

# SVETI PAVAO SHIPWRECK

A 16TH CENTURY VENETIAN MERCHANTMAN  
FROM MLJET, CROATIA

WITH ITALIAN AND CROATIAN ABSTRACTS



Carlo Beltrame, Sauro Gelichi  
and Igor Miholjek

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*by*

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*Front cover:* Galleon on the Contarini monument in the Saint Anthony's church in Padua (middle of the XVI century AD). Chart "Golfo di Venezia, olim Adriaticum" (1688) by Vincenzo Coronelli; courtesy of the Yale University Map Department, Sterling Memorial Library

Croatian Conservation Institute  
Department for Underwater Archaeology  
Zagreb



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Dipartimento di Studi Umanistici  
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# Preface

We present a large joint project which the Croatian Conservation Institute started in 2007 with the help of the Ministry of Culture. Although the research is not yet completely finished, the importance of the site and finds induced a cooperation with the Dipartimento di Studi Umanistici of Ca' Foscari University of Venice, as well as a sponsorship from Regione del Veneto. This publication is a result of a three-year joint cooperation and research on uncovering the secrets of the Mljet seabed, but also the way of life, trade and events in the 16th century. Such research creates new connections and friendships, and the recovered finds allow a deeper and a more systematic insight into the way of life at that period of time. Although a majority of organic material from the shipwreck perished, we are still left with many items of more durable material which give us enough important information. We hope that these amazing results will intensify and encourage further excellent cooperation between our institutions and countries, not only in the field of research, but also in fields of restoration and conservation of the cultural, historical and artistic heritage of the Adriatic Sea and coastline, which is also another important function of the Croatian Conservation Institute.

We kindly thank all participants on their efforts, energy and assets which they invested into this extraordinary publication, and we hope that the readers will enjoy the book and enrich their knowledge about the topic.

Mario Braun  
Director of Croatian Conservation Institute, Zagreb

This volume, financed by the Regione del Veneto, presents the results of a three years scientific collaboration between the Croatian Conservation Institute of Zagreb and the Dipartimento di Studi Umanistici of the Università Ca' Foscari of Venice for the excavation and the study of a Venetian shipwreck of the 16th century found near the island of Mljet. The importance of this excavation, sponsored in part by the Regione del Veneto, is mainly in the fact that it is one of the very few shipwrecks of this period in the Mediterranean and that it is one of the rare underwater sites of the Adriatic which has been systematically studied. It is also precious evidence of the traffics in the 16th century and a document, almost unique, about the transportation of Iznik pottery from Constantinople to the Adriatic, probably toward Venice. Although there is still no identification of the ship's name, the study has allowed to date it very precisely and to attribute it to a Venetian merchant. The fruitful collaboration between the Croatian Conservation Institut and the team of Venice has continued with the excavation, begun together in the 2012, on the interesting Byzantine shipwreck of Cap Stoba, dated to the 10–11th century, found in the same island.

These enduring common scientific interests open the way to new collaborations between the two institutions which could continue also with the diffusion of the scientific results during exhibitions and other events, which could value the cultural heritage between the two sides of the Adriatic, often belonging to a common cultural origin.

Paolo Eleuteri  
Director of Dipartimento di Studi Umanistici,  
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# Foreword

In this book we publish the results of archaeological research carried out between 2007 and 2012 in the context of a collaboration between the Department for Underwater Archaeology of the Croatian Conservation Institute from Zagreb and the Department of Humanistic Studies of the Ca' Foscari University of Venice. This research concerns a shipwreck of the 16th century which, in terms of the variety and quality of the cargo and of other items, proved to be one of the most important underwater sites discovered in recent years in the Adriatic Sea. Although the excavation is not completed, the aim of this publication is to demonstrate the value of what has been recovered so far, to offer scholars and the public a useful preview and to provide a stimulus for further work through the increased visibility of maritime archaeology afforded by this project. It also provides concrete evidence of how it is possible to build opportunities for cooperation between researchers, who work in opposite coasts of the Adriatic, when methods and goals are shared through collaboration.

The volume is composed, apart from an introduction and the conclusion chapter, of three main chapters. The

second is dedicated to the methodological and technical aspects of the underwater investigation of the site, such as the method of documentation by photogrammetry. The third chapter is devoted to the historical and archaeological context of navigation in the late Medieval period in the eastern Mediterranean. The fourth focuses on the study of the typology of finds, from the cargo to the personal items of the crew, from the artillery recovered from the site to the remains of the ship and its equipment that, because of the depth and of the problems of conservation, have been left *in situ*. In addition, some contributions concerning the conservation and restoration of the finds are available in a special appendix.

The editors want to thank everyone who has collaborated to the good success of this volume, producing the text in a very short time. Our gratitude goes to the Regione del Veneto which, also this time, has not been lacking in its help for the publication of this volume. Finally, a sincere thanks goes to Dr Monica Tonussi and Pavle Dugonjić for their precious work of editing.

