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INTEGRATED METHODOLOGIES IN THE STUDY OF POTTERY FUNCTION

Florinda Notarstefano, Barbara Pecere*, Grazia Semeraro**

* University of Salento, Department of Cultural Heritage, Italy.

Abstract

The paper describes the application of integrated methodologies for the reconstruction of functional aspects of archaeological pottery, through spatial analysis of ceramic functional categories by GIS tools and chemical analysis of organic residues by gas chromatography-mass spectrometry (GC-MS). The research focused on the pottery assemblages from the archaic building (6th century BC) identified in the Messapian settlement of Castello di Alceste (San Vito dei Normanni, Apulia, Italy). The application of integrated approaches contributed to better understand the role played by ceramics and their content in different functional areas.

Keywords

Pottery function, GIS, Spatial analysis, Residue analyses, GC-MS.

1. Introduction

The studies on pottery function, developed since the last decades of the past century[1], represent a fundamental tool for refining the investigation methods applied to the reconstruction of archaeological contexts. Indeed, the evaluation of technological, morphological and dimensional properties[2] can contribute to better define the relationship between the shape of a vessel and its function and, therefore, the activities involving the use of ceramic containers.

The integration with more advanced research strategies, such as spatial analyses and archaeometric investigations[3], can provide further insights about the cultural, social and economic organization of ancient societies: food preparation and consumption, economic and productive activities, trade, ritual practices.

This paper presents the methodologies and results of a study on the archaic pottery (6th century BC) from the Messapian settlement of Castello di Alceste (San Vito dei Normanni, Apulia, Italy). The excavations carried out by the University of Salento[4] in the central sector of the archaic settlement brought to light an impressive building complex, called the 'big building' (Fig. 1).

Since the first investigations, this structure appeared to be a residence of higher social status, also intended for ceremonial activities.

Many Greek imported pottery sherds were recovered during the excavations, together with local wheel made ceramics, imitating Greek pottery shapes (*hydriai*, craters, cooking pots).

Ionic, Corinthian and Attic vessels are mostly drink cups and craters for wine consumption, together with a high number of sherds belonging to transport amphorae.

The classification of pottery assemblages followed a methodology aimed at identifying the functional categories related to the primary use of the containers (e.g. preparation/cooking, serving/consuming, transport/storage)[5].

The quantitative and spatial distribution of pottery assemblages has been analysed through a GIS system for the management of excavation data (Web_Odos), developed by the "Laboratorio di Informatica per l'Archeologia" (LIA)[6]. This is a very important tool for the identification of the role played by ceramics in archaeological contexts, as well as for the reconstruction of the

[1] Rice, 2015; Orton & Hughes, 2013; Skibo & Feinman, 1999.
[2] See Avella et al., 2017; Notarstefano, 2015.
[3] For some applications on archaeological contexts of the Mediterranean area, see Notarstefano, 2012; Semeraro & Notarstefano, 2013; Pecci, 2009; Pecci & D'Andria, 2014.
[4] Semeraro, 2003, 2009.
[5] The methodology is described in Semeraro, 2004.
[6] About the development of the GIS system and its applications see Semeraro, 2011 (with previous references); Semeraro, Pecere & Mianulli 2012.

functional aspects of spaces and structures. For this purpose, a significant part of the research is represented by functional analysis of pottery, through the application of chemical analysis of organic residues by gas chromatography-mass spectrometry (GC-MS), developed in collaboration with the Organic Chemistry Laboratory (Di.S.Te.B.A.) of the University of Salento.

The results of this interdisciplinary work provided important information for the reconstruction of the activities carried out in the rooms of the “big building”.

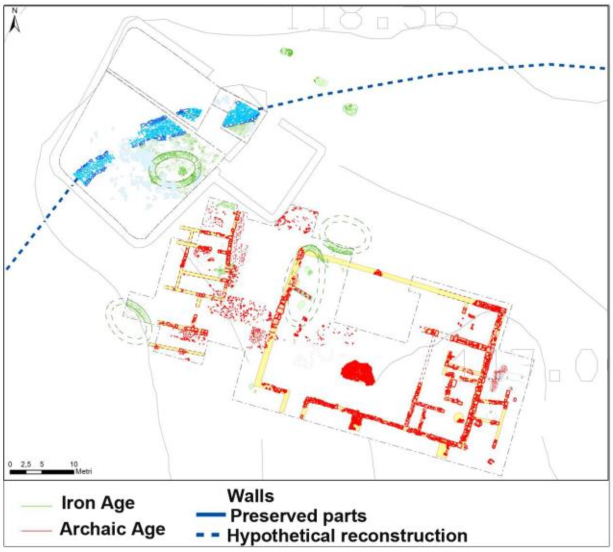

Fig. 1: Castello di Alceste. General plan of the “big building”

2. *Methodology and management of excavation data*

The GIS system developed by the LIA for the management of the excavation data from Castello d’Alceste is able to elaborate graphical and alphanumeric data through an integrated application.

