Late Bronze Age pottery from Lossow (Brandenburg, Germany);
- in the analysis of pottery with a blue-painted surface (Amarna project, Egypt);
- in the analysis of glass artefacts from Komariv (Ukraine).

5 The projects

The archaeometrical investigation, combined with analysis of the spatial contexts of pottery found in various regions, forms the bracket uniting all the subprojects, geographically distributed from Germany, across Jordan and the Sudan, to the Persian Gulf (Fig. 3), and chronologically from the origins of pottery production in the Neolithic Near East to the European Early Middle Ages. The combination of the research results of the various individual teams will enable us to investigate multiple forms of economic structures as they are embodied in the distribution and production of pottery.

Obviously, each project deals with a society with its own specific cultural, political and economic circumstances. It is precisely this diversity that offers the comparative

42 Daszkiewicz, Schneider, et al. 2013.

43 E.g. for forming technique, project A-6-4 (Daszkiewicz, Bobryk, and Schneider 2010).

44 Näser and Daszkiewicz 2013; Daszkiewicz 2014; Näser and Wetendorf 2014.



Fig. 3 | Map of Topoi Projects A-6-1 to A-6-10: 1 Late Bronze Age ‘*Turbanrandschalen*’ in and around the fortified site of Lossow; 2 The analysis of spheres of exchange in southern Iran; 3 Systems of pottery distribution from the Neolithic to the Islamic era along the Middle Euphrates Valley in Syria; 4 Wheel thrown pottery of the Roman imperial periods in northeastern Germany; 5 Meroitic fine pottery: production, distribution, use; 6 The economic landscape of Hellenistic, Roman and late antique Bithynia; 7 Distribution and production locations of Nabataean ceramics; 8 Distribution of ceramics in the larger settlement of Cornești-Iarcuri and its settlement history; 9 Select pottery at Tell el-Amarna; 10 Glass working of the 3rd to 4th century AD in Komariv, Ukraine.

potential for the common project. With common goals and shared methods dealing with contrasting types of materials, the joint critical discussion of the distribution of the pottery must always take account of the entire set of materials, contexts, and analyses. Highlighting the nature of the various different structures of production and distribution of pottery allows apparent similarities to be integrated into variable economic interpretations and it is through the contrasts that such phenomena can be recognized and analysed. The cultural diversity of the projects is methodologically united by the unified archaeometrical analysis. Using comparative perspectives, our projects can be divided into three groups.

5.1 Spatially oriented analyses of specific pottery types and production methods

One set of projects aims at archaeometrically analysing the spatial distribution of highly specific pottery types that are parts of larger assemblages. For example, the Bronze Age *Turbanrandteller* on the ramparts of Lossow (Oder) and the surrounding region might have been assumed to be products of a specialized, attached production with a larger distribution in the wider region. By contrast, the quantitative distribution of imperial Roman era wheel-thrown pottery produced among the populations beyond the Limes reveals great differences ranging from (a) a full-time nucleated workshop (Haarhausen) and a part-time dispersed independent workshop (Brandenburg) with a wider distribution to (b) individual dispersed workshops producing for their own settlements (Chernyakhov-Culture, Ukraine). A retainer workshop is assumed for the Nabataean fine wares produced

in Petra (Jordan). The Meroitic fine wares of Sudan were produced in attached specialized workshops – and first results⁴⁵ suggest that they were only distributed intra-site.

We are running a study on glass as a methodological comparison. In Komariv (Ukraine), a specialized nucleated workshop seems to have recycled Roman glass and distributed it through a system of prestige goods exchange.

5.2 Studying regional ranges of pottery

Another set of projects is geared towards the analysis of the regional spread of entire assemblages of ceramics. The Early Chalcolithic pottery of the south Iranian Zagros was possibly produced by specialists in nucleated workshops but apparently without any specific direction of spread. The exchange of pottery probably took place ‘down-the-line’ or was distributed by the producers themselves. The pottery of the north Syrian Euphrates Valley is being investigated diachronically, in time slices reflecting different socio-economic and political conditions. At Tell el-Amarna (Egypt) we have Mycenaean pottery possibly produced in retainer workshops on the Peloponnesian peninsula and local Egyptian inscribed amphorae; it is probable that the wine amphorae were produced in the neighbourhood of the vineyards, and both types were distributed by exchange of their content.

5.3 Intra-site analysis

The Bronze Age Romanian mega-settlement of Cornești-Iarcuri allowed the team to study both regional pottery distribution and the distribution of the various products within the settlement, for which a household production in dispersed workshops is probable.

6 Two project examples

6.1 Pottery at the Late Bronze Age mega-site of Cornești-Iarcuri

The Bronze Age mega-site of Cornești-Iarcuri lies in Romanian Banat. The Late Bronze Age settlement is the largest hitherto identified prehistoric settlement in Europe, fortified with four sets of circumvallation walls, the outermost of which has an outer circumference of 15.8 km, surrounding an area of 1772 ha, within which were three further interior wall systems. An international team including the Berlin Museum für Vor- und Frühgeschichte⁴⁶ has been working at the site since 2007.