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# 1. Introduction

*Carlo Beltrame and Igor Miholjek*

### Abstract

*Le coste croate hanno restituito numerosi relitti di ogni epoca tra cui un consistente numero di relitti di età post-medievale. Tra questi, i più importanti e meglio studiati sono quelli delle isole di Gnalic e di Sipan. I relitti scoperti negli ultimi anni sono quelli di Brsečine, Catvat, Mijoka e Lastovo. Quello dello scoglio di Sv. Pavao (San Paolo) localizzato a poche decine di metri dalla costa occidentale dell'isola di Mljet (Meleda), vicino alla località di Saplnara, però è uno dei pochi ad essere stato oggetto di un'indagine sistematica e a non essere stato saccheggiato dai clandestini. Oggetto della prima campagna di ricerche organizzata dal Dipartimento di Archeologia Subacquea dell'Istituto Croato per il Restauro di Zagabria, sulla secca di San Paolo, è stato il recupero dei pezzi di artiglieria in bronzo a rischio di trafugamento. Nel 2008 e 2009 sono seguite altre campagne finalizzate allo scavo e al recupero del carico costituito da vasi di ceramica di Iznik. Nel 2010, grazie ad un finanziamento della Regione del Veneto, è iniziata anche la collaborazione con il Dipartimento di Studi Umanistici dell'Università Ca' Foscari di Venezia incaricato di studiare i resti dello scafo. Altre missioni sono state organizzate nel 2011 e nel 2012. Dal relitto provengono, oltre alla ceramica ottomana, anche bottiglie di vetro, una campana di bronzo con la data 1567, monete ottomane e sassoni, ceramica impiegata a bordo di produzione veneziana, parti dell'attrezzatura della nave e alcuni oggetti personali oltre a dei manufatti in bronzo. Nel sito sono state individuate anche tre ancore lasciate al loro posto. Le indagini di scavo non si possono dire completate ma, data la grande profondità a cui giace il giacimento che arriva fino a m 46, il proseguimento delle ricerche sarà possibile solo con una disponibilità di fondi sufficiente per organizzare un cantiere adeguato alle esigenze tecniche.*

*Jadransko more i obala Republike Hrvatske skrivaju mnoge brodolome iz različitih perioda od kojih velik broj pripada novovjekovnim. Među njima su najvažniji i ujedno detaljno istraženi brodolomi kod Gnalica i Šipana. Osim njih u posljednjih su 20 godina pronađeni i brodolomi kod Brsečina, Cavtata, Mijoke i Lastova. Brodolom kod Plićine Sv. Pavao nalazi se u blizini južne obale otoka Mljeta, pokraj Saplnare, i jedan je od rijetkih sistematski istraživanih brodoloma koji prije otkrića nije bio opljačkan ili devastiran. Cilj prve sezone istraživanja pod vodstvom Odjela za podvodnu arheologiju pri Hrvatskom restauratorskom zavodu bio je podići s dna brončane topove koji su predstavljali lak plijen brojnim tragačima za blagom. Cilj istraživačkih etapa iz 2008. i 2009. godine bio je otkriti, dokumentirati in situ i prikupiti brodski teret pronađenog Iznik posuda. Zahvaljujući sponzorstvu Regije Veneto započela je 2010. suradnja između Dipartimento di Studi Umanistici pri Università Ca' Foscari u Veneciji i Hrvatskog restauratorskog zavoda. Uloga talijanskog dijela tima bila je proučiti i detaljno dokumentirati ostatke brodske konstrukcije. Istraživanja su produžena u 2011. i 2012. godini. Uz otomansku keramiku pronađene su i staklene boce, brončano zvono s natpisom 1567, otomanski i saksonski novac, keramika venecijanskog porijekla, elementi brodske opreme, neki osobni te raznovrsni brončani predmeti. Tri otkrivena sidra ostavljena su in situ. Istraživanje nije u potpunosti dovršeno ponajviše radi velike dubine nalazišta koja na nekim dijelovima doseže i 46 metara. Nastavak će istraživanja biti moguć uz dostatna financijska sredstva koja bi osigurala najviše standarde istraživanja.*

Croatian heritage is richer for one more valuable archaeological site, the remains of a merchant ship from the 16th century that, in unlucky circumstances, ended its voyage at the bottom of the sea in the Mljet archipelago. The find is unique and extremely valuable in the sense that it represents the only archaeological site discovered in a perfectly intact state in the Croatian sea. The significance of the site rests in the fact that it gave the archaeologists a chance to explore a totally preserved modern shipwreck, after many years of working on completely or partially devastated and looted sites.