The acquisition of graphical data is carried out through the close integration between measurements by topographic precision instruments (total station) and archaeological detail survey by hand. The total station, positioned inside a geo-referenced topographic system (Fig. 2), speeds up and, above all, increases the accuracy in the execution of all the relevant operations[7]. Furthermore, the advantage of this approach is to obtain a series of georeferenced points in order to place the archaeological surveys carried out on the field inside the GIS excavation system (Fig. 3)[8].

The paper drawings are transformed into raster and georeferenced format. As a result, the geographic database acquires the information in vector format. Moreover, the data provide the database for further processing, because all the points originated by the calculation program contain, in addition to the two planimetric coordinates x and y, also the indication of z.

The data entry of descriptive (US), quantitative (TMA) and analytical (RA) data from different stratigraphic units is performed into a specific Oracle database, developed by LIA at the beginning of the Nineties as a system for the management of excavation data (Odos).

The selected projection system, U.T.M. (Universal Tranfert Mercator) fused 33 N, with reference to European Datum 1950 (Haynford ellipsoid 1909), is able to directly connect the geodatabase of Castello d'Alceste within the GIS application on a territorial scale.

This work has been realized in order to survey the archaeological sites and evidence contained in the publications about pre-Roman Salento.

The data are also accessible on-line through a specific WebGIS application (http://landlab.unile.it/webgis).

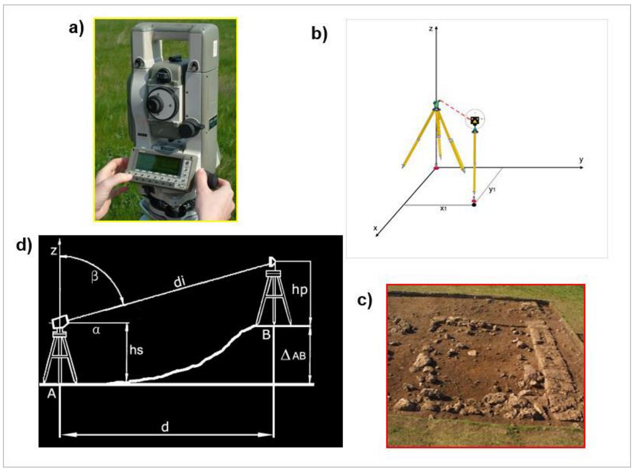

Fig. 2: Castello di Alceste. Methodology and acquisition technique of graphical data.

[7] See Look & Stančič, 1995; Wheatley & Gillings, 2002.

[8] Pecere & Semeraro, 2007.

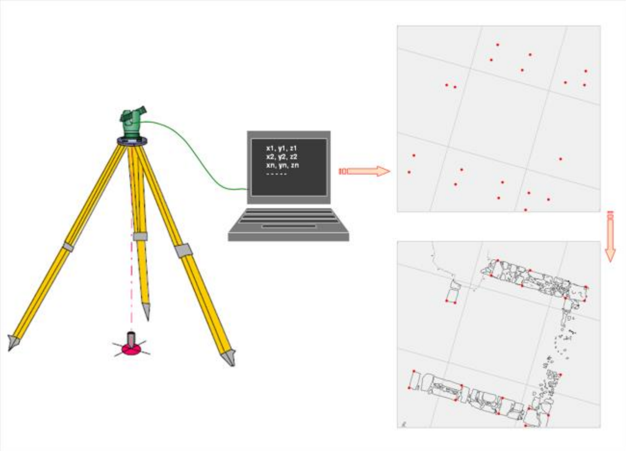

Fig. 3: Castello di Alceste. Georeferenced points elaborated by the GIS System for the archaeological survey.

2.1. The Computer Application

The data acquisition within the geographic database is carried out through three different categories of data in vector format: points, polylines and polygons.

The points are useful for the management of all the spatial elements corresponding to a single graphical entity; the polylines for the management of spatial elements that can be graphically represented as open or closed lines; the polygons for the management of all those spatial elements that can be closed within defined areas.

Each graphic layer generated within the geographic database is associated to an attribute table that describes its properties and can be customized according to the requests of each user.

In the "Castello d'Alceste" GIS project, the graphical data are organized on two levels: territorial and excavation data.

The first level corresponds to all the information layers deriving from the digitization of the airfields, cadastral surveys and geomorphological maps, suitable both for the elaboration of spatial analysis on a territorial scale (e.g. *Viewshed* and *Cost Surface Analyses*), and for the reconstruction of the ancient landscape (Fig. 4)[9].

The second level corresponds to the information on topographic data (quadrature, polygonal network, etc.), necessary for survey operations, comprising those from the digitization of the archaeological detail maps. These are organized through themes of points, polylines and polygons. The points themes are used to vectorize the dimensions of the single stratigraphic units on the excavation plans. The polylines themes are used for the management of all the spatial elements of the detail map, graphically represented as open or closed lines (stones and tiles constituting the collapses of roofs and walls, stone blocks constituting the foundations of the walls, cuts of agricultural holes, traces of roots or plows, potholes, etc.). Finally, the polygon themes are used to manage all the spatial elements that can be enclosed within defined areas.