For our purposes, a site of the size of Cornești-Iarcuri offers analytical possibilities allowing a multitude of research questions. However, given the surface area of almost 2000 ha, the usual method of typological classification of pottery and other materials in relation to the stratigraphy must be complemented by spatial information. Individually, the excavation trenches with stratified material are large, but in relation to the overall size of the site they are quite small and thus of limited validity when drawing more general conclusions. We have, therefore, also carried out systematic large-scale surface surveys since the beginning of the excavations. At present we have collected c. 27 000 sherds from c. 127 ha (cf. the overall plan, Fig. 4).⁴⁷ Only a small proportion of such a large quantity of

45 Näser and Daszkiewicz 2013.

46 Other members are: the Banat Museum Timișoara (Romania), the University of Exeter (Great Britain), the Johann Wolfgang Goethe Universität Frankfurt/Main (Germany).

47 For the fieldwork through 2011: Heeb, Szentmiklosi, and Wiecken 2008; Szentmiklosi et al. 2011; Heeb, Szentmiklosi, Harding, et al. 2012.

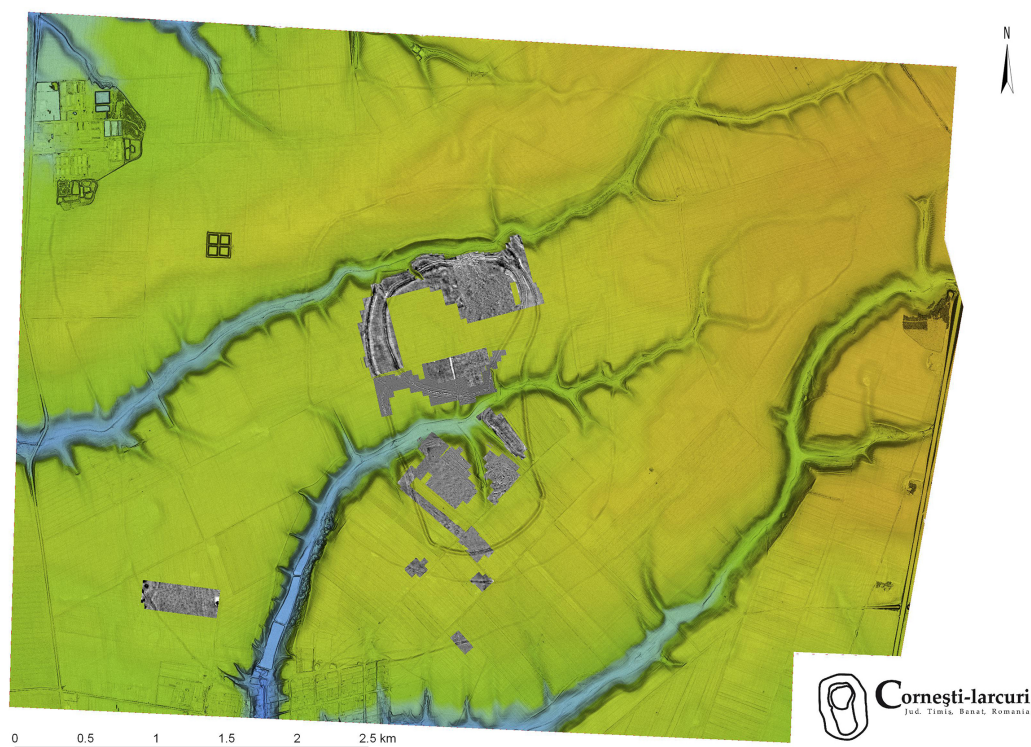


Fig. 4 | Plan of the Late Bronze Age mega-site of Cornești-Iarcuri. The inner fortifications are easily recognized with the aid of the inserted sketch.

relatively small fragmentary material can be typologically and chronologically classified – but offers a perfect source for the overall understanding of the site, since all the material can be assigned to specific squares; in combination with magnetometric surveying for Magnetic Resonance Imaging (MRI) the initial indications of settlement density and concentration, as well as chronological shifts can be recognized. Out of this collection of fragmentary ceramic material – and material from six other settlements – 447 fragments were selected for a multi-level analysis.

The research is thus being pursued on two different spatial levels: on the one hand the level of intra-site analysis encompassing the two settlement phases (Middle and Late Bronze Age), and on the other a regional study.

Cornești-Iarcuri allows the investigation of the continuity of production and the distribution of products of the different workshops within the site, with the surveys contributing to the discovery of the clay deposits used. The regional approach offers access to the exploration of the type and intensity of pottery exchange in the region.

All 447 ceramic sherds underwent chemical composition analysis by pXRF, which was conducted using a Niton RF-Analyser.⁴⁸ The results of this analyses were used as the basis for selecting samples for further analysis. Abridged MGR-analysis was carried out on 170 ceramic sherds; 103 samples were chosen for WD-XRF analysis and these samples also had their physical ceramic properties determined (open porosity, apparent density and water absorption). In addition, full MGR-analysis, structural MGR-analysis⁴⁹ as well as TG (thermogravimetric analysis), DTG (derivative thermogravimetric analysis), DTA (dif-

48 Niton XL3t900S GOLDD RF-Analyser, MINING software; calibration based on twelve ceramic standards analyzed by WD-XRF; 8-mm measuring spot; measurement time of 120 seconds to 30 sec per filter; measurements without Helium, in a sample chamber.

49 Daszkiewicz 2014; Daszkiewicz 2016.

ferential thermal analysis) and XRD (X-ray diffraction analysis) was conducted on ten samples. Twenty samples were the subject of thin-section studies.

