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Archaeological and instrumental analyses of pottery and wood from the 'Leudo' wreck of Varazze, Italy

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Summary

The wreck of a small boat found in the Ligurian sea (north west of Italy), known as 'Leudo del Mercante', and its cargo of pottery represent a unique case study of ceramic provenance and dating that can help in providing further insight about the coastal trade performed by minor ships in the Mediterranean regions. In this paper we review archaeological investigations on pottery and present results of instrumental analyses both on the cargo and on parts of the wooden hull. Our aim is to confirm the origin of the pottery and to try to solve the fundamental issue of dating. Elemental analysis of pottery was performed using PIXE (Particle Induced X-ray Emission); dating of wood samples from the hull was performed by radiocarbon Accelerator Mass Spectrometry (AMS). Both kinds of measurements were performed at the LABEC laboratory in Florence. The elemental composition of ceramic bodies shows that the pottery could have been produced in the area of Savona or Albisola, not far from the shipwreck site. With the detailed archaeological study of the cargo and using radiocarbon data, we can deduce that the boat was built, sailed and sunk most probably during the first half of the 16th century.

Introduction

The wreck of the so-called *Leudo del Mercante* (Leudo of the Merchant) was discovered in December 1990, about 1 mile to the south of Varazze, a town on the coast of the Ligurian sea, in the north-west of Italy (see Figure 1). The wreck sat on a muddy sea-bed about 50 meters below the surface, within a depression surrounded by rocks that had fortunately protected the site from damage due to drag-nets. Archaeological campaigns began in 1991 (Riccardi and Chamberlain, 1992) and by 1994 the recovery of the cargo has been completed. On the other hand, due to major difficulties in managing and preserving wet wood, the wreck is still in its original context; in 1995 many wood samples were taken in order to perform an extended investigation of the hull.

The remains of the hull and the peculiar arrangement, in particular, of five jars, tightly aligned across the boat axis, indicate that it was a wind propelled boat of small draught, about 10 m long and 3 m wide, probably without a deck, with a maximum admissible load of 3 tons (Martino, 2006). Only minimal equipment was found on board: a mortar and a chopping board both made of marble, a sword and part of a pottery statuette (probably an amulet); this finding indicates that the boat was probably used only for short journeys. From all these observations, it was deduced that this wreck was likely an example of one of the minor ships that had been the backbone of the maritime trade in the Mediterranean regions since 13th century: it was probably a *leudo*, a small boat propelled by a lateen sail. Actually, the size and the small draught made this kind of boats particularly suitable for the coasting trade and to berth at piers as well as on the sandy coves so common on the Ligurian Riviera. A notarial act dated July 17, 1489, and kept in the State Archive of

Figure 1
Find site of the Leudo along the coast of the Ligurian Sea (north-west of Italy) and other locations mentioned

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Genoa, depicts remarkably well the role of such type of boats in relationship to the local economy (Ruzzin, 2006). It states that: *Domenico Lugaro of Savona, owner of the leudo 'Santa Maria' with a cargo load of 80 'mine', sells half of the boat to Peregro Maruffo, spice-seller, for 24 golden 'ducati', committing himself to cover the course Genoa–Savona and Savona–Genoa every 15 days*.

A previous study (Prati et al., 1998) addressed a few pottery samples from the Leudo which were analysed by PIXE at the old KN3000 Van de Graaff accelerator in Florence. By bombarding with 3.0 MeV protons, we measured the ceramic bodies of some of the pottery from the Leudo and some pottery of known origin, comparing the X rays yields of 21 elements ranging from Na to Pb. Concentrations were not extracted. The analysis of furnace rejects from workshops of Savona and Albisola, both to the west of Varazze (see Figure 1), as well as of samples produced in Pisa, Montelupo (a small town near Florence), Northern Africa and Spain, showed (Pio et al., 1996) that the compositions of Savona and Albisola productions were very similar and appeared separated only when looking at the Ni/Fe yield ratios versus the Al/Fe ones. In the same plane Ni/Fe–Al/Fe, the Leudo points (Prati et al., 1998) mixed partially with the Albisola group but were separated from the Savona group. This association emerged also from a discriminant analysis that gave the Leudo points a higher probability of belonging to the Albisola group, although the distances from Savona were not much higher.

With the present study we aim at reviewing the most important issues of the archaeological study, at attempting to solve the fundamental question of dating and possibly at confirming the origin of the pottery on the basis of the elemental analysis. Radiocarbon dating of four wood samples from the hull was performed at the LABEC laboratory of the Istituto Nazionale di Fisica Nucleare (INFN) in Florence, using the Accelerator Mass Spectrometry (AMS) dedicated beam line of the Tandetron accelerator (Fedi et al., 2007). A few more pottery samples have also been analysed at the external proton micro-beam line (Giuntini et al., 2007) with measurements taken on ceramic bodies and glazes. All PIXE spectra, including the old ones, have been deconvoluted to extract elemental oxide concentrations (not only yields), in order to compare the Leudo data with those available in literature.

Materials

The cargo recovered from the Leudo and archaeological considerations on its dating and provenance

The load recovered from the wreck consists of more than 350 items that can be divided in 12 groups due to their types and shapes (same examples are given in Figure 2). If we focus on the different uses of these objects, we can recognize (Martino and Bracco, 1999) pottery for cooking (pots, frying pans, food heaters),

Figure 2
A selection of pottery objects recovered from the Leudo.

Figure 3
The cargo as it was found on the wreck archaeological site. Many pieces are piled up and interstices are filled with smaller objects

Table 1
Vessels found on the Leudo; they are divided into four categories with respect to their coatings.

	painted slipped pottery	monochrome slipped pottery	glazed ceramic	terracotta
objects	jugs	pots truncated-conical basins hemispherical bowls jars albarellos food heaters chamber pots	frying pans flower-pots clay pipes	bowls
decoration on inner side	yellow or grey/green glaze	white slip and green glaze	brownish glaze	none
decoration on outer side	yellow or white or greenish slip (only on the neck)	none	none	none

for eating (dishes, bowls, jugs), for storage (jars, albarellos), for hygiene (chamber pots, basins), for home use (flower-pots) and for building (terracotta pipes, also called *trombette,* fitting one into the other). All these vessels were carefully loaded onboard (Figure 3) with no packaging, in direct contact with the hull: many pieces were piled up; smaller vessels, like the frying pans, filled the interstices; big jars sat upside down. Considering the quantity and quality of the recovered pieces, we can be led to believe that this boat was probably used by a merchant selling his goods to a broad range of customers in the villages along the coast. Table 1 summarizes the different types of pottery found in the wreck by differentiating them according to their decoration on both inner and outer sides. Four categories are found: painted slipped pottery, monochrome slipped pottery, glazed ceramics and terracotta. In the painted slipped pottery group, jugs are characterized by a trefoil lip, a flat base, an ovoid body and a ribbon shaped handle. They are decorated with yellow or grey-green glaze on the inside and with yellow or white or greenish slip on the outside (only on the neck). Moreover, green brush strokes are present on some of the yellow slipped pottery, thus reminding of archaic majolica. The group of monochrome slipped pottery includes many kinds of vessels, each of them present in different sizes: globular pots, truncated-conical basins, hemispherical bowls, jars, food heaters, albarellos and chamber pots. All these objects are decorated with white slip and green glaze on the inside and only partly on the outside. The truncated-conical basins, in particular, are also characterized by a sgraffito decoration with straight and wave lines. Shapes of the objects vary greatly for each typology. Truncated-conical basins have a flat base and the rim extending outwards; food heaters have a bi-conical body with three wide triangular holes to feed them with hot embers; chamber pots have a truncated-conical body with a flat base, a flat rim and two handles below the rim. One of the peculiar aspects of these chamber pots is their size: they are quite big, their height reaching up to 38 cm. As for the use of these monochrome slipped pottery, some of them (the globular pots, the hemispherical bowls and, partly, the truncated-conical basins) were probably used for cooking. The jars, which are heavily glazed inside to guarantee impermeability, were probably used to store different kinds of food, such as oil, grains and olives. The reel-shaped albarellos were probably used to store spices; their shape anticipates the pharmacy and hospital albarellos, made of majolica that would have become so common in 17th century. The group of glazed ceramics includes flower-pots, terracotta pipes and 40 frying pans with flat base truncated-conical section, two small handles and a grooved rim to accommodate a lid. They are all made of coarse terracotta, with no slip, and are decorated only inside with light brownish glaze. Finally there are a series of items with no slip or glaze at all that appear to have had a double use either as bowls or lids.

As one can deduce from the description above, the variety of decorations and shapes of the recovered items offers a contribution of absolute relevance to the study of Ligurian pottery production in a transitional phase between the medieval tradition and the new morphological types that characterise slipped pottery of the late 16th–17th century (Gardini and Benente 1997; Gardini and Benente 1994). Some indicators deserve special attention. The jugs in the painted slipped pottery group feature stripes painted in copper flake and find correspondence in the 16th century production of polychrome slipped pottery. In the monochrome slipped pottery group, the truncated-conical basins represent a new type of vessel: they are frequently found in 17th century contexts and it is known that their use continued until the end of the 18th century. The chamber pots begin to be found in 16th century sites; it looks indeed that the circulation of such kind of hygienic implement was typical of the 17th–18th centuries. The truncated-conical pots for food storage are also innovative, because they are rarely found and rarely reported in archaeological excavations of post medieval sites.

As far as the site of production is concerned, the already mentioned towns of Savona and Albisola, a few miles to the west of the wreck location, are the best candidates. Both towns are well known for their pottery industry; The Leudo finds fall within their typical production (Gardini and Benente, 1997) and it is reasonable that the boat's cargo was acquired locally. Historical documents indicate that the common pottery production died out in Savona at the end of the 15th century. During the 16th century Albisola was a very active little village: the majority of pottery kilns were located close to the beach, easily reachable from the sea for loading purposes. In this way, a large and sunny area for drying the pottery was available. Moreover, using this area for manufacturing activities left the fertile soil next to the houses free for essential domestic agriculture. The second half of the 16th century and the beginning of the 17th century were marked by a series of destructions due to sea washouts, which forced to relocate the village beyond the coastal road and this severely disrupted the pottery industry. Archaeological and historical considerations thus give the idea that the Leudo was carrying pottery produced in one or several of the Albisola kilns in the first half of the 16th century.

Choice of wood samples for radiocarbon dating

For radiocarbon dating, we chose samples from different portions of the hull, made of different types of wood (Arobba and Martino, 1999). The wood species has been determined by transmission optical microscopy at 20–400 enlargements in 39 samples, taken from the hull during the archaeological campaign in 1995 (see introduction). Oak (21 samples) is the species most used for the hull and for the planking. Beech (10 samples) is also found in the hull, although in contracts dating to the end of the 16th century, this wood species was ordered to be used only for the deck since it was more vulnerable to the attack of marine bio-organisms. Besides, the presence of ash (2 samples), maple (1 sample), poplar or willow (3 samples) and rosaceans (probably apple, 1 sample) is a strong indication that the ship might have been repaired as a consequence of a major accident. While ash and apple are good wood species for repairing the hull, maple and poplar are not adequate and their presence may indicate a bad repair. Radiocarbon dated samples have been coded as follows:

GHI From the stern flooring timber made of oak.
OR5 From a frame probably made of apple tree.
GS5 From a knee in the left side of the boat made of ash.
OR3 From a frame made of poplar or willow, definitely a low-quality wood in naval construction.