Before the discovery of the shipwreck in the shallows of Sveti Pavao (a shortened version of the same name is Sv. Pavao used throughout the publication, which is the equivalent of English name St Paul), little information was available regarding the traces of the intense passage of Venetian ships, ships of the Dubrovnik republic, British vessels (HMS) and others, from the 10th to the 18th century, along the Eastern coast of the Adriatic. Post-Medieval shipwrecks have already been investigated in the past. The most famous among them are the shipwrecks from the second half of the 16th century near the island of Gnalić (Radulić, 1970) and island Šipan (Kisić, 1987). The most important wreck of the 17th century is the site at Drevine in the channel of Koločep near Dubrovnik (Kisić, 1982), and the most important one from the 18th century was found on Vis (Frka and Mesić, 2002). It is important to mention that the sites were excavated with modest financial resources and that further research is planned. Except from the shipwrecks investigated in the 1970s and 1980s, new research conducted over the last ten years has yielded three new post-Medieval shipwrecks. Two are located in the Dubrovnik aquatorium, near Brsečine (Jurišić and Mihajlović, 2010) and in front of Cavtat, and the third was found near the Mijoka shallow close to Murter. Both sites in the Dubrovnik aquatorium were surveyed, their condition documented, and the only items which were taken out were the ones which could be easily taken out by looters. According to the retrieved cannon parts, the shipwreck near Brsečine can be dated to the end of the 16th century (Ridella, 2011) or later, and the site in front of Cavtat to the time of the Napoleonic wars. Detailed research into these sites is planned and, hopefully, under way soon. The shipwreck near the Mijoka shallow near Murter is, on the basis of material similar to one part of the material found at Gnalić, dated to the beginning of the 17th century (Zmaić, 2009). The seabed around the island of Lastovo also contains a post-Medieval shipwreck from the 16th century. The site was discovered in the early 1990s and is legally protected although it was never systematically investigated. It was dated to the 15th century, a date which has proved erroneous. A new survey conducted in 2007 provided new insight about the site and a completely new dating. A ceramic jug characteristic of the 16th century, with a motif of the face of an angel, was found during that survey, and it defined a completely new datation (Bradara, 2006b). Regarding the fact that other finds from the site indicate an earlier date of the site, further

research is necessary in order to establish a more exact date of the shipwreck.

Although post-Medieval wrecks are not a rarity in the Croatian seabed, they are seldom found in such an intact state, and we can rarely talk about systematically investigated post-Medieval wrecks. The researches carried out on the Mljet wreck from 2007 to 2012 are just the initial part of the systematic salvage excavations which, with the drawn, photographic and video records of the site and the finds, will be used in an attempt to obtain an as wide as possible view of the circumstances of this shipwreck, and provide knowledge about production, economic conditions, commercial navigation routes and the dangers of sailing during the turbulent 16th, 17th and 18th centuries.

The favourable winds and the indented coast with a multitude of islands and islets have always been the main pre-condition for navigating along the eastern Adriatic seaboard, ever since ancient times. These islands, indeed, offered both easily recognisable land marks and possibilities of refuge in case of storm, while the strong winds allowed efficient sailing. Nonetheless, navigation in the eastern Adriatic sea has never been completely safe. The same winds that facilitated the traffic and cultural development of the coast, the same islands and bays that provided the seafarers with safe anchorages, would occasionally play rough with the destinies of ships and their sailors. For this reason, a large number of shipwrecks lie hidden at the bottom of the eastern side of the Adriatic sea. Most of them are shipwrecks from the period of antiquity (4th century BC–6th century AD), only six of those identified thus far belong to Byzantium (11th–14th century), and about a dozen are post-Medieval shipwrecks (16th–18th century). In addition, there are also shipwrecks from the two World Wars, but most of those fell victim to the whirlwinds of war in naval battles, or they ran into anti-shipping mines.

The Sv. Pavao shallow is situated on the southern side of the island of Mljet and around 200 m from the shore. Since the name for the shallow does not exist in sea charts and maps, the shallows were initially named after the closest island of Preč. It was later found out that the local inhabitants call the shallow Sv. Pavao (Fig. 1.1). The position of the shallow is fully opened to southern winds and rough sea (Figs 1.2 and 1.3). The island of Preč is situated to the west, along with cape Dugi rat with its inlet. The mentioned island and cape form a natural hiding place and a good anchorage point on the route towards the southern part of Mljet, from the area of Mljet lakes to Saplnara bay.

The objective of the first research campaign conducted in 2007 was to bring together the whole drawn and photographic records of the condition and situation of the site. Because of the great value of the bronze artillery pieces and the other preserved objects, it was decided that all the objects that had been documented would be retrieved in order to prevent possible devastation. On this occasion, seven bronze artillery pieces and about 30 additional items were recovered.

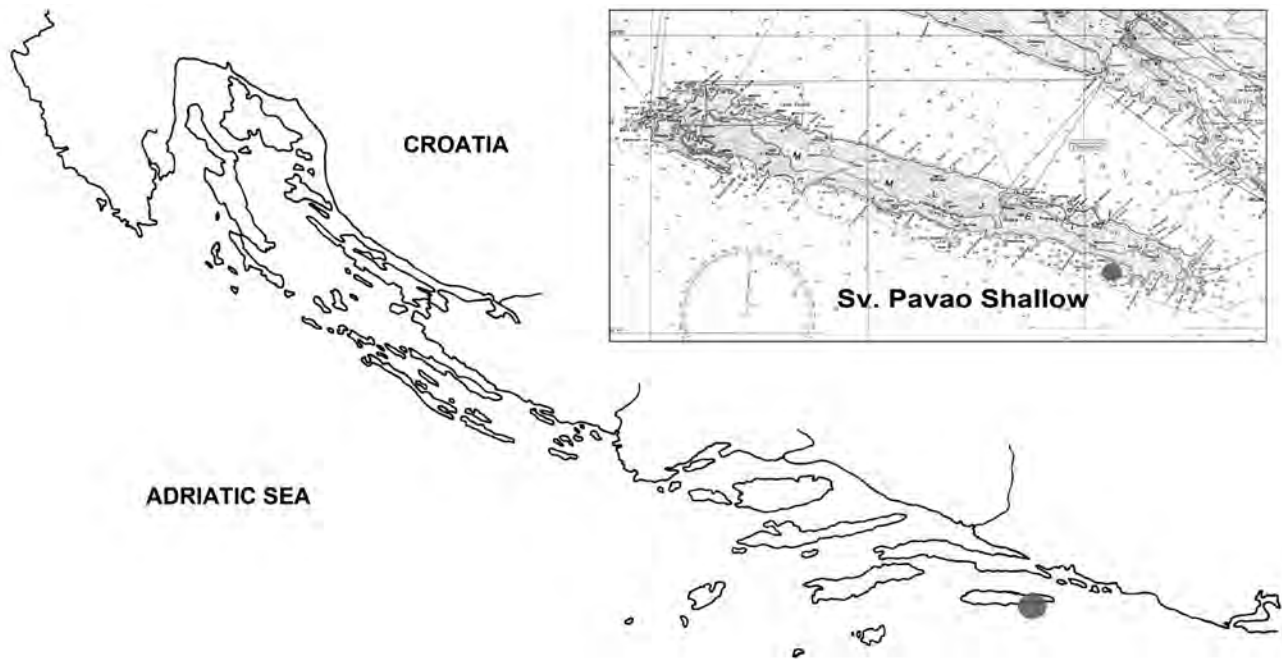


Fig. 1.1. Position of the Sv. Pavao shallow in relation to the Adriatic and island of Mljet

Because of the great value of this material and the intact state of the site, research was continued in 2008 and 2009. The material that emerged was related to that from 2007, and among the many objects, one more artillery piece was discovered, recovered together with an iron breech and an iron swivel; the artillery piece would have been mounted on the rail with this swivel. Before conservation and cleaning, the artillery piece which, in the recovered encrusted part, had a partially preserved breech chamber, and of course the last cannon found, were X-rayed in order to take a better look and clearly see and study the breech mechanism, and ultimately to be able to make a theoretical reconstruction of the ordnance. As for the newly discovered items, seven large luxury Iznik plates, fitted one on top of the other, were of particular interest as well as several bowls packed for transportation, confirming the hypothesis that the ship contained oriental commercial cargo meant for the western market.

In 2009, Igor Miholjek and Igor Mihajlović from the Department for Underwater Archaeology, Croatian Conservation Institute, proposed a collaboration in the research of the shipwreck to Carlo Beltrame. They were interested in the competence of this Italian colleague and his staff in the history of ship-construction and in the documentation of hull remains. The invitation was then extended to Sauro Gelichi for its competence on the history of sea traffic in the Medieval and post-Medieval periods. Thanks to the funding of the Regione del Veneto – Direzione Relazioni Internazionali Cooperazione Internazionale through a regional law for the safeguard and

conservation of the heritage of Venetian origin in Istria and Dalmatia, in May 2010 a first joint mission, was organised, comprising the Department for Underwater Archaeology of the Croatian Conservation Institute and a team of students and technicians of the Dipartimento di Studi Umanistici of the Università Ca' Foscari di Venezia. Other two joint missions were organised in 2011 and 2012.