In applying the GIS methodology to a stratigraphically investigated site, the thematizations are functional to the graphical representation of the stratigraphic units, in particular surface levels and soil layers deposited over time on the ancient structures that, once excavated, can be virtually reconstructed by a GIS system.

The attribute tables associated to the individual graphical themes contain the fields Id_Sas and N_Us, primary connection keys with the alphanumeric data archive (Odos). These keys allow the connection between the results of the database queries and the corresponding graphic themes through numerous spatial joins.

The consultation and processing interface available by the new GIS software release for the graphic data acquisition (ArcGis 10.2) is able to organize the information into a "tree structure". This structure can separate the spatial data from those relating to surface surveys and excavation data, but above all can reproduce the stratigraphic sequence through a series of distinct layers for different chronological phases (Modern Age, Archaic Age, Iron Age).

[9] Van Leusen, 2002; Pecere, 2006, 2007.

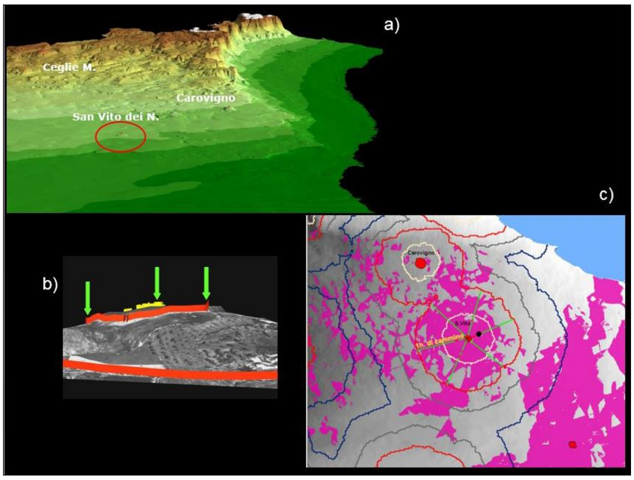

Fig. 4: Castello di Alceste. Cost Surface Analysis in overlay to the line of sight, developed by GIS System on territorial scale.

2.2. Quantitative and spatial pottery distribution

The integration between the relational database (Oracle RDBMS) for the management of alphanumeric data (SAS, US, TMA) and the ArcGis software for the graphical data management and the database connection provides a graphical representation of quantitative and spatial distribution of ceramic objects according to their stratigraphic provenance.

The spatial visualization of the results through diagrams and distribution maps[10] allows the elaboration of analyses aimed at studying the functional aspects of spaces and artefacts.

The GIS application for the study of the "big building" at Castello di Alceste is, therefore, an important tool for accessing, consulting and interpreting the archaeological contexts brought to light in this area of the archaic settlement.

The data relating to the classification of pottery assemblages have been archived in the alphanumeric database for the management of the Archaeological Material Tables (TMA), according to vocabularies based on the morphological and functional parameters of the ceramic shapes. This approach emphasizes the functional correlations useful for the analysis of the use of the space in different areas.

The connection between graphical and alphanumeric data has been carried out through a procedure that allows obtaining quantitative data directly from the TMAs in the database, by selecting through queries the parameters related to category, class and shape of the ceramic objects. The result is the association between quantitative data and individual graphic elements, in order to produce distribution maps of ceramic assemblages.

The distribution of pottery shapes is quantified according to their stratigraphic unit, by calculating the minimum number of individuals (m.n.i.).

The attested ceramics classes and shapes belonging to different functional categories (preparation/cooking, serving/consuming, transport/storage) are displayed in a single graphic solution, in order to give relevance to the functional aspects of the containers and to better evaluate the composition of pottery assemblages.

2.3. Results

In the "big building" of Castello di Alceste, the results of spatial analyses on pottery functional categories suggest that the rooms had different functions, related also to their different dimensions and planimetric features.

For instance, the vessels for the consumption of food and beverages (wine) are more abundant in room 4 (Fig. 5). The abandonment levels of this space with a decentralized entrance are characterized by a relatively high presence of attic imports, including three sherds of black-figure craters (Fig. 6).

The distribution of kitchenwares reveals an intense activity related to cooking and food processing, confirmed also by the presence of fireplaces in rooms 2 and 3 (Fig. 7). Furthermore, the high number of cooking pots suggests the preparation of meals for many people.

Storage vessels are more abundant in room 1 (Fig. 8), together with transport containers for liquids (*amphorae* and *hydriai*). Imported transport amphorae mainly belong to the most common typologies attested in western Mediterranean and in the indigenous settlements of the Salento Peninsula during the archaic period (Corinthian Type A and B).

The data related to the distribution of pottery functional categories confirmed the centrality of the "big building" in the archaic settlement of Castello di Alceste, also considering the frequency of storage and transport containers (too much for

[10] Barbara Pecere and Alessandro Monastero worked on GIS applications for the elaboration of quantification and distribution maps in Figs. 5-8.

one family), particularly in room 2, probably a warehouse for foodstuffs.