As one can see from the list above, we chose samples from both long-lived tree species and short-lived tree species, in order to have average information on the age of the boat, thus minimizing the effect of the so-called 'old wood problem' (Bowman, 1990).

Selection of pottery samples measured by PIXE

Since we performed external PIXE measurements (i.e. with no need to place the object to be analysed in a vacuum chamber), it was possible to study both whole objects like a frying pan (catalogue reference 5049), a jug (cat. ref. Q8), a truncated-conical vase (cat. ref. RCGE64727) as well as many shards. The external PIXE experimental set-up lets us to put the analysed sample few millimetres far from the beam exit window, thus minimizing the deterioration of beam characteristics due to the path in atmosphere. Eleven different objects were analysed (Table 2). To avoid any invasive practise no surface preparation was done on the samples, which were therefore exposed to the proton beam in sites that looked sufficiently flat and clean. Actually, after recovery and before storage, pottery samples had been cleaned and water washed to reduce and control their residual salinity.

Methods

AMS radiocarbon measurements

Before being measured by Accelerator Mass Spectrometry, after an accurate cleaning procedure, samples to be dated have to be converted to the chemical form suitable for the ion source. In the case of AMS beam line at LABEC, samples are inserted in the source as graphite pellets. In the case of the samples presented here (GHI, GS5, OR5 and OR3), they were first dried in a vacuum oven, since they were previously kept in marine water, and then chemically cleaned following a procedure which is quite typical for wood (see, for example, Mook and Streurman, 1983): in fact they were sequentially washed in acid and alkaline solutions to remove contaminants such as carbonates or humic residues. After this pre-treatment, samples were converted to CO_2 using an elemental analyser (Thermo FlashEA 1112) and then converted again to graphite by chemical reaction of carbon dioxide with hydrogen (Vogel et al., 1984). Masses of untreated samples were in the order of few tens of mg; final graphite pellets used for the measurements were in the order of 500–800 μg. In order to calculate radiocarbon concentrations, $^{14}C/^{12}C$ isotopic ratios measured in the AMS beam line were corrected for fractionation effects using the $^{13}C/^{12}C$ isotopic ratios also measured in the accelerator and then normalized to isotopic ratios measured in samples prepared from standard material (NIST Oxalic Acid II). Background counts were also subtracted. Radiocarbon ages were converted

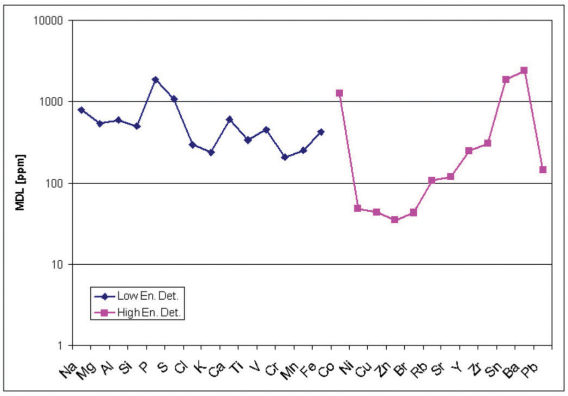


Figure 4
The PIXE minimum detection limits allowed by our setup

Table 2
Summary of the objects on which PIXE analysis of pottery has been performed; in the column named code are the labels used to indicate the samples in the discussion about PIXE results

catalogue	type of object	measuring spot	code
1 5049	frying pan	bottom-clay	LE
		rupture on handle-clay	LE
2 Q8	jug	on clay	LE
		on glaze	LE
3 RCGE64727	truncated-conical vase	on clay	LE
		on glaze	LE
4 VAR 96,5017	basin rim	on clay	LE
5 VAR 96,5016	chamber pot rim	on clay	LE
6 VAR 96,5047	bottom of jug	on clay	LET
7 VAR 96,5031	Rim of jug	on clay	LET
8 RCGE54733	two handled pot	on clay	LE
9 RCGE64735	albarello	on clay	LET
		on glaze	LE
10 RCGE93428	bowl	on clay	LET
11 RCGE68498	jar	on clay	LET
		on glaze	LE
		on marine concretion	LE

to calendar ages using the OxCal software, version 3.10 (Bronk Ramsey, 2001) and the IntCal04 calibration curve (Reimer et al., 2004).

PIXE measurements

As said in the introduction, in addition to measurements on new pottery samples, in the present study we have re-analysed the old data (Prati et al., 1998) in order to extract elemental oxide concentrations. In both the old and the new measurements campaign, X-ray spectra were collected by two detectors optimised (Mandò, 1994) respectively for the detection of low (1.0 to 15.0 keV) and high (5.0 to 35.0 keV) energy X-rays. Analysis of PIXE spectra was performed using the GUPIX package (Maxwell et al., 1995). The used protocol has been somehow different for the two sets of data. For the old series of data, a set of thin elemental standards was available: therefore, in GUPIX, we used the so called HUC factor to adjust the model for uncertainties in the basic detector's parameters (solid angle, dead layer, active detector depth, etc.). For the new set of data, two thick glass standards were available (an alkaline glass from the Corning Museum of Glass (Brill, 1999) and a lead based glass from the British Glass Industry Research Association). In this case we used GUPIX in its thick target configuration mode with an iterative procedure. Calculated concentrations obtained from the measured standards have been used (Zucchiatti et al., 2002) to correct small deviations that appear in the analysis of low Z elements. Figure 4 shows minimum detection limits (MDL) obtained in our set-up. In most of the measured samples, we detected all the elements Na, Mg, Al, Si, Cl, K, Ca, Ti, Cr, Mn, Fe, Ni, Cu, Zn, Br, Rb, Sr, Zr, Pb. P and S were seldom detectable, while Co, Sn and Ba were never detected because their MDL were quite high, between 1100 and 2500 ppm.

Results

Radiocarbon dating

Results of radiocarbon measurements are shown in Table 3, where a summary of the characteristics of the samples is also presented: ^{14}C concentrations are reported in pMC (per cent of Modern Carbon); conventional radiocarbon ages are expressed as years BP (Before Present, namely 1950); calibrated ages are quoted at 68% (1σ) confidence level. In the case of all of our samples, calibration has given as a result two calendar time intervals, each of them characterised by a certain probability (written in brackets in the column of Calibrated Date in Table 3). Results of calibration are also shown in Figure 5, where distribution of probability for true calendar age is reported for each of the samples. Measured ages are all consistent between each other. However, they identify quite a large time span for the age of the hull: between the second half of the 15th century and the first half of the 17th century, therefore giving only a very rough estimate about the age of the Leudo. Integration of these results together with archaeological considerations, data about pottery production sites, and also historical chronicles is thus definitely fundamental to solve the question of the age of this boat.

Elemental composition of pottery by PIXE

The main goal of PIXE analysis was to check whether comparing elemental composition instead of simple X-rays yield might separate the productions of Savona and Albisola and therefore might give further support to the first deduction that the Leudo cargo should have been produced in the Albisola kilns, as suggested by the archaeological and historical investigation. Reconstruction of provenance of the pottery from this area is a difficult task because only a few sets of composition analyses have been published and because their conclusions are often contrasting. Fabbri and co-workers (Fabbri et al. 1996) state that, given the elements detected (8 major plus 15 trace) in their XRF analysis of the ceramic body of 16th–17th century majolicas from Savona and Albisola (and also some from Genoa), it is not possible to discriminate between the two sites. On the contrary, we showed (Pio et al., 1996) that this was possible by comparing nickel and aluminium yields in furnace rejects. Mannoni

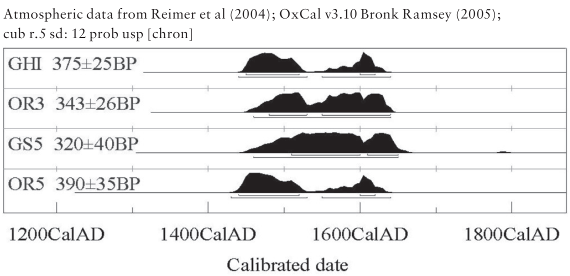


Figure 5
Comparison of calibrated ages of the four measured wood samples: distribution of probability for true calendar age is reported for each sample as calculated by OxCal software

Table 3
Results of radiocarbon dating of four pieces of wood recovered from the Leudo hull

code	**object**	**species**	**^{14}C** (pMC)	**tRC** (years BP)	**calibrated date AD** (1σ confidence level)
GHI	stern floor timber	oak	95.45 ± 0.28	375 ± 25	1450–1520 (53%) 1600–1620 (15%)
OR3	frame	poplar/willow	95.82 ± 0.31	343 ± 26	1480–1530 (24%) 1550–1640 (44%)
GS5	left knee	ash	96.12 ± 0.46	320 ± 40	1510–1600 (54%) 1610–1650 (15%)
OR5	frame	rosacean	95.24 ± 0.41	390 ± 35	1440–1520 (56%) 1600–1620 (12%)

and Mazzucotelli (Mannoni and Mazzucotelli 1980) explain that, despite the fact that the two towns are very close, the geological basin of Savona is dominated by acid crystalline rocks, while the Albisola one includes both acid and basic rocks. Indeed they find from the neutron activation analysis of 19 Medieval furnace rejects from Savona and Albisola (and some also from Pisa and Genoa) that cobalt and tantalum are both below 3 ppm in Albisola and between 20 and 30 ppm in Savona. However, in our PIXE set-up these two elements were not detectable.

Summarizing, we have used for comparison all the previously published data:

a The above mentioned set of red or yellow ceramic bodies of 16th century majolicas (Fabbri et al. 1996) from Savona, Albisola and Genoa. This is the closest set of objects to the Leudo cargo both because of provenance and of period. The reddish ceramic bodies should have been made in the first half of the 16th century and the yellowish ones from the second half onwards (Mannoni, 1969). In Figures 6–9, they are indicated as ABR (for Albisola red), ABY (for Albisola yellow) and similarly SVR, SVY, GER, GEY, respectively for Savona and Genoa.

b The average values of some Savona archaic (12th century) sgraffito (Capelli 2007), indicated in Figures 6–9 as SVC (no values for any of the measured samples have been published).

c Two series of 13th century Ligurian basins from the medieval churches of Santa Cecilia and San Francesco in Pisa, indicated in Figures respectively as LISC and LISF (Berti and Tongiorgi 1981).

d The average values of 13th– 15th century ceramic bodies from Pisa (Berti and Mannoni 1990) indicated as PI (no values for any of the measured samples have been published).

e The average values of some sgraffito from Liguria (probably Savona) dated from the end of 13th century (Berti and Mannoni 1990) indicated as LIM (no values for any of the measured samples have been published).

The first evidence provided by the Leudo data is that, despite the salinity reduction procedure mentioned in the section about materials, significant quantities of elements incorporated from sea water like sodium, sulphur and rubidium still remain in all samples (Figure 6). This means that the comparison with other data can be done only in terms of concentration ratios for elements that should not be altered (for leakage or intake) during the long residence below sea water. The second evidence is that the elemental oxide values are generally more

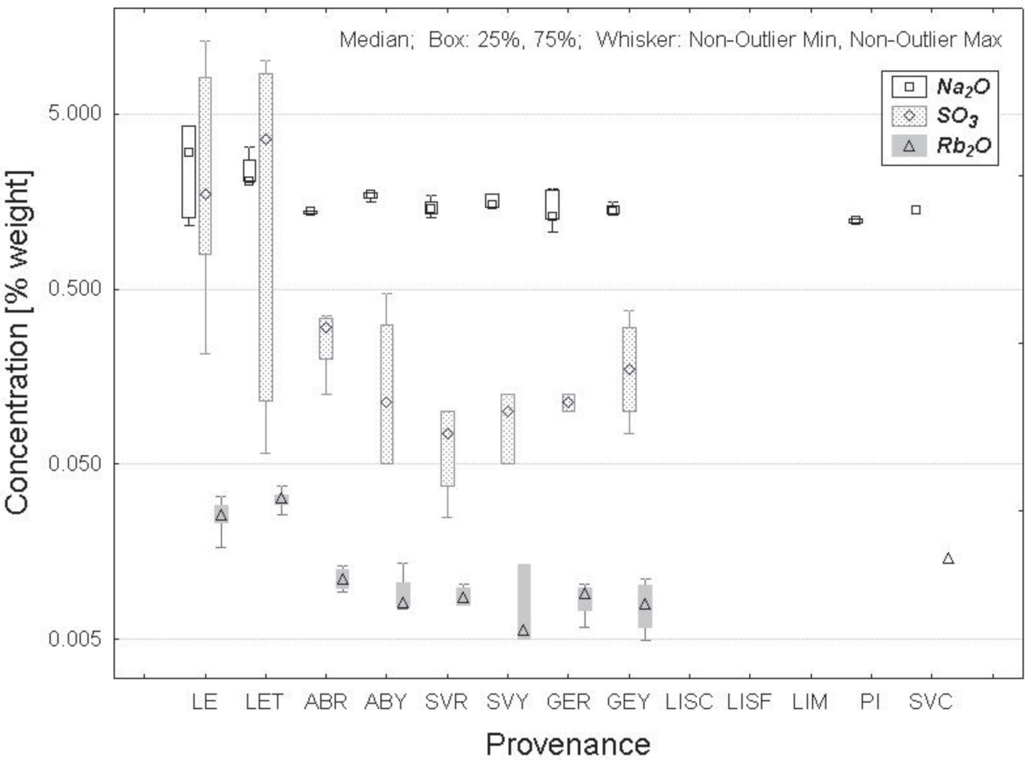


Figure 6
The Na_2O, SO_3 and Rb_2O concentrations, compared to those of other ceramics sets, showing that there is a significant residual contamination from sea water in the Leudo samples

dispersed for the Leudo objects than for the other groups taken into consideration (see Figures 7, 8 and 9). In particular, it seems that there are two groups of Leudo samples (Figure 7): one that has a TiO_2/ Fe_2O_3 ratio close to 0.08 (samples coded as LET) and another that has a TiO_2/ Fe_2O_3 ratio close to 0.11 (samples coded as LE). The latter value is similar to that of all other groups, except Genoa (GER, GEY) which averages at 0.13. This must not surprise. The two groups in Leudo pottery might be related to the use of different kind of sand in the preparation of the body and there is no reason to presume that the merchant had bought all its merchandise from a single kiln at the same time. We have considered as well the Al_2O_3, SiO_2, Cr_2O_3, Fe_2O_3 and NiO ratios. As seen in Figure 8a the Al_2O_3 to Fe_2O_3 ratio cannot distinguish between the Albisola and Savona points (ABR, ABY, SVR, SVY) that have similar averages and dispersions. However the ratio observed for the Pisa production (PI), the Genoa production (GER, GEY) and the earlier XII–XIII century productions from Liguria (LIM, LISC, LISF, with the exception of SVC) have higher averages and their distributions are poorly superposed to those of Savona and Albisola. Those Leudo samples that have a higher titanium oxide concentration ratios (LE) have average Al_2O_3 to Fe_2O_3 ratios close to those of samples from both towns, while those with low titanium oxide concentration ratios (LET) have also a lower Al_2O_3 to Fe_2O_3 ratio. Comparison of SiO_2 over Fe_2O_3 ratios also give the idea that Leudo objects, at least LE samples, should come from the restricted area of Savona and Albisola (Figure 8b): again the Leudo samples with higher titanium superpose to those of both towns; those with low titanium have a lower average, while all other groups of samples (GER, GEY, PI, LISC, LISF, LIM, PI, SVC) have higher averages. Comparison based on other minor elements is less significant due to the lack of data in some sets present in literature. Looking at the NiO to Fe_2O_3 ratio we see from Figure 9a that average ratios of the Leudo samples (LE, LET) are only close to the reddish ceramic bodies from the first half of the 16th century from Albisola (ABR) and Savona (SVR). The other Ligurian groups (ABY, SVY, SVC) have higher averages, while the Genoa samples (GER, GEY) are characterised by lower averages. In particular, there is no superposition of the Leudo distributions with those of pottery from Albisola and Savona produced after mid XVI century (ABY, SVY). A similar picture is given by the Cr_2O_3 to Fe_2O_3 ratios (Figure 9b). Although in this case the distributions are more dispersed than

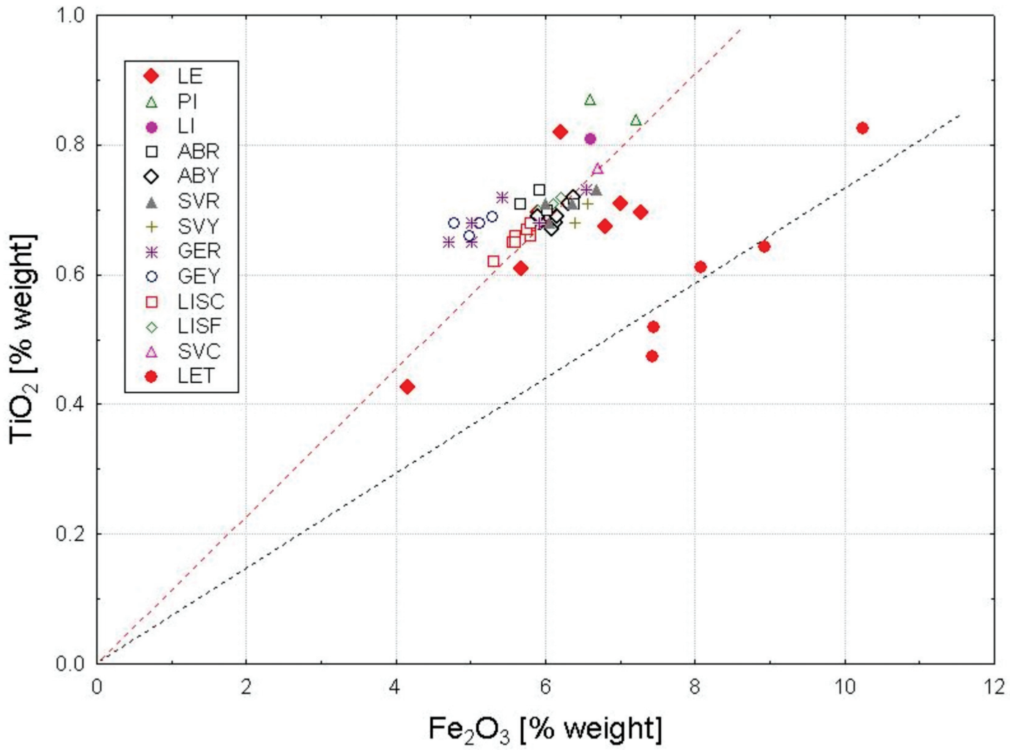


Figure 7
The TiO_2 concentration versus the Fe2O$_3$ concentration for the Leudo ceramic bodies and for comparison materials (12th to 17th century) from Liguria and Pisa

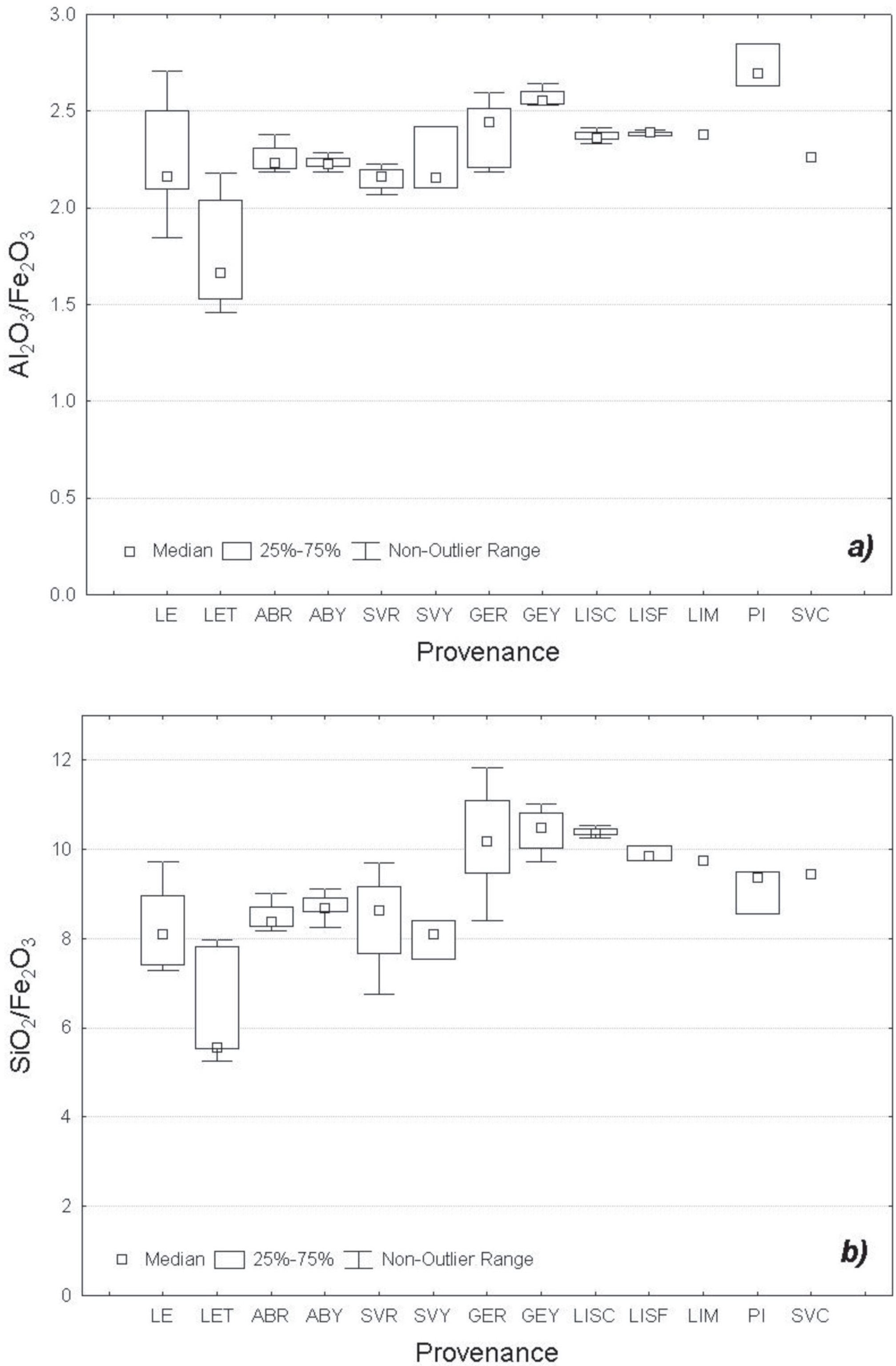
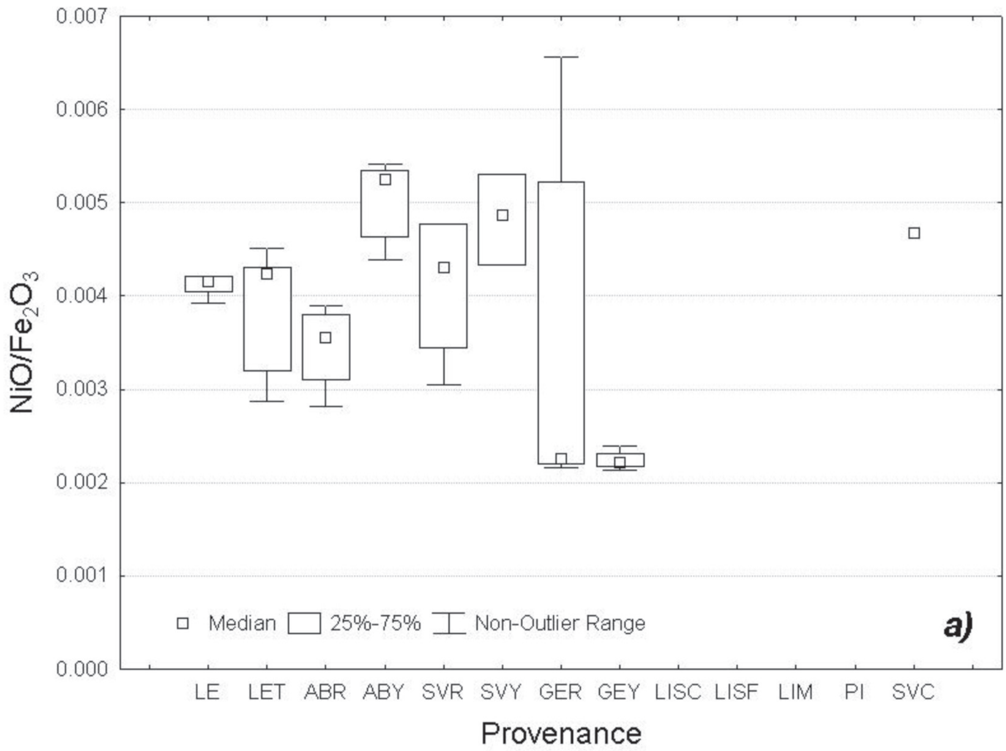


Figure 8

a The box and whisker Al_2O_3 to Fe_2O_3 concentration ratio.
b the box and whisker SiO_2 to Fe_2O_3 concentration ratio for the Leudo ceramic bodies and for comparison materials (12th to 17th century) from Liguria and Pisa.
Groups are labelled as explained in the text



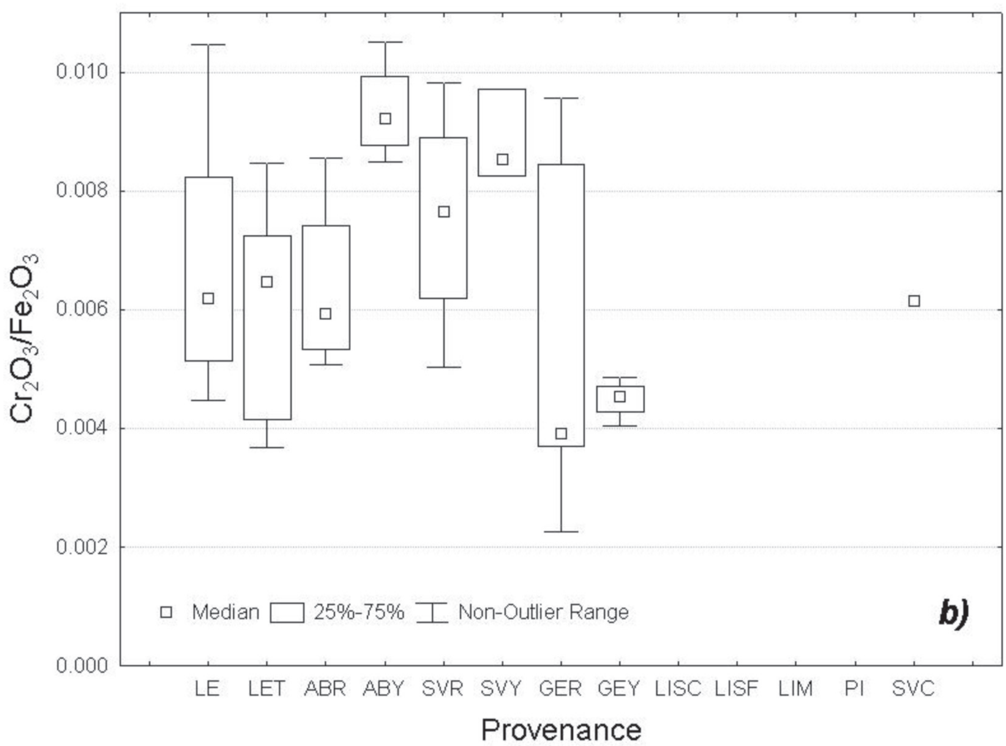


Figure 9
a The box and whisker NiO to Fe_2O_3 concentration ratio.
b The box and whisker Cr_2O_3 to Fe_2O_3 concentration ratio for the Leudo ceramic bodies and for comparison materials (12th to 17th century) from Liguria and Pisa.
Groups are labelled as explained in the text

the data about nickel oxides ratios, the Leudo average is only close to those of group ABR and SVC. Although the distribution of GER samples is highly dispersed, the average of all Genoa groups is definitely lower; on the contrary, the other groups from Albisola (ABY) and Savona (SVR, SVY) have higher averages.

The analysed glazes (see Table 2) are only four: the analysis shows that they are all lead based but does not provide evidence of further difference between the various types of objects.

Conclusions

More than 15 years of investigations, representing a good example of inter disciplinary research where each approach (botany, physics, archival research, archaeology) has given its contribution, have attempted to trace back the story of the Leudo wreck. The thesis that the Leudo was the boat of a merchant sailing the Ligurian Sea to sell local products to a local market was first supported by archaeological investigation of the abundant and very peculiar pottery load. Types, shapes, techniques, all reminded of the local production (Savona and Albisola) but gave evidence of a stylistic transition between well established Medieval models and new shapes that became popular later in the 16th and 17th centuries. Historical documents also indicated that such common pottery might have been produced in the kilns of Albisola in the first half of the 16th century, when most of the production had already moved from Savona and before the natural disasters that drove Albisola kilns into a serious commercial crisis. The way of building the Leudo corresponds to the techniques used in the Ligurian shipyards since 15th–16th centuries; young wood was used and the wood species are all local. Experimental measurements by AMS and PIXE were performed to support the archaeological thesis. Elemental analysis of ceramic bodies indicates that the load should have been composed from different sources but restricted to the local area, since the materials of different origin (Pisa, Genoa) or earlier times (sgraffito, polychrome slipped pottery) are dissimilar. Distinguishing between Albisola and Savona remains very difficult even because the distribution of the Leudo data is rather dispersed. Only the average of Cr to Fe oxide ratio seems to associate the Leudo load to the production of Albisola kilns in the first half of 16th century. Radiocarbon data alone does not add particular information about the age, since calibrated age of all measured samples embrace a time span of two centuries. However, like the PIXE analyses, it does not belie the deductions made on the basis of archaeological considerations. From the whole acquired information, we can thus deduce that the boat was probably built, sailed and sunk in the first half of 16th century.

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Résumé

L'épave d'un petit bateau retouvée dans la mer ligurienne (nord ouest de l'Italie) connu sous le nom de Leudo del Mercante et sa cargaison de poteries représentent une opportunité unique d'étudier la provenance et la date des céramiques. Ils permettent de comprendre plus en détail le commerce côtier fait par les bateaux de petit tonnage dans les régions autour de la Méditerrannée. Dans cet article nous passons en revue l'analyse archéologique de la poterie et présentons les résultats d'analyses sur la cargaison et la coque en bois. Notre but est de confirmer l'origine de la poterie et d'essayer de résoudre la question fondamentale de la datation. Grâce à l' étude archéologique détaillée de la cargaison et l'utilisation de radiocarbone, nous avons pu conclure que le bateau a été très probablement construit, utilisé et coulé dans la première moitié du 16ème siècle.

Zusammenfassung

Das Wrack eines kleinen Boots mit einer Ladung Töpferware, das in der Ligurischen See (Nordwest Italien), auch Leudo del Mercante genannt, gefunden wurde, bietet die Grundlage für eine einzigartige Fallstudie, mit der die Herkunft und Datierung der Keramik bestimmt werden und weitere Einsichten in den Küstenhandel, wie er von kleineren Schiffen in Mittelmeergegenden betrieben wurde, gewonnen werden können. In diesem Artikel untersuchen wir die archäologischen Funde von Töpferwaren und stellen die Ergebnisse der instrumentalen Analyse sowohl der Ladung als auch von Teilen des hölzernen Rumpfes dar. Unser Ziel ist es, die Herkunft der Töpferwaren zu bestätigen und zu versuchen, die Grundsatzfrage der Datierung zu lösen. Durch detaillierte archäologische Untersuchungen der Ladung und unter Verwendung der Radiocarbon-Methode kommen wir zu dem Schluß, daß das Boot wahrscheinlich in der ersten Hälfte des 16. Jhs. gebaut und gesegelt wurde, und auch sank.