The material found in the 2010–2012 campaigns is consistent with material found in previous campaigns. The material is composed of few complete luxurious plates, tea pots and small bowls made in Iznik and a large number of pottery fragments of the same provenance, pottery of western (European) provenance, a large number of glass bottle shards and copper alloy vessels. The most interesting find was a small bronze ship's bell bearing the year MDLXVII (1567) in relief. Along with ten silver Ottoman coins found in 2009, the 2010 campaign produced two silver talers (1559) glued together with forty Ottoman coins (1512–1595). Textile or leather sacks had probably rotted away, but their contents were saved. The year indicated on the ship's bell and the Ottoman coins could provide a dating for the ship from its launch to its sinking. Two iron anchors were documented in 2012 at the depth of 46 m. Although the shipwreck is scattered over the area of more than 200 m<sup>2</sup> (Plan 1), Sector 1 (area with removable finds), which was the object of investigation in each research campaign, covered an excavated area of around 100 m<sup>2</sup> (Plan 2). Sector 2 (area with the remains of the ship's hull) covered an excavated area of around 20 m<sup>2</sup> (Plan 1). Certain finds such as the anchors were found



Fig. 1.2. View from Mljet toward the Sv. Pavao shallow (research ship seen on the right side of the photo) (photo: I. Miholjek, HRZ archive, HRZ = Hrvatski restauratorski zavod (Croatian Conservation Institute))



Fig. 1.3. View from the sea toward the Sv. Pavao shallow (photo: I. Miholjek, HRZ archive)

almost 30 m away from the largest concentration of finds. One anchor was found at a depth of 37 m (Sector 3, Plan 1), while the other two were at a depth of 46 m (Sector 4, Plan 1), which correspond respectively to the depths that, at the same time, mark the less deep and the deepest levels of the site. In total 316 objects were taken out during the campaigns in 2007–2012. All archaeological material recovered during the research was restored in the Croatian Conservation Institute, Department for conservation of underwater archaeological finds.

Because of the extent and the depth of the site, we cannot say that the excavation of this shipwreck is complete; these kinds of archaeological activities are not only expensive but also relatively dangerous because they require technical equipment for deep diving and technical or expert diving education. This means that continuation of the investigation

on the site could be prolonged in the near future, but only if sufficient funding necessary for paying expert staff is provided. In the face of both uncertainty as to the economic availability and a sufficient number of data collected through both the analysis of the items recovered and of the remains of the hull and its equipment documented *in situ*, we decided that it was the moment to begin to tell the story of this ship and its voyage through a book.

As the reader will be able to understand, this shipwreck presents a series of important aspects from the original cargo of Ottoman items and the important pieces of bronze artillery to the original details of the ship-building which have allowed the researchers to learn many new things about navigation and traffic at the end of the 16th century in the Mediterranean sea, which demonstrates how worthwhile was this complex underwater adventure.<sup>1</sup>

## Composition of the research teams

Leader of the Croatian team of the underwater archaeological excavation was Igor Miholjek (2007–2012 seasons), Department for Underwater Archaeology, Croatian Conservation Institute. The Croatian team was then composed of Igor Mihajlović (2009–2012) and Vesna Zmaić (2008–2012); Domagoj Perkić (2007, 2010), Croatian Ministry of Culture, Directorate for the Protection of Cultural Heritage; Damir Banković (2007–2012), Special Police Diving Centre; Mali Lošinj (2007–2012) and Miljenko Marukić (2007–2012), Diving Centre MM Sub, Lumbarda; Jurica Bezak (2007–2012), RedTech Zagreb; Ivan Paić (2007–2008), Diving Centre Panitula Šibenik; Rade Čakić (2007, 2008–2010), Diving Centre Panitula Šibenik; Esad Humo (2007–2008), Diving Centre Neretva, Mostar, Bosnia & Herzegovina; Jerko Macura (2008–2010, 2012), Diving Centre Panitula, Šibenik; Mario Orlandini (2008–2012), Diving Centre Aquatica – Mljet, Dubrovnik; Robert Kordić (2008), student of archaeology; Suzana Čule (2009) and Robert Mosković (2009–2012), underwater photo and video documentation; Pavle Dugonjić (2009, 2011–2012), for whom the editors want to express their gratitude in all help with publishing the book, student of archaeology; Kruno Zubčić (2010); Ante Plančić (2010, 2011), RedTech; Vlado and Damir Onofri (2010–2012), Eco-mar, Mokošica; Kruno Sanjković and Bruno Sanjković (2010); Ana Skračić (2011–2012); Kristijan Majer and Tomislav Stipčević (2011), Special police divers.

Director of the Italian mission was Carlo Beltrame

(2010–2012 seasons), Dipartimento di Studi Umanistici, Università Ca' Foscari Venezia. The Italian team was then composed of the archaeologists Dario Gaddi (2010) and Cristiano Alfonso (2010); Ca' Foscari students Elisa Costa (2010) and Vladimir Danilovic (2011); technicians Francesco Dossola (2010), Duilio Della Libera (2011–2012, photographer) and Stefano Caressa (2012, mini-ROV pilot). Five Ca' Foscari students participated, not diving, in this last mission

## Acknowledgements

The research conducted by the Croatian Conservation Institute on the site Sv. Pavao was financed by the Ministry of Culture, Republic of Croatia. The mission and the research made by the Ca' Foscari University of Venice has been financed by the Regione del Veneto which has also financed the publication of this volume.

We want to thank Jurica Bezak and the divers of the Diving Club Sava-Medveščak, divers of the Special Police, Public Institution National Park Mljet, all other associates, volunteers and the students who have participated in the excavation and the restoration of finds.

## Note

- 1 In addition to the references quoted in the text we suggest the reader to see also Božulić (2006); Kelez (1970); Kisić (1979); Perkić (2009); and Miholjek (2009).



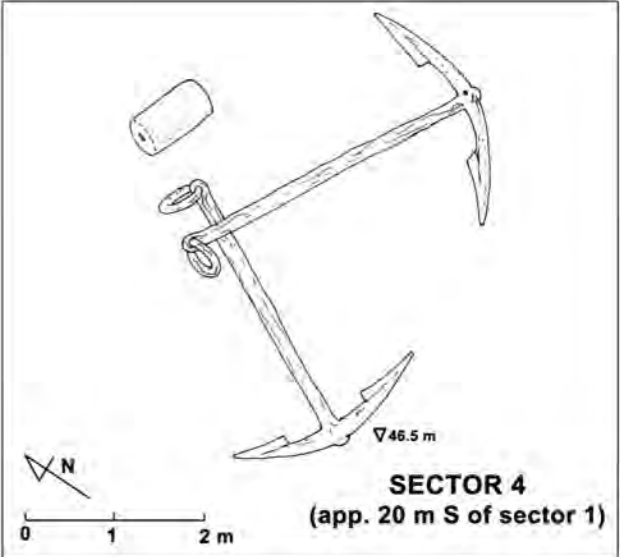
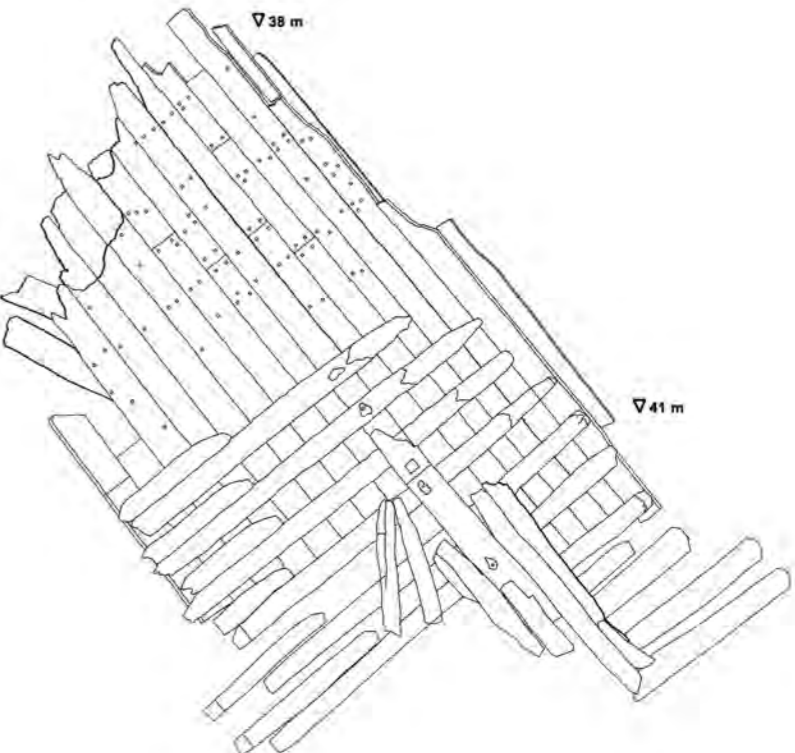
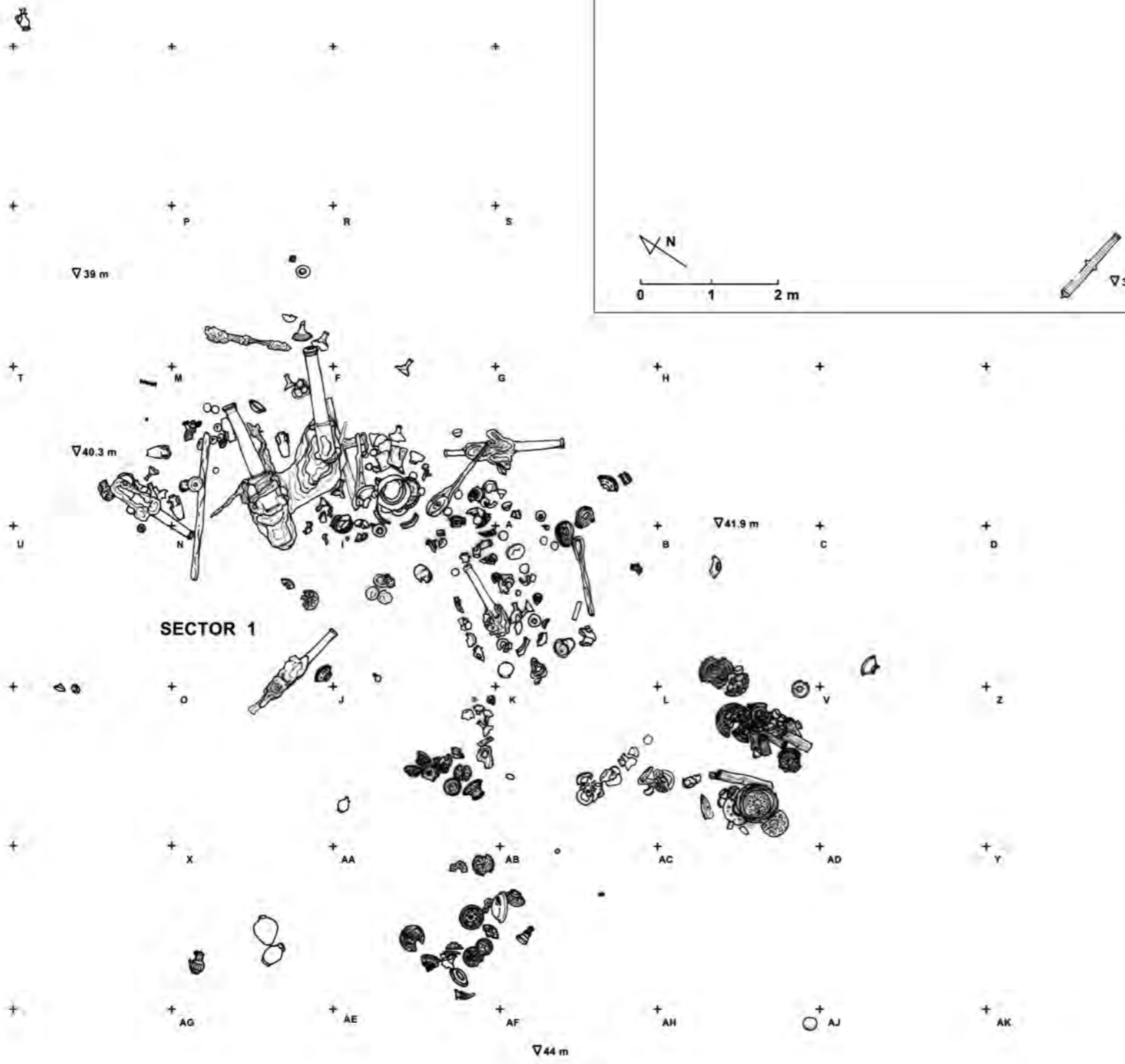
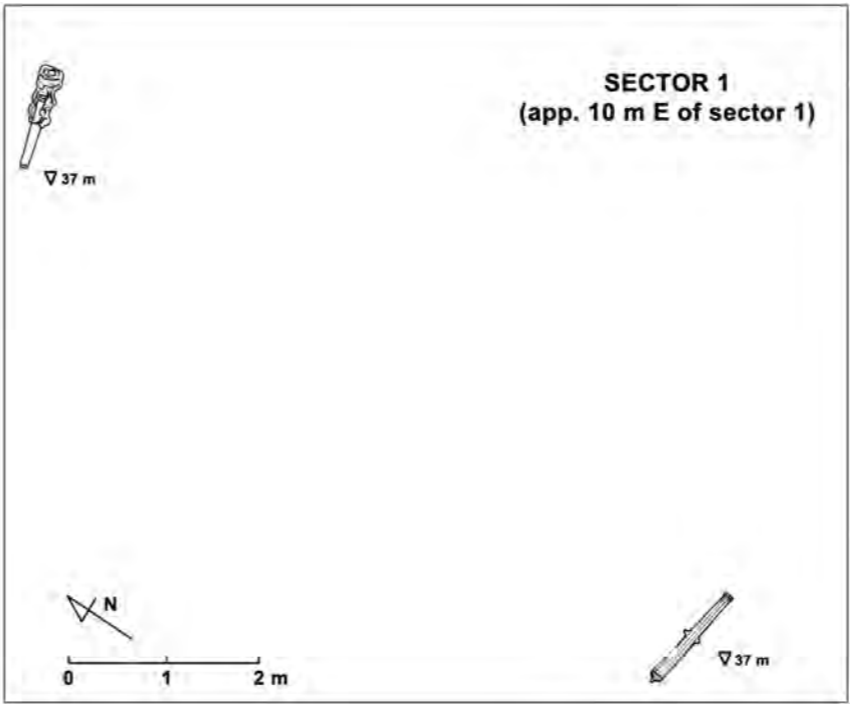
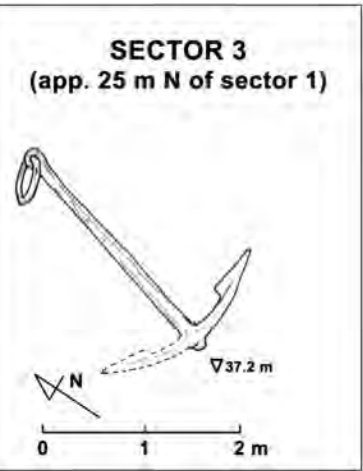


Chart 1.

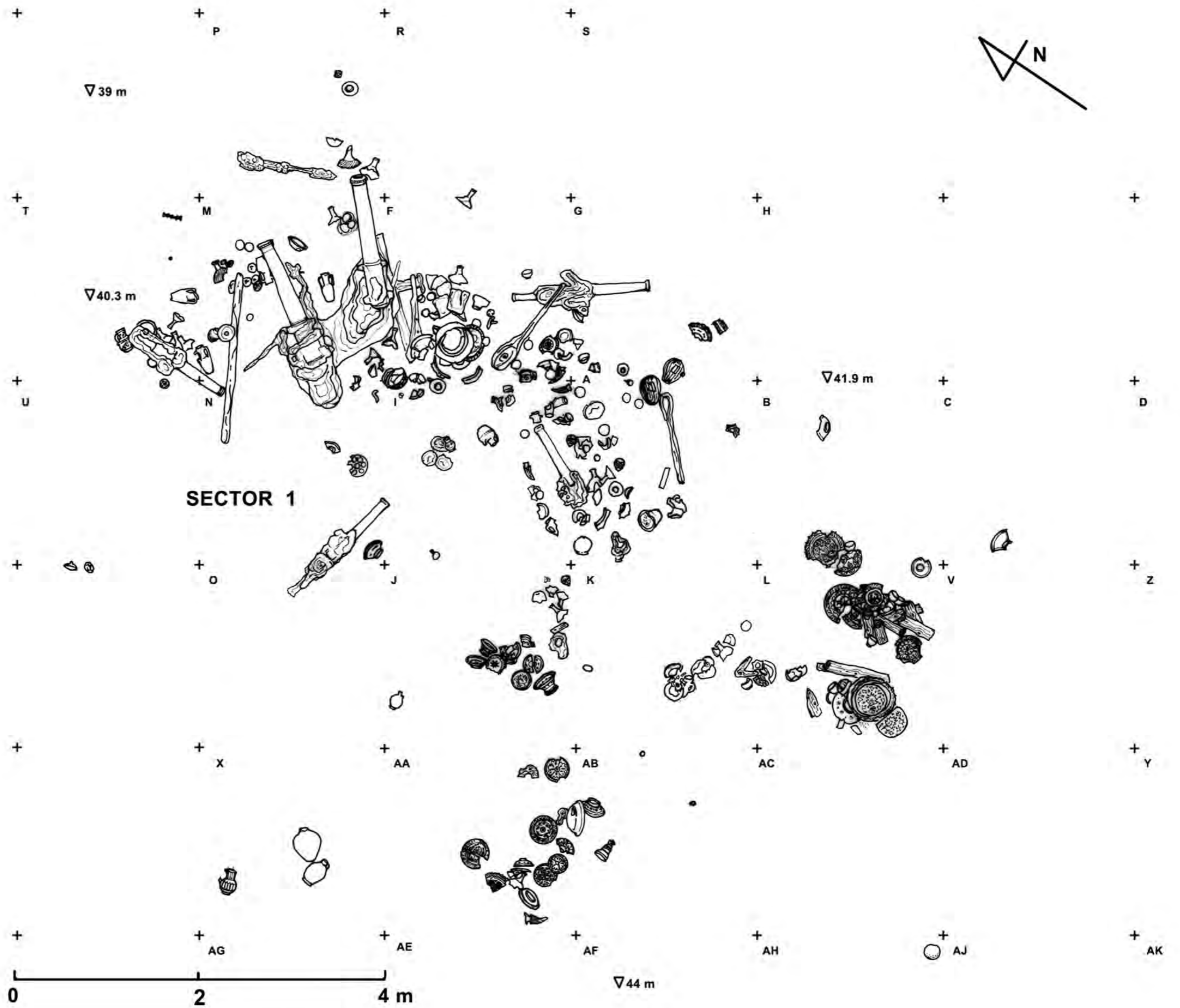


Chart 2.

### 2.1. Discovery, research methods and techniques

*Igor Miholjek and Domagoj Perkić*

#### Abstract

*Grazie ad un finanziamento del Ministero per la Cultura, nell'ottobre 2007 il Dipartimento di Archeologia Subacquea dell'Istituto di Restauro Croato ha potuto condurre le prime indagini su questo importante sito archