CHARACTERIZATION OF *DOLIA* FROM THE GUADALQUIVIR VALLEY AND FOUND IN THE SOUTHERN LUSITANIAN SITES (ALGARVE, PORTUGAL).

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INTRODUCTION

The research in this paper is integrated in an investigation project in course entitled "Roman presence and economy in central and eastern coastal Algarve". This project is centered in the study of different categories of pottery (fine wares, local /regional and imported common wares and amphorae) from several excavations that took place in Roman towns or other urban areas. This was a clear option to study material that was deposited for a long time in both Municipal Museum in Faro and in the National Museum of Archaeology (Lisbon) even if the stratigraphic context was lost in most cases. In concrete, the discussed *dolia* in this paper come from both rural sites (*Pedras d´el Rei* and *Manta Rota*) and towns of the Roman *Algarve* (*Ossonoba, Balsa* and *Baesuris*). They are sited in the Southern Portugal and they belonged to the ancient province of *Lusitania*, which showed strong commercial and economic relations with its neighbour province of *Baetica*. Although we do not have preserved stratigraphic data for most of the pottery, the chronological scope of the material studied covers a period from late Roman Republican to the High Empire.

At the end of the 19th century Estácio da Veiga identified the Roman town of *Balsa*, in the rural area today the place and farm called ***Torre de Ares***. To confirm this identification several data was taken into consideration. The ruins suggested an ancient Roman town, which was confirmed not only by the distances between towns given by the Antoninus Itinerary, but also by the epigraphic data. He identified parts of the a bath building, fish sauce factory, as well as some of the *necropolis* of *Balsa*, but unfortunately there was never a systematic study of the town or a publication with the results of his investigations and the finds recovered were collected in the National Museum of Archaeology (in Lisbon). In 1977 there was a campaign of excavations in *Torre de Ares* (*Balsa*), in 3 different sectors, by Maia & Maia (1978). Unfortunately there are no preserved levels since every stratigraphic unit shows ceramics from the 1st until the 3rd or 4th century AD (south gaulish sigillata along with ARS wares, etc). Common wares were imported in large proportions from both the *Cádiz* region and *North Africa* (african cooking ware of Tunisian origin in late Roman period) (Nolen 1994). Imported common wares from the *Guadalquivir* region (Spain) are a minority and consist of the large dolia presented here.

The site of ***Pedras d'el Rei*** was probably a suburban *villa* of Balsa. The Roman pottery recovered during preventive excavations that took place in the site in last decades of the 20th century, show that along with local common wares, there was also identified common wares from the *Cadiz* region and *dolia* from the *Guadalquivir* valleys. Unfortunately there is no publication on these excavations that were directed by Maia & Maia (1978).

First references to archaeological findings in ***Manta Rota*** date back to the 19th century. Roman pottery was recovered and deposited in the National Museum in Lisbon. In the second decade of the 20th century, L. de Vasconcellos refers to the site as a Roman pottery production center. More recently, in 1992 urban development of the costal area in the *Algarve*, determined the emergency excavations that took place in the site called *Manta Rota* which were carried out by C. Garcia. According to the dispersion of the findings and the constructions mentioned by

Estacio da Veiga, the site might be the place of a Roman rural settlement, possibly a villa, that produced mainly the Dressel 14 amphorae, although there is also evidence for the production of Almagro 51C type (Viegas forthcoming a). Despite the production of both amphorae and common wares is attested in the area, the presence of common wares produced in the *Cadiz* bay is also significant, with a number of *dolia* from the *Guadalquivir* valley that are studied in this paper.