According to our results, pottery from both the Late Bronze and Middle Bronze periods was made from various non-calcareous clays coloured by iron compounds and fired at 700 to 800° C in an oxidizing atmosphere with incomplete combustion of organic matter (a few exceptional pieces were briefly fired at higher temperatures in a fully oxidizing atmosphere). The variety of clays (matrix groups, Fig. 5) used may be evidence of many local workshops.

Major MGR-group	MGR-group	Dating / finding spot			
		LBA Ring I	LBA Ring II	MBA Ring I	MBA Ring II
		number of samples			
101	6	3			
101	7 a.v.	7			
101	9	1			
101	11 a.v.	2			
101	14 a.v.		13		
101	17		1		
101	18		1		
101	18.01		3		
101	21		1		
101	27 a.v.			1	3
101	24				1
101	25				2
102	29			2	
102	31				1
102	32 a.v.			2	1
102	33				2
102	34				1
103	4	2			
103	20 a.v.		2		
103	22		1		
301	10	1			
401	30				2
501	23				1
201	3	6			
201	5	3			
201	8	1			
201	12	1			
201	13	1			
201	15		1		
201	16		1		
Imp 1	1	1			
Imp 2	2	1			
Imp 3	19		1		
Imp 4	26				1
Imp 5	28			1	

Fig. 5 | Matrix groups (MGR-groups) of the Late Bronze Age (LBA) and Middle Bronze Age (MBA) pottery at Cornești-Iarcuri.

Ceramic bodies were intentionally tempered with grog. Neither organic nor mineral tempers were used; isolated examples of mineral tempers were observed at individual sites beyond, but not at, Cornești-Iarcuri. Figure 6 shows typical photo-micrograph images of sherds from Cornești-Iarcuri viewed through a polarising microscope.

The grog was proven by MGR-analysis to have been the same composition as the main body to which it was added. Pottery produced on-site was identified based on the geochemical characteristics of the ceramic body, in the absence of any other evidence. Therefore frequency of occurrence and compositional similarity to clay samples was the criterion used to determine whether or not pottery was local. Carrying out MGR-analysis

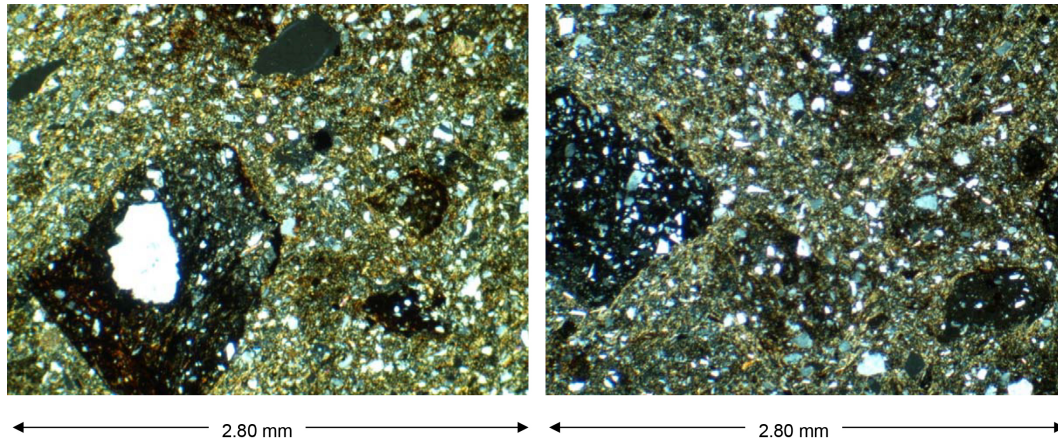


Fig. 6 | Sherds from Cornești-Iarcuri (left LBA, right MBA) viewed through a polarising microscope. In the matrix grog is clearly visible.

enabled the identification of the clays used (MGR-groups), which revealed that there was no on-site continuity in the use of clay raw materials between the MBA and the LBA (Fig. 5). None of the clays used in the Middle Bronze Age were used in the following era. In terms of pottery manufacturing technology, however, there were no significant differences between the Middle and Late Bronzes ages; it was only the raw material that differed significantly.

This raises the question of the origins of Cornești-Iarcuri: did the Late Bronze Age settlement emerge out of the preceding Middle Bronze settlement? As the practice of pottery production depends upon pottery-making individuals and intergenerational learning, one could suspect that the analytical results point to population continuity. The change in the type of clay used can be ascribed to a shift in the recovery of the raw material, possibly due to the exhaustion of the deposits used in the Middle Bronze Age. Such a development need not necessarily be interpreted as a discontinuity in any other area than raw material acquisition. With all due caution, the analyses stressing technological continuity can be taken as indications of the development of a large settlement growing out of the Middle Bronze settlement.

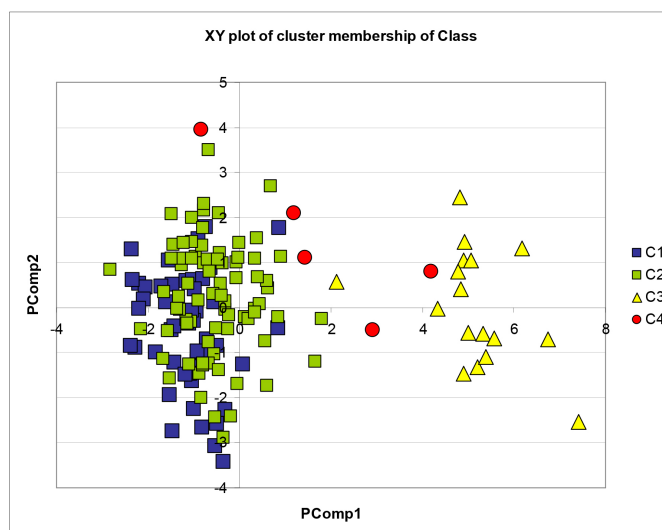


Fig. 7 | Principal components analysis using the elements: Ti, Fe, Ca, K, V, Rb, Sr, Zr. Analysis by a pXRF was carried out on 150 samples from Cornești-Iarcuri. MBA pottery (C1) cannot securely be distinguished from LBA (C2) pottery on the basis of chemical analysis. There is a clear distinction, however, between sherds of local pottery from Cornești-Iarcuri (C2) and regional pottery (C3). Probably imported pottery is also distinguished (C4).

The study of the Middle and Late Bronze Age pottery in and – for the Late Bronze Age – around Cornești-Iarcu led to some other clear results seen using pXRF analysis (Fig. 7). In a principal component analysis, C1 encompasses all of the Middle Bronze Age pottery materials distinguished by MGR-analysis, cluster C2 comprises all Late Bronze Age materials, cluster C3 unites Late Bronze Age materials also appearing at other sites.

C1 and C2 clusters consist of samples belonging to several MGR groups which probably represent local Cornești-Iarcu household production which did not contribute to exchange processes beyond the settlement. This contrasts with the strikingly different cluster C3 found in small quantities in six sites explored. Until now we have not been able to propose any specific place of production for the pottery of this cluster. It follows that we have a pottery group which was exchanged on the regional level. The economic image is rounded off by a small number of pieces (C4), each different in MGR analysis and with its own individual chemical fingerprint – and none of which appears to have been produced at any of the places hitherto explored.

Fig. 8 shows the spatial distribution of the Late Bronze Age pottery groups. The three-fold classification of the pottery distribution is easily recognized: local products (blue in Cornești-Iarcu, marked with various green tones are local productions at six other places) which were not exchanged. They make up the majority of the material found at each place. Then there are regionally exchanged products (yellow) with a presence at all of the settlements hitherto explored, and a series of individual vessels (red), about the production of which we have not yet been able to draw any conclusions.

As understood today, taking account of technological aspects of pottery production, general household production can be assumed. Yet larger workshops may have been responsible for specific products, as illustrated by the more widely distributed C3 group, and meaning that production for exchange purposes could potentially be proposed. This hints at a complex distribution of production systems.

For Cornești-Iarcu, it remains to establish distribution patterns displaying vessel types according to our archaeometrical pottery groups insofar as this is possible with our fragmentary material. The origins of the raw materials and the locations of the production centres still remain unclear.

7 The grey wheel-made ceramics in Olbia and its surrounding of the first centuries CE

The investigation of the pottery from the area of the Southern Bug river forms a part of this project. In this case, the general aim is to clarify the relationship between the ancient center of Olbia and its surrounding region. The analytical results of the production of pottery are considered an important element of the economic structure of the ancient city. As described below, the history of this area is characterized by the interruption of settlement and population shifts during the first centuries CE. Therefore, the project was focused on the development of pottery production under different cultural, economic and political conditions. The pottery samples derive from ten sites,⁵⁰ six of which include material from the 1st to 4th centuries CE. Two sites (Radsad, Skelka) yielded only ceramics from the 1st to 3rd centuries. From three sites (Adzhigolska Kosa, Novokondakove, Stanislav) only grey pottery deriving from the 3rd to 4th century was analyzed. For the sites of the Olbian *chora* we tried to base the analysis on grey ceramics found in well recorded archaeological complexes. For Olbia itself the selection of samples was focused on complexes and layers of

50 Adzhigolska Kosa, Kozyrka, Novokondakove, Olbia, Petukhivka, Radsad, Skelka, Stanislav, Stara Bogdanivka, Zoloty Mys.

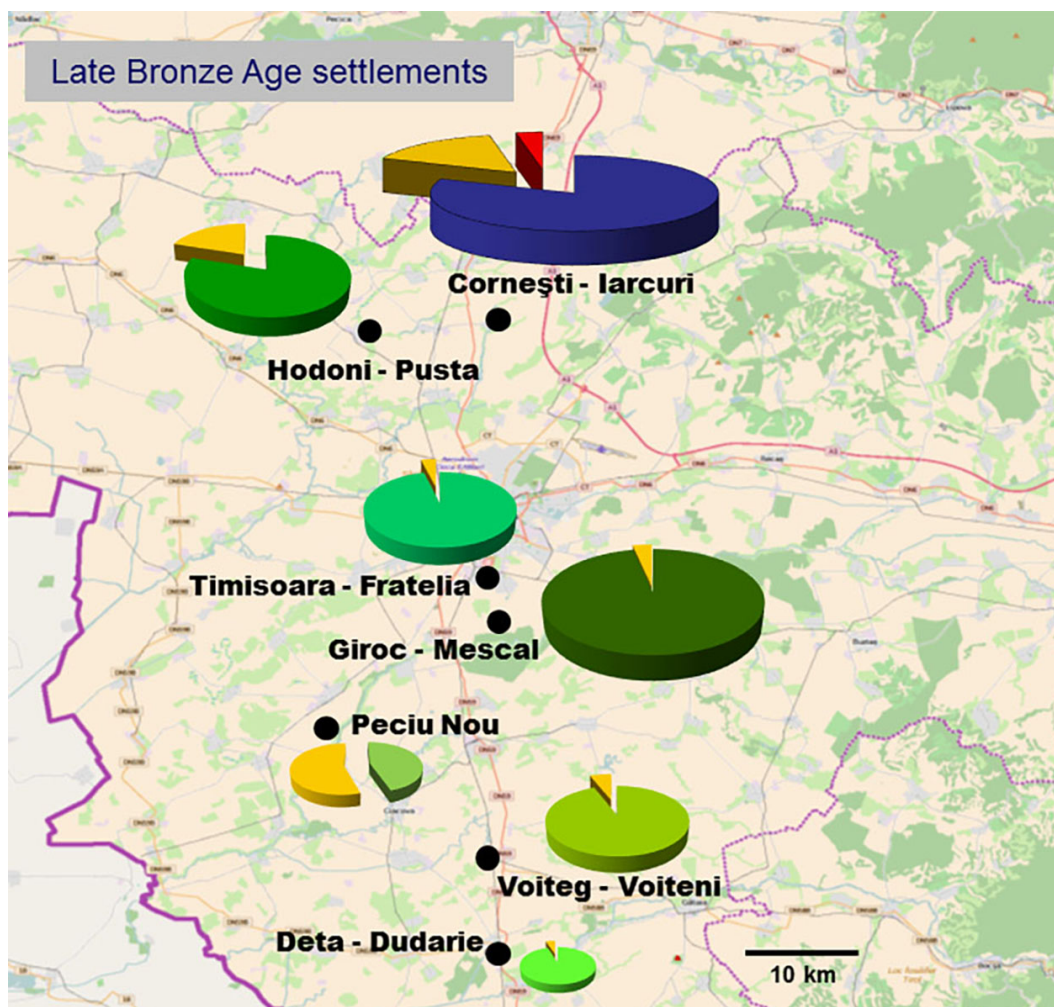


Fig. 8 | Spatial distribution of Late Bronze Age pottery Groups in the Banat. Blue (Cornești-Iarcuri), various green tones (other sites): local production. Yellow: regional products. Red: a series of individual (imported?) vessels.

the 3rd to 4th century CE. The samples of settlements in Novokondakove and Adzhigolska Kosa present random collections.

The polis of Olbia Pontica is situated where the Southern Bug flows into the Dnirovskiy Lyman, in the modern district of Mykolaiv (Ukraine). The production of grey ceramics is already known for the final centuries BCE in this polis, originally founded by Greek colonists. For the period from the 1st to 3rd centuries CE it is presumed that grey ceramics were produced here for the polis and the settlements, as well as the hillforts in the *chora*.⁵¹ Remains of at least 10 kilns dating to this period were discovered, testifying to the local production of several kinds of ceramics.⁵² Production of ceramics for local demand was also presumed for Kozyrka, the best investigated hillfort of the *chora*, based on finds of slag and remains of a workshop for metal or ceramics.⁵³ As parts of an administrative and defensive system, the polis and hillforts were in constant contact with each other, by both overland and water routes. Thus grey ceramics could reach every point of the *chora*. Furthermore one can expect the import of ceramics from the Roman provinces. During

51 Krapivina 1993, 128

52 Krapivina 1993.

53 Burakov 1976, 132.

this period, grey wheel-made pottery was one part of the ceramic range consisting of grey ware, red ware, *Terra Sigillata* and other ceramics.

In the third century, these hillforts, like Olbia itself, were destroyed during the so-called ‘Scythian’ or ‘Gothic’ wars. Part of Olbia was rebuilt in the traditional fashion at the end of the century, surviving until the middle of 4th century CE. A pottery kiln found in Olbia is evidence of local pottery production during this period.⁵⁴ But with a *chora* only 5–10 kilometers in diameter, the polis had contracted slightly in comparison to the previous period. Territories in the surroundings were now occupied by settlements of the Chernyakhov culture – the former hillforts served as unfortified rural settlements. For this archaeological culture, grey wheel-made pottery is one of the most striking features dominating the material. Until now there is no evidence of pottery production within the settlements of this area, though it is well known from other regions of the Chernyakhov culture. Relations between Olbia and these settlements in the surrounding region certainly existed in various ways. Exchange of ceramics or ceramics as packing material could both have played a role.

Typological and macroscopic study allowed the separation of the grey wheel-made ceramics of the area into two separate ranges – Græco-Roman and Chernyakhov.⁵⁵ The Græco-Roman range consisted of tableware, including bowls, jugs and jars, mostly from the 1st – 3rd centuries CE. The Chernyakhov range of the 3rd – 4th centuries CE involved not only tableware, but also considerable quantities of kitchenware, such as pots, simple bowls, and storage vessels. Using archaeological methods, it was impossible to determine the provenance of the pottery or to distinguish local characteristics this material.⁵⁶

7.1 Description of methods used

Our analysis was based on a selection of sherds from the Olbia region. From the ten sites, altogether 284 sherds were selected for archaeometrical analysis in the laboratory. The analytical methods employed encompassed: chemical analysis by pXRF,⁵⁷ abridged MGR-analysis and chemical analysis by WD-XRF. The first procedure undertaken was pXRF analysis, which was carried out on all 284 samples. After that, 210 samples were selected for abridged MGR-analysis (refiring at 1100°, 1150° and 1200° C) (examples, Fig. 9). On completion of the MGR-analysis, the samples were reclassified according to the results of this analysis and the subsequent selection of 33 fragments for WD-XRF analysis was based on this new classification.

The chemical data determined by pXRF measurements were statistically analyzed with a hierarchical cluster analysis, by the Ward method. This analysis revealed a 4-Cluster solution, with clusters particularly separated due to the Fe₂O₃ amount from each other (see Fig. 10).

The conclusions on the basis of the chemical data were, however, initially limited. Only the comparison of the clusters with the results of the MGR analysis gave a more finely nuanced picture. The MGR-analysis revealed four different clay types which were used to prepare the ceramic bodies: calcareous clay (CC), iron-rich non-calcareous clay (NC), iron-rich non-calcareous clay with carbonates in the matrix (NC cc) and non-calcareous clay with low contents of iron compounds (NC Fe-). Examples of clay types are given in

54 Krapivina and Schultze 2011.

55 Schultze, Magomedov, and Bujskich 2006.

56 Schultze, Magomedov, and Bujskich 2006, 335–336.

57 Niton XL3t900S GOLDD RF-Analyser, MINING software; calibration based on twelve ceramic standards analyzed by WD-XRF; 8-mm measuring spot; measurement time of 120 seconds to 30 sec per filter; measurements on fresh breaks, in a sample chamber, without helium.

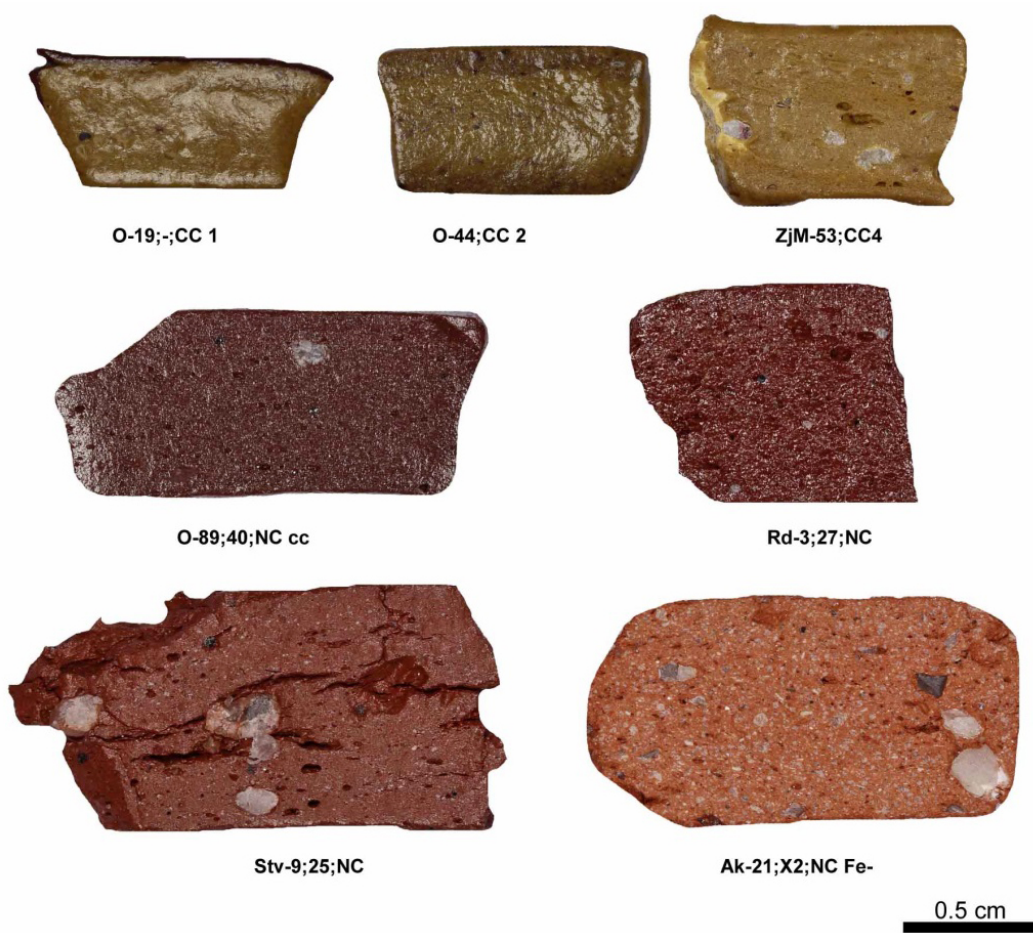


Fig. 9 | Olbia and its vicinity. Different clay types, samples after refiring at 1150°C. CC = calcareous clays CC1, CC2 and CC4, NC = non-calcareous clays coloured by iron compounds, Fe- = few iron compounds.

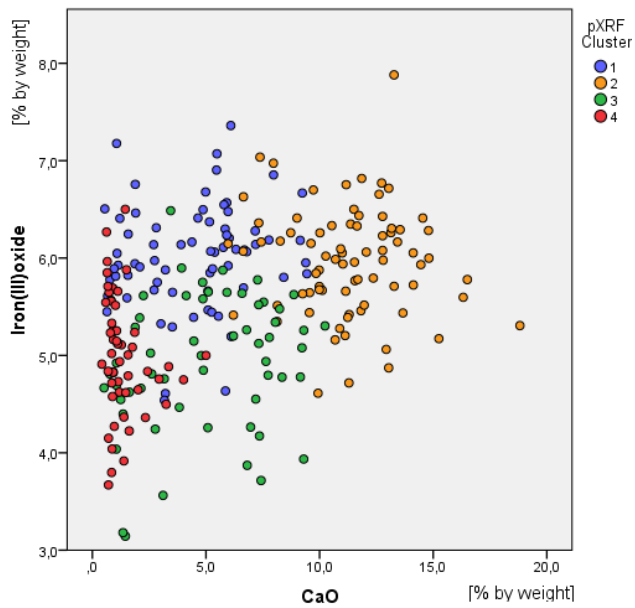


Fig. 10 | Cluster analysis of pXRF-data (Ward method). Distribution of Cluster 1 to 4 according to Fe₂O₃ (% by weight) and CaO (% by weight).

Figure 9. Besides this, there is evidence for heterogeneous mixing of two different clay types, non-calcareous iron-rich clay and calcareous clay, with different recipes.

The comparison of Ward-based clusters, clay types and the ceramic range (Graeco-Roman as well as Chernyakhov) makes it apparent that calcareous clay (CC) is mainly associated with Cluster 2 and is mainly connected to the Græco-Roman range, whereas Chernyakhov pottery is found in all four clusters (mostly clusters 1–3) and mainly made of various non-calcareous clay (NC/NC cc/NC Fe-) (Fig. 11).

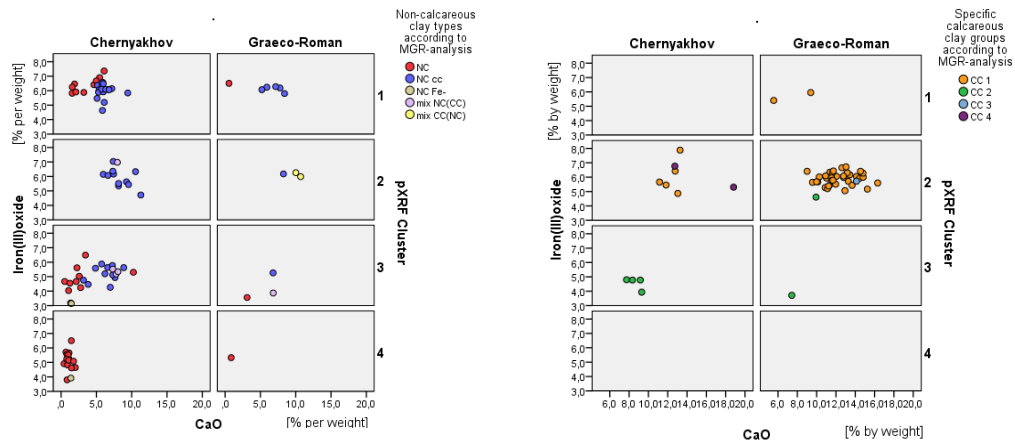


Fig. 11 | Distribution of clay types according to four clusters and pottery range. Left: non-calcareous clay types; Right: calcareous clay MGR-groups.

The results of MGR-analysis not only presented different clay types, but specific MGR-groups within the clay types as well. Within the samples made of calcareous clay, the MGR-analysis provided one major group CC1 and five other groups consisting of a few samples each (CC2 – C4). Græco-Roman pottery is mainly made up by group CC 1, whereas CC 2 and CC 4 are mainly connected to Chernyakhov pottery (see Fig. 11 right). Since calcareous clay itself was more often than not connected to Ward cluster 4, most of the MGR CC groups appear in cluster 4 as well. Cluster 3 only contains samples of MGR-group CC 2 which are mostly samples from the Chernyakhov range.

In contrast to calcareous clays with few MGR-groups, there are quite a few non-calcareous MGR-groups, which each consisted of just a few samples (in general 1–3 samples per non-calcareous MGR-group). The non-calcareous MGR-groups spread through all four clusters.

The comparison of the results based on several analytical methods allows the following conclusions:

- Grey pottery of the Græco-Roman spectrum was mainly made using the same calcareous clay (CC1), probably at one place of production (*nucleated workshop*). Due to a number of kilns in Olbia, we work on the hypothesis that this one place of production was situated there. During the 1st to 3rd centuries, this pottery was distributed to other sites within the *chora* by regional trade and exchange (Fig. 12 left). Apparently, the production continued into the 4th century CE, but we have Græco-Roman pottery dated to this period only from Olbia.
- Evidence for an import of grey ceramics of the Græco-Roman range from Roman provinces is utterly absent. Just one sample is clearly different and likely an import (ES-ZjM-7).

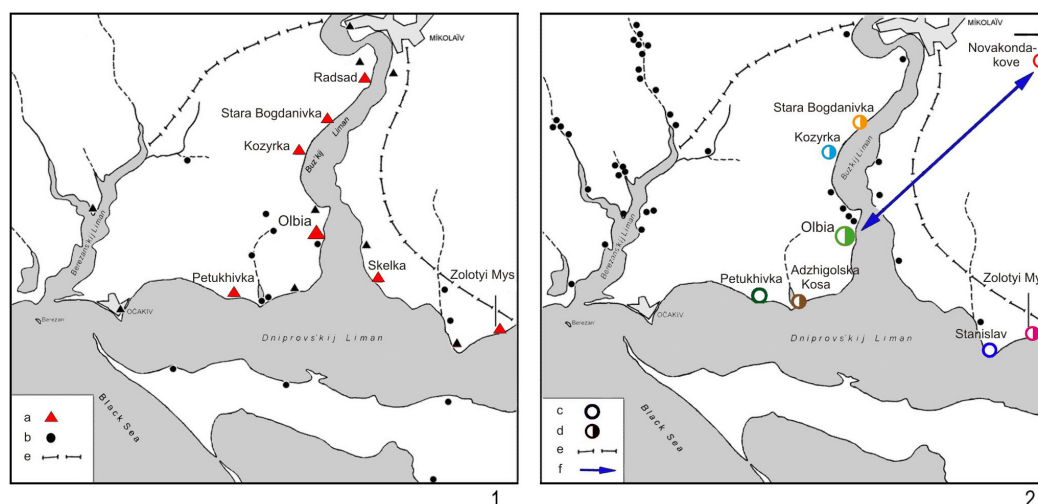


Fig. 12 | Grey wheel-made ceramics, groups of composition and their distribution. Left: Græco-Roman range, calcareous clay CCI, distribution of samples from the 1st to 3rd century CE. (a) hillforts and the polis of Olbia; (b) rural settlements; (e) border of the *chora* of Olbia. Right: Chernyakhov range from the end of the 3rd to 4th century CE, black spots – settlements of Chernyakhov culture; (c) sites with specific local compositions of non-calcareous clay; (d) sites with additionally calcareous samples; (e) former border of the *chora* of Olbia; (f) relation between the sites according to distribution of clay type NC cc MGR-Group 40.

- Grey pottery of the Chernyakhov range was mainly made with non-calcareous clay. Numerous groups with a composition specific to each site were detected indicating local places of production (Fig. 12 right). In Olbia, several specific groups are found, underscoring the existence of local production there as well. Based on the knowledge of pottery production within the Chernyakhov culture in general we assume a number of *dispersed workshops* with more or less seasonal production.
- Locally produced non-calcareous pottery of the Chernyakhov range mainly remained in particular sites. Only some samples from Olbia and one sample from Novokondakove, a settlement some 40 km away, have the same provenance.
- Separate sherds of the Chernyakhov range with calcareous compositions were found at several sites. Their composition does not match the particular local groups of non-calcareous clay and they can be considered to be products of exchange from other settlements/workshops (Fig. 12 right). Thus, in addition to the mainly local distribution of Chernyakhov pottery we can assume a low level exchange between the sites. Ceramics as a container for other goods could also have played a role in the distribution of such vessels.

Summing up, we can conclude that the two temporally distinct pottery ranges detected by archaeological investigations differ not only in clay composition, but the production and distribution of pottery clearly differed as well – corresponding to changes in settlement and economic structure. Production of grey pottery at one place and its distribution within the *chora* presents a different organization of economic space of the 1st to 3rd centuries CE that contrasts markedly to the mainly local production of the Chernyakhov culture with a marginal rate of regional exchange. Some questions remain open due to the limited number of samples. It was only possible to establish the distinctions within the range of grey wheel-made ceramics of this region through a combination of archaeological and archaeometrical methods.

8 Conclusion

At the core of our research outlined here is the analytical method of archaeometrical pottery analysis. Our goal is to transfer the results obtained into a comparative ceramology that takes account of the *milieu technique* in which pottery is made and used. In the cases we analyze, specific types of pottery may be means for ulterior ends when used for cooking, storage, or the distribution of other materials. Or pottery may be an end in itself, a group of things appreciated for their functional and aesthetic characteristics. While these dimensions play a role in our interpretations, our main emphasis is on production and distribution characteristics that provide insight into three different kinds of knowledge.

Specific ways to mix the various raw materials in pottery production are each part of local *practical know-how*, a knowledge that can be assumed to be mainly if not exclusively embodied. This kind of situated, historically and geographically specific knowledge is the result of a *point de contact entre le milieu intérieur et le milieu extérieur [où] se matérialise cette pellicule d'objets qui constituent le mobilier des hommes*.⁵⁸ That is, technologies of pottery production, like other technologies, cannot be evaluated against some universal standard of 'efficacy' but need to be considered within the socio-economic structures and collective mentalities in which they developed. Our position, as specialist observers, does not allow us insights into the past reasoning that led to the mixing of specific clays and tempers, firing procedures and other productive practices. Nevertheless, we can identify operational chains, and compare them and their complexities.

Two other kinds of knowledge are both spatial. The identification of clay sources or at least of different clays used for specific wares is a correlate for *resource knowledge*. In some cases, it is possible to specify quite accurately the origin of raw materials, while in others, already the mixing of different clays in one body of pottery makes the identification of a specific source problematic. Easier to reconstruct is *infrastructural knowledge*. By this term we mean the apparent knowledge about landscape potentials that were mobilized in the past for transportation and distribution of specific types of potteries. Distributional patterns can be related to topography, hydrology, and other features of physical space, but of course also to the potential and limitations of social and political spaces.

Both the combination of practical know-how and spatial knowledge can be unravelled for specific (pre-)historic cases by applying the described set of archaeometrical methods. Combining the archaeometrical work with archaeological contexts is essential for research that aims to close the gap between empirical material culture research and the modelling of past economic and spatial knowledge.

58 Leroi-Gourhan 1945, 339.

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