The high number of vessels for the consumption of food and beverages in room 4 suggests the presence of a banquet hall. The abandonment levels of this room contain indeed a relatively high number of Attic pottery for wine consumption together with transport amphorae.

Room 3 probably was used as a kitchen or for food processing, considering the occurrence of a fireplace.

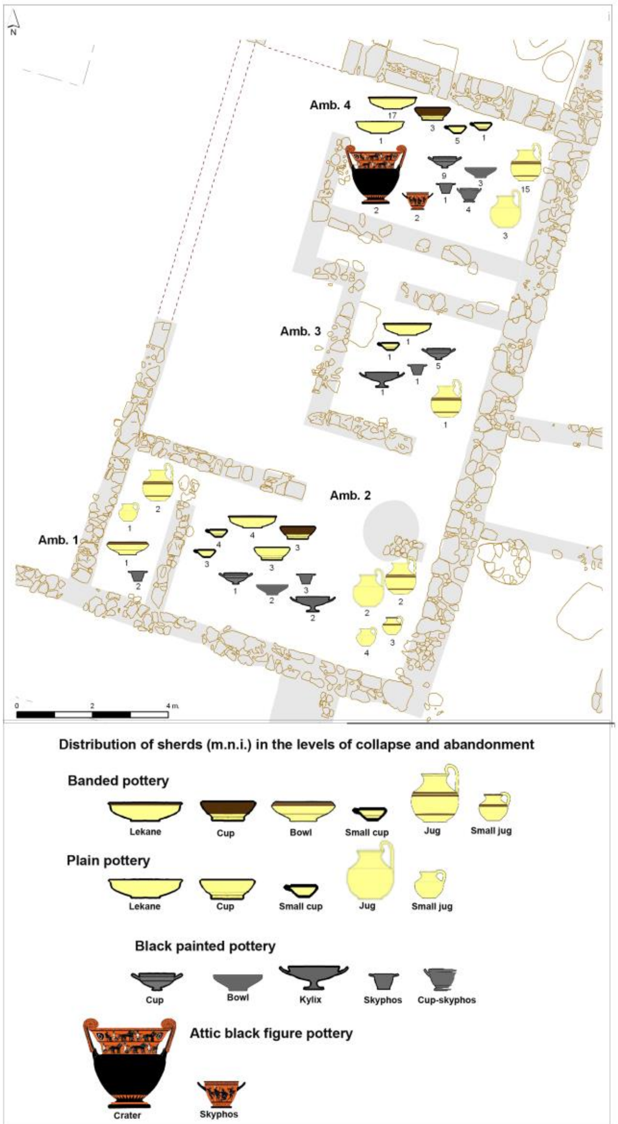

Fig. 5: Castello di Alceste. Distribution map of pottery shapes for serving/consuming

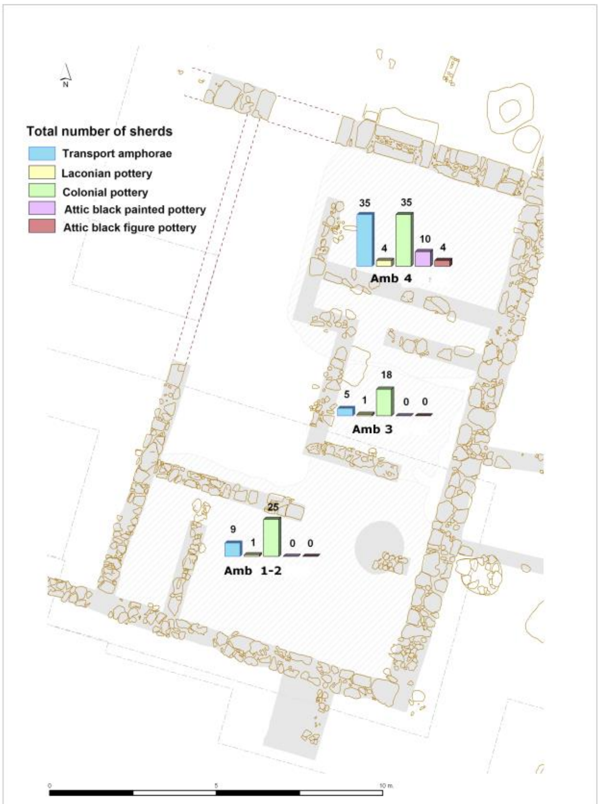

Fig. 6: Castello di Alceste. Distribution map of imported pottery

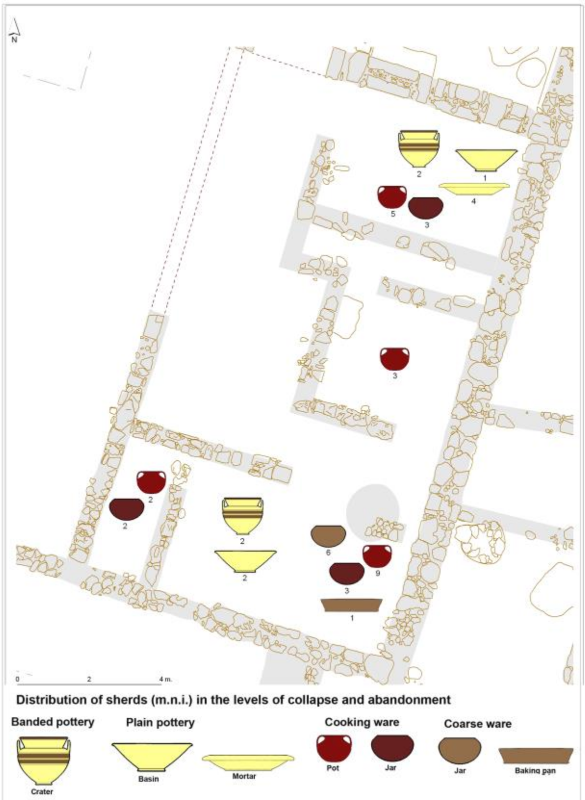

Fig. 7: Castello di Alceste. Distribution map of pottery shapes for preparation/cooking.

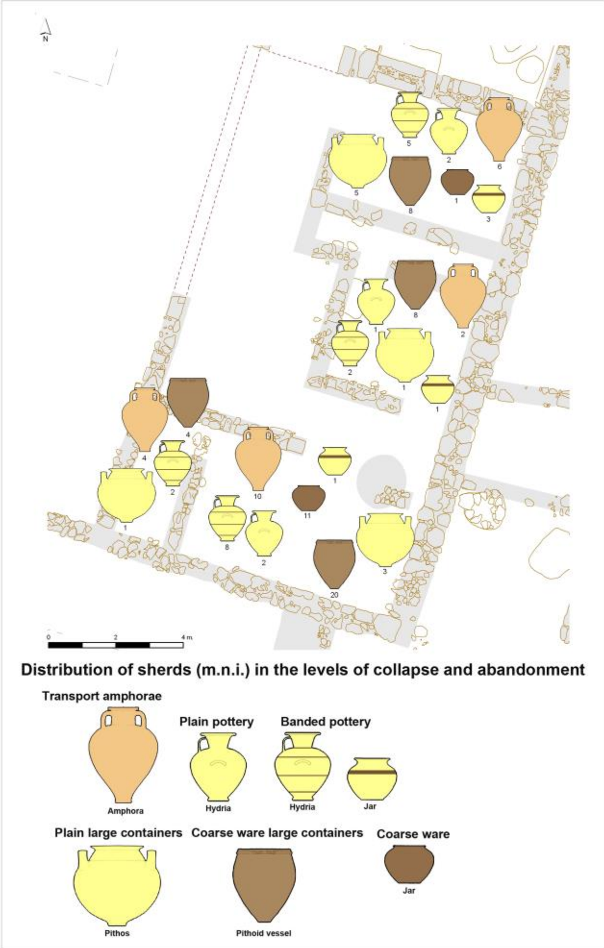

Fig. 8: Castello di Alceste. Distribution map of storage/transport containers.

3. Organic residue analyses by GC-MS

Gas chromatography-mass spectrometry (GC-MS) has become a common technique for the identification of the organic residues deriving from the foodstuffs processed in archaeological ceramic containers, integrating traditional archaeological investigation on pottery function and contributing to the reconstruction of dietary habits, cultural and economic practices in antiquity[11].

GC-MS was applied to the chemical characterization of the organic residues absorbed into the ceramic matrix, with the aim of identifying the original content of some pottery shapes and to better understand what kind of activities took place in the rooms of the "big building".

3.1. Materials and methods

A total of 50 pottery samples were investigated in this study. The sampling included two distinct wares: cooking wares and transport amphorae. Cooking wares (pots and pans) had burnt traces on the exterior walls, while no visible residues adhering on the interior surfaces were observed on these vessels. Some sherds of transport amphorae showed instead the presence of a dark residue on the interior surface.

Potsherds (1-2 g) were crushed into a fine powder using a mortar and pestle. After the addition of 1 mL of a standard solution of nonadecane, the powdered ceramics were solvent extracted and derivatized using two different extraction procedures: a chloroform/methanol mixture was used for the extraction of lipids; for the identification of wine markers, portions of the powdered samples were extracted with a potassium hydroxide solution (KOH 1M)[12].

Samples were analysed using an Agilent Technologies 6850 II series gas chromatograph (5% phenyl-polymethylsiloxane capillary column, 30 m, internal diameter 0.25 mm, 0.25 µm film thickness), with a split/splitless injection system used in the splitless mode and maintained at 300 °C, coupled to an Agilent 5973 Network mass spectrometer operating in the EI mode (70 eV). The mass spectrometer was set to scan in the range of m/z 50 to 600 in a total cycle time of 1 s. The GC oven temperature was programmed from 100 °C to 280 °C at 10 °C/min, and held at 280 °C for 15 min. Helium was used as the carrier gas at a constant flow rate of 1 ml/min.

Compounds were identified partially by their retention time within the GC, based on comparisons with analysed reference compounds, but mainly by their mass spectra. Mass spectral data were interpreted with the aid of the NIST Mass Spectral Database and by comparison with published mass spectra and chromatograms.

3.2. Results

The chemical characterization of the samples of cooking pots indicated the presence of animal fats, which can be associated with the boiling of herbivores, probably cattle, sheep and goats, as confirmed also by the analysis on faunal

[11] Evershed, 2008; Pollard & Heron, 2008; Roffet-Salque et al., 2017.

[12] Extraction procedures were carried out following established protocols: Charters et al., 1993; Pecci et al., 2013.

remains[13]. The chromatograms show in fact higher concentrations of stearic acid (C18:0), together with the presence of cholesterol and odd numbered (C15:0, C17:0), branched chain fatty acids (Fig. 9).

A mixture of vegetable and animal fats was observed in some samples, suggesting the addition of plants and spices during meat processing.

The lipid extraction of the samples of transport amphorae provided very small amounts of fatty acids, except for the presence of plant sterols (β-sitosterol) and dehydroabietic acid, indicating that the amphorae were coated with pine resin. In some samples, methyl-dehydroabietic acid was detected, considered the marker of pine pitch.

Pine resin or pitch are generally associated to wine transport and their presence can be interpreted both as results of surface treatments for sealing and lining the amphorae, or as residues of an additive to flavour and preserve the content, such as resinated wine.

In order to verify the presence of an alcoholic beverage the amphorae samples have been submitted to the extraction protocol for wine biomarkers.

Tartaric acid was positively identified in some samples, together with other compounds usually found in grapes and fruits (succinic, fumaric, malic acids)[14], confirming that the amphorae contained wine (Fig. 10)[15].

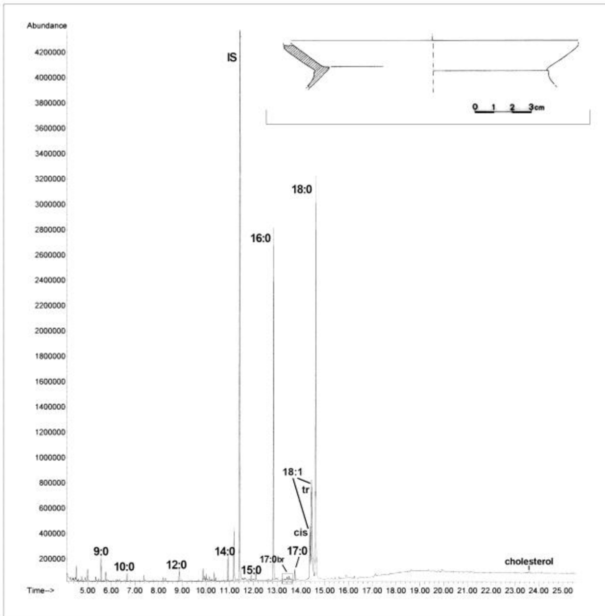

Fig. 9: Chromatogram of the lipid extract of one sample of cooking pot, showing the presence of animal fats. IS=Internal Standard.

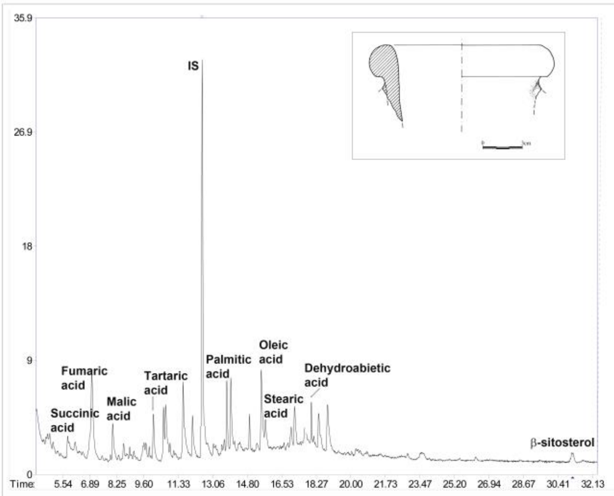

Fig. 10: Chromatogram of the KOH extract of one sample of archaic transport amphora, showing the presence of wine markers and pine resin. IS=Internal Standard.

4. Conclusions

The integration between quantitative and spatial analyses of pottery functional categories by GIS applications and chemical analyses of organic residues by GC-MS showed that the application of integrated methods is an essential approach both for the reconstruction of functional aspects of pottery and for the

[13] De Grossi Mazzorin et al., 2015.

[14] Garnier & Valamoti, 2016; Guasch-Jane et al., 2004; Ribéreau-Gayon et al., 2006.

[15] For a detailed discussion of the results, see Notarstefano et al., 2011; Notarstefano, 2012; Semeraro et al., 2017.

interpretation of the actual use of the structures identified during archaeological excavations.

The potential of the GIS system for the management of excavation data developed by the LIA at the University of Salento has been exploited according to a methodological approach aimed at reconstructing and interpreting the function of archaeological contexts.

The application of chemical analyses of organic residues in pottery containers was able to provide more detailed information about food preparation and consumption methods and, consequently, about the activities that took place in the archaic settlement, including those relating to wine trade and consumption.

The integrated approach provided indeed further insights about the interpretation of the role played by the ceramics in relation to the use of the spaces in the archaic building at Castello di Alceste, also in the framework of exchange and contact dynamics among Greek and indigenous populations.

The residue analyses on cooking pots revealed the presence of ruminant animal fats. The integration with pottery distribution and the study of faunal remains, confirmed the practice of animal sacrifice during ritual feastings organized by local *élites*[16]. Along with meat consumption, wine drinking was also an important element of local commensality, as evidenced by the high number of transport amphorae and imported wine drinking vessels recovered in some rooms of the big building. Residue analyses by GC-MS confirmed that the amphorae contained wine.

Quality and composition of both foodstuffs and pottery assemblage confirmed that the rooms of the building had different functions - not only residential, but also political and ceremonial - where local *élites* used to articulate and reinforce their power using fine pottery in contexts of ritual consumption.

In conclusion, the contextual study of pottery function by GIS applications and by chemical analysis of organic residues can represent an investigation method to be applied to the reconstruction of food habits and their role in the use of space. Furthermore, another important aspect can be investigated: the social and cultural dimension in which ceramics were used by past human societies.

[16] About the role of feastings in ethnographic and ethnoarchaeological perspectives see Dietler & Hayden, 2001.

Author Contributions

Grazia Semeraro: § 1; 4. Barbara Pecere: § 2, 2.1, 2.2; Florinda Notarstefano: § 2.3, 3, 3.1, 3.2.

REFERENCES

Avella, F., Pezzini, E., Sacco, V., & Magro, R. (2017). Integrated prototyping and rendering system for the display of ceramic finds. *SCIRES-IT - SCIentific RESearch and Information Technology*, 7 (1), 45-56.

Charters, S., Evershed, R. P., Goad, L. J., Blinkhorn, P. W., & Denham, V. (1993). Quantification and distribution of lipid in archaeological ceramics: implications for sampling potsherds for organic residue analysis. *Archaeometry*, 35, 211-223.

De Grossi Mazzorin, J., De Venuto, G., Minniti, C., & Semeraro, G. (2015). I resti faunistici dal Castello di Alceste (San Vito dei Normanni – BR). *Studi di Antichità*,13, 233-246.

Dietler, M., & Hayden, B. (2001). *Feasts. Archaeological and ethnographic perspectives on food, politics and power*. Washington, D.C.: Smithsonian Institute Press.

Evershed, R. P. (2008). Organic Residue Analysis in Archaeology. The Archaeological Biomarker Revolution. *Archaeometry*, 50 (6), 95-924.

Garnier, N., & Valamoti, S. M. (2016). Prehistoric wine-making at Dikili Tash (Northern Greece): Integrating residue analysis and archaeobotany. *Journal of Archaeological Science*, 74, 195-206.

Guasch-Jane, M. R., Ibern-Gomez, M., Andres-Lacueva, C., Jauregui, O., & Lamuela-Raventos, R. M. (2004). Liquid chromatography with mass spectrometry in tandem mode applied for the identification of wine markers in residues from ancient Egyptian vessels. *Analytical Chemistry*, 76, 1672-1677.

Look, G., & Stančič, Z. (1995). *Archaeology and Geographic Information Systems: A European Perspective*. London: CRC Press.

Notarstefano, F., Lettieri, M., Semeraro, G., & Troisi, L. (2011). Food Habits and Social Identity During the Archaic Age: Chemical Analyses of Organic Residues Found on Pottery Vessels from the Messapian Settlement of San Vito dei Normanni (South-Eastern Italy). In *Proceedings of the 37th International Symposium on Archaeometry* (pp. 465-471). Berlin Heidelberg: Springer-Verlag.

Notarstefano, F. (2012). *Ceramica e alimentazione. L'analisi chimica dei residui organici nelle ceramiche applicata ai contesti archeologici*. Bari: Edipuglia.

Notarstefano, F. (2015). La ceramica a fasce arcaica dallo scavo di Castello di Alceste a San Vito dei Normanni (Brindisi). *Studi di Antichità*, 13, 191-226.

Orton, C., & Hughes, M. (2013). *Pottery in Archaeology* (2nd Edition). Cambridge: University Press.

Pecci, A. (2009). Analisi chimiche delle superfici pavimentali: un contributo all'interpretazione funzionale degli spazi archeologici. In G. Volpe, P. Favia (Ed.), *V Congresso Nazionale di Archeologia Medievale* (pp. 105-110). Firenze: All'Insegna del Giglio.

Pecci, A., Giorgi, G., Salvini, L., & Cau, M. Á. (2013). Identifying wine markers in ceramics and plasters using gas chromatography-mass spectrometry. Experimental and archaeological materials. *Journal of Archaeological Science*, 40, 109-115.

Pecci, A., & D'Andria, F. (2014). Oil production in Roman times: residue analysis of the floors of an installation in Lecce (southern Italy). *Journal of Archaeological Science*, 46, 363-371.

Pecere, B. (2006). 'Viewshed' e 'Cost Surface Analyses' per uno studio dei sistemi insediativi antichi: il caso della Daunia tra X e VI sec. a.C. *Archeologia e Calcolatori*, 17, 177-213.

Pecere, B. (2007). GIS Applications to the study of Daunian settlement patterns in the pre-Roman Age. In *The World is in your eyes. CAA 2005, Computer Applications and Quantitative Methods in Archaeology:*

Proceedings of the 33th Conference, *Tomar, March 2005* (pp. 429–439). Lisbon: Instituto Portugues de Arqueologia.

Pecere, B., & Semeraro, G. (2007). Gestione informatizzata dei dati archeologici e dei sistemi GIS. Applicazione al sito di Hierapolis di Frigia. *Archeologia e Calcolatori*, 18, 2007, 313-330.

Pollard, A. M., & Heron, C. (2008). *Archaeological chemistry*. Cambridge: University Press.

Ribereau-Gayon, P., Glories, Y., Maujean, A., & Dubourdieu, D. (2006). *Handbook of Enology. The Chemistry of Wine: Stabilization and Treatments*. Chichester: John Wiley & Sons.

Rice, P. M. (2015). *Pottery Analysis; A sourcebook* (2nd Edition). Chicago: University Press.

Roffet-Salque, M., Dunne, J., Altoft, D. T., Casanova, E., Cramp, L. J. E., Smyth, J., Whelton, H., & Evershed, R. P. (2017). From the inside out: Upscaling organic residue analyses of archaeological ceramics. *Journal of Archaeological Science: Reports*, 16, 627-640.

Semeraro, G. (2003). San Vito dei Normanni (Brindisi). In M. Guaitoli (Ed.). *Lo sguardo di Icaro* (pp. 320-322). Roma: Campisano Editore.

Semeraro, G. (2004). Forma e funzione: osservazioni sul rapporto fra i nuovi sviluppi dell'archeologia e il linguaggio descrittivo. *Archeologia e Calcolatori*, 15, 161-183.

Semeraro, G. (2009). Forme e funzioni dei vasi attici in contesti cultuali di età arcaica: nuovi dati dall'insediamento messapico del Castello di Alceste (S. Vito dei Normanni-BR). In S. Fortunelli, C. Masseria (Ed.). *Ceramica attica da santuari della Grecia, della Ionia e dell'Italia. Atti del Convegno Internazionale, Perugia, 14-16 marzo 2007* (pp. 495-506). Venosa: Osanna Edizioni.

Semeraro, G. (2011). Banche dati, GIS e Web GIS: breve storia delle tecnologie applicate ai beni archeologici nel Laboratorio di Informatica per l'Archeologia dell'Università del Salento. *SCIRES-IT - SCIentific RESearch and Information Technology*, 1(1), 125-144.

Semeraro, G., Pecere, B., & Mianulli, A. (2012). Applicazioni GIS alla ricerca archeologica: il Santuario di Tas Silg a Malta. *SCIRES-IT - SCIentific RESearch and Information Technology,* 2 (1), 83-104.

Semeraro, G., & Notarstefano, F. (2013). Integrated methodologies for the study of cultual contexts. Case studies from the Mediterranean area: Malta and Hierapolis. In L. Giardino, G. Tagliamonte (Ed.). *Archeologia dei luoghi e delle pratiche di culto. Atti del Convegno, Cavallino, 26-27 gennaio 2012* (pp. 57-68). Bari: Edipuglia.

Semeraro, G., Notarstefano, F., Caldarola, R., Quarta, G., & Calcagnile, L. (2017). Investigations on provenance and content of archaic transport amphorae from Castello di Alceste (S.Vito dei Normanni-Br) by chemical analyses through XRF/FP and GC-MS. In *Proceedings of 3rd IMEKO International Conference on Metrology for Archaeology and Cultural Heritage (MetroArcheo 2017), October 23-25, 2017, Lecce, Italy* (pp. 344-349). Lecce: IMEKO.

Skibo, J. M., & Feinman, G. M. (1999). *Pottery and People: a dynamic interaction*. Salt Lake City: The University of Utah Press.

Van Leusen, P. M. (2002). *Pattern to Process: methodological investigations into the formation and interpretation of spatial patterns on archaeological landscape*. Rijksuniversiteit Gröningen: Universiteitsbibliotheek.

Wheatley, D., & Gillings, M. (2002). *Spatial Technology and Archaeology. The archaeological applications of GIS*. London-New York: Taylor & Francis.