The ancient *Ossonoba*, today ***Faro***, was probably the most important Roman town in the *Algarve* region during ancient times. Archaeological research was never a systematic activity and several preventive excavations and occasional findings show that it is considered the monumental area of the Roman town (inside the medieval fortress) and industrial area along the coast near the ancient road that lead to the west (Mantas 1990). More recently, in the first years of the 21st century, preventive excavations took place in the Faro Municipal Museum premises. This area is close to the place where, in the first decades of the 20th century, A. Viana identified the podium of the Roman temple (Viana A 1949). Despite the small area of the excavation, (64 square meters) D. Paulo and N. Beja (Paulo & Beja 2002; 2003) excavated a 6 meter stratigraphy, and uncovered a sequence from the 4th century BC until Modern/Contemporary period. The study of Roman pottery shows occupation since the 2nd century AD with strong imports from the High Empire and Late Roman period (Viegas forthcoming b).

Castro Marim is the ancient *Baesuris* from the Roman period. Excavations that took place since 1983 in the medieval Castle were part of a research project directed by AM Arruda and have shown an occupation from the Iron Age period until today (Arruda 1999/2000). The archaeological context of the large tubs and dolia from the *Guadalquivir* valley, which are analyzed here, is a Late Republican deposit. In fact, the pottery recovered from this stratigraphic unit point to a date between 50 and 30BC (Arruda 1988; Arruda & Gonçalves 1994, Viegas 2006) and consist of Campanian wares, amphorae and common wares mainly imported from *Cadiz* bay area. The study of *terra sigillata* showed that the site was still very active in the second half of the 1st century AD and the imported south Gaulish *sigillata*, which sum up to 68% of the *sigillata* recovered in the site (Viegas 2003). All data point to the abandonment of the medieval Castle area, in the end of the 1st century and the beginning of the 2nd century AD since African red slip wares, from Late Roman period, are very rare.

This paper focus on both: typological and functional data. Several physical and chemical analyses were made in order to carry out the studies about the origin of the *dolia,* the manufacturing process and the products that they might have transported from *Baetica*. Due to the high number of variables involved in the manufacturing process, it is often very difficult to establish a connection between the ceramic object and the raw materials. This circumstance, joined to the large number of samples analyzed, drove us to use statistical procedures that provide a way to find possible connections among a high number of variables and classify samples into compositional groups (Garcia-Gimenez et al 2005 and 2006, Vigil de la Villa, Garcia-Gimenez, Petit-Dominguez & Rucandio 2003).

EXPERIMENTAL

Description of the samples

The *dolia* discussed in this paper come from both rural sites (*Pedras d'el Rei* and *Manta Rota*) and towns of the Roman *Algarve* (*Ossonoba, Balsa and Baesuris*), sited in the Southern Portugal and belonged to the ancient province of *Lusitania*. A total of 39 samples were analyzed. From them, 9 samples corresponded to *Tavira*, 8 to *Pedras d´el Rei*, 7 to *Castro Marin* (3 of them were dolia and 4 were tubs), 5 to *Manta Rota* and 4 to *Faro* (1 dolia and 3 tubs). Also were analysed 6 dolia coming from *Cadiz* (Spain). Samples for the corresponding analyses were obtained by taking a minimum part of the archaeological object, with the aid of a scalpel with diamond tip, to minimize any damage and contamination. These samples were previously ground in an agate mortar and pestle, in order to reduce the particle size and to secure homogeneity.

Physicochemical Analyses

In the physical characterization, X-Ray Diffraction Spectrometry for the mineralogical composition and Polarizing Petrographic Microscopy for the observation of thin layers and mineral identification were used. After dissolution of each sample, contents of Al_2O_3, CaO, MgO, K_2O, Na_2O, Fe_2O_3, MnO, and TiO2 were determined as major constituents by Flame Atomic Absorption spectroscopy (FAAS), and SiO_2 was deduced by difference. Concentrations of Ag, Ba, Be, Cd, Co, Cr, Cs, Cu, Ga, Li, Ni, Pb, Rb, Sc, Sn, Sr, Y, Zn, Zr were also obtained as minor or trace elements by Inductively Coupled Plasma-Mass Spectrometry (ICP-MS). The statistic treatment has been applied through the Statgraphics Plus 5.0 program to 39 samples.

Analysis of dolia contents

Residues of the contents of these *dolia* were analyzed by using a Varian 1200 Quadrupole Gas Chromatography-Mass Spectrometry (GC-MS) instrument. In the derivatization procedure, samples were dissolved in methanol and derivatization was carried out using m-trifluormethylphenyl-trimethylammonium hydroxide to obtain the corresponding methyl esters of the organic acids. Instrumental parameters were: 30m x 0.28mm i.d. x 0.25µm Factor Tour VF-5ms column; carrier gas, helium (1 mL/min); column temperature, programmed from 60°C (0.5 min) to 100°C (3 min) at 10°C/min; from 100º to 150º (1.0 min) at 15ºC/min and from 150 to 285 (18 min) at 7ºC/min; injector block temperature, 180°C; detector temperature, 280°C; and sample size, 1:10 split 1 µL. The mass spectrometer was run in the scan mode, where a series of mass spectra were acquired in a continuous mode by the spectrometer. A total ion chromatogram (TIC) was obtained in each analysis. Every point of this chromatogram represented a mass spectrum that could be analyzed by the system and compared with those kept in the library of the data base (Petit-Dominguez & Martinez-Maganto 2000).

RESULTS AND DISCUSSION

Chemical Analyses

Major elements such as Si, Al, Mg, Ca, Na, K and Fe were determined in the samples and results expressed as percentage of their respective oxides. In Figure 1, the Box & Whisker plots were represented in the top for the major elements, distinguished among dolia and tubs coming from *Algarve* and the dolium samples from *Cadiz*. The chemical compositions of the major elements indicate in all cases that the *Cadiz* dolia are clearly different from those of *Algarve*. The concentrations of the corresponding oxides in dolia and tubs from *Algarve* are similar, disagreeing only in the great proportion of CaO, that would indicate amphorae have a greater variability compared to the tubs, whose margins are more narrow (probably due to the tubs are less samples and collected in only two locations, while the dolia are from different places).

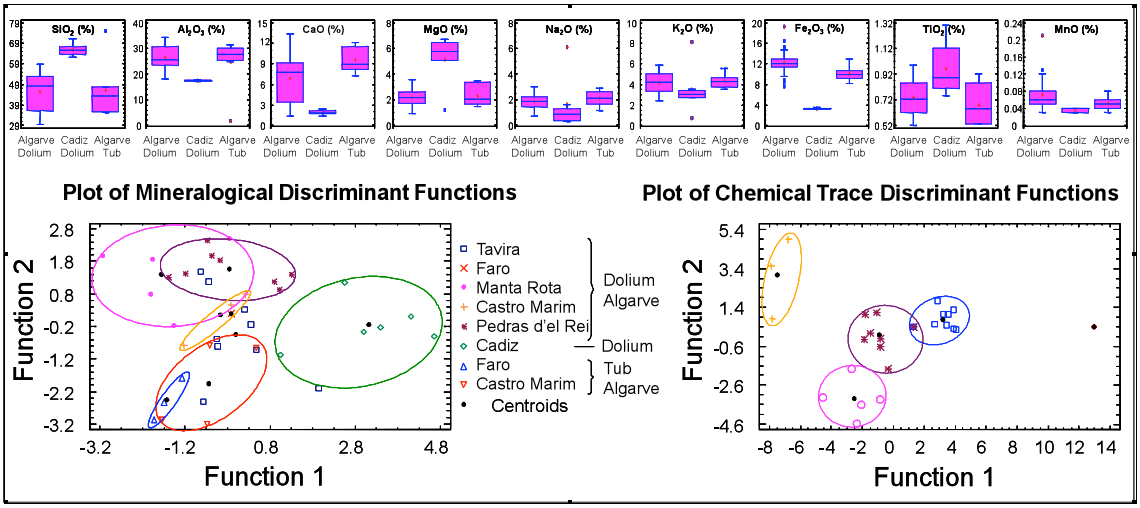

FIGURE 1. Statistical results. Top: Box & Whisker plots for major chemical constituents. Right: Discriminant Analysis for trace chemical elements of *Algarve* dolia. Left: Discriminant Analysis for mineralogical data.

A Supervised Patterns Recognition Study was applied to trace chemical results for dolium samples. Linear Discriminant Analysis was designed to develop a set of Discriminating Functions which can help to classify samples and to extract all those amphorae with significant differences in chemical composition. 26 cases were applied to this study and 19 predictor variables were entered corresponding to the analyzed trace elements (Ag, Ba, Be, Cd, Co, Cr, Cs, Cu, Ga, Li, Ni, Pb, Rb, Sc, Sn, Sr, Y, Zn, Zr.). At the bottom of Figure 1, on its right side, there is a representation of the samples as a function of the two Discriminant Functions. F1 represents 72.7 % of the total variance, where the most important standardized coefficients are: -11.9 for Co, -8.1 for Cu and -6.7 for Rb (in the negative part of the function) and 12.6 for Ga, 8.3 for Li and 8.0 for Ag (in the positive part of the function). F2 represents 13.7% of the total variance, and of particular interest are the following standardized coefficients: -5.3 for Co, -4.1 for Zn and -3.6 for Rb (in the negative part) and 4.9 for Ga, 4.39 for Be and 3.89 for Li (in the positive part). These functions with *P*-values less than 0.05 are statistically significant at 95% confidence level. From this point of view, populations are totally independent, discriminated and separated by groups of different origin: *Tavira, Faro, Manta Rota, Castro Marim* and *Pedras d'el Rei*. Maybe that it indicates that they have not been manufactured in a same place, but each group was accomplished on a different site.

Mineralogical Analyses

For this statistical study, 39 samples were considered and quartz, phyllosilicates, K feldspars, Ca and Na-feldspars, calcite and dolomite have been taken account as independent variables. The graphic (Figure 1, on the left) difference clearly the *Cadiz* samples from those of *Algarve*. F1 separate those from *Cadiz* in the positive part of the axis. *Tavira* samples are the most dispersed, while those of *Pedras d'el Rei* are related to those of *Manta Rota*. The *Algarve* tubs are similar in composition, and they are located in negative values of F2. However, *Algarve* dolia are sited at higher values.

Analysis of dolia contents

Identified compounds by GC-MS in dolium samples from *Tavira* are shown in Figure 2.

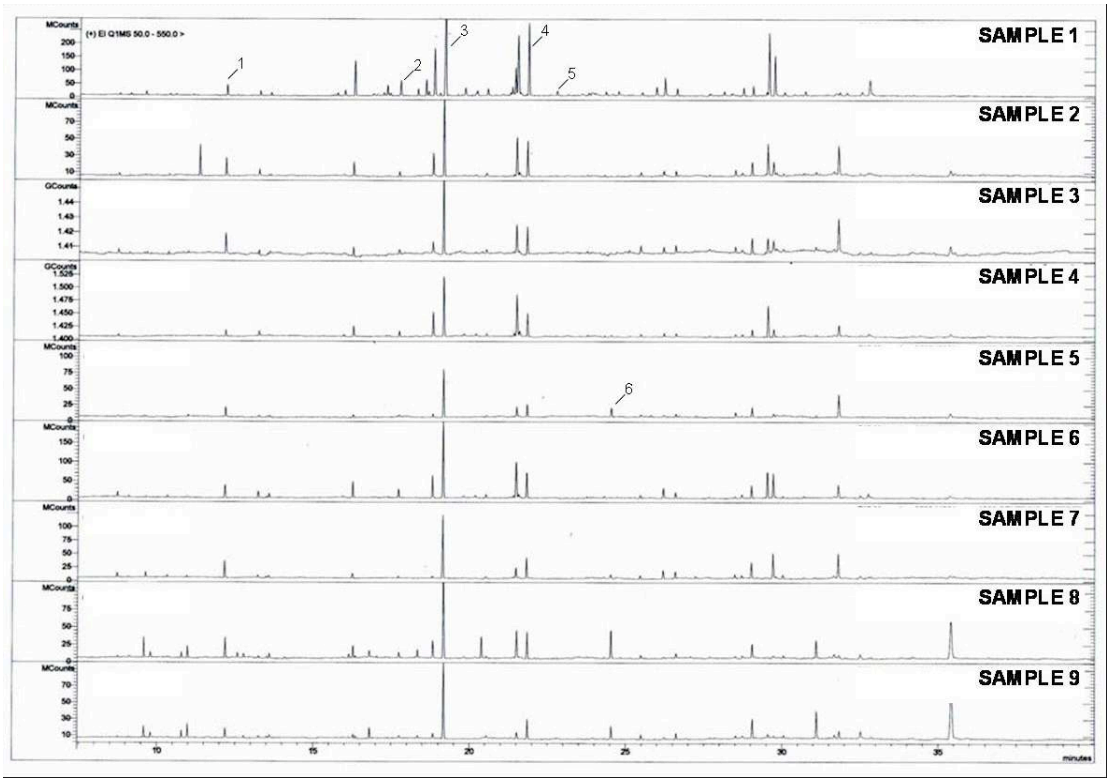

FIGURE 2. Gas chromatography-Mass Spectrometry results. <u>*Fatty acids*:</u> 2. Myristic acid methyl ester 3. Palmitic acid methyl ester, 4. Stearic acid methyl ester and 5. Oleic acid methyl ester. <u>Coniferous resins compounds:</u> 6. Methyl Dehydroabietate. <u>Others:</u> 1. Dimethylphtalate

Study of thin sections

Dolium samples correspond to two well differentiated families: (1) clayey-carbonate pastes, with large quartz crystals, feldspars and sedimentary rocks and in those which are recognized typical fossils of marine origin and that they are similar to those of Guadalquivir basin. In them the clayey bulk is formed by small size crystals of phyllosilicates, quartz and carbonates, calcite and dolomite. (2) clayey trend pastes and grain finer than the previous, they can be considered as globular pastes, being the globules quartz crystals, feldspars and even, carbonates. In the clayey bulk the minerals that certify it are for the most part phyllosilicates of very fine grain. Tubs are made of two types of pastes.

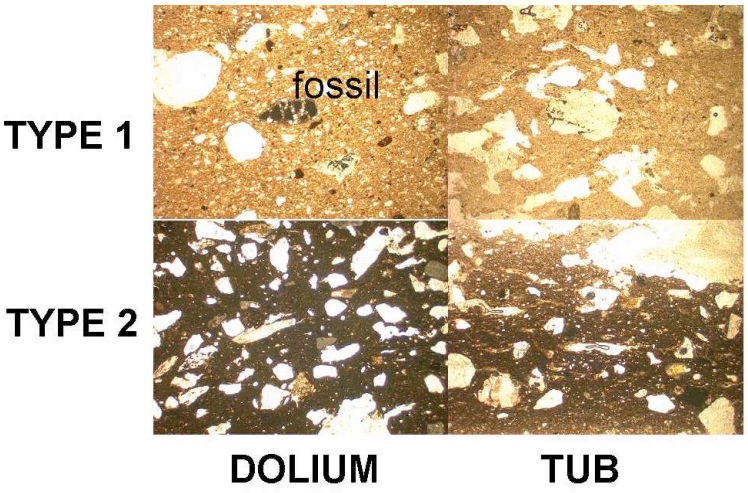

FIGURE 3. Observation of thin layers by Polarizing Petrographic Microscopy.

CONCLUSIONS

The commercial link between southern *Algarve* and *Baetica* region is based on the supply of both olive oil and wine transported in amphorae (Dressel 20 and Haltern 70), but also in other categories of pottery such as *terra sigillata* from the production centre of Andujar and thin walled wares. Mineralogical data indicate that *Algarve* dolia are clearly different from the *Cadiz* ones. In the same way, analyses of trace chemical elements show groups of different origin among *Algarve* samples: *Tavira, Faro, Manta Rota, Castro Marim* and *Pedras d'el Rei*. The presence of this large *dolia* and tubs shows a provenance of dolia and tubs in *Algarve* area from different production centers, either from *Algarve* area or from *Cadiz* region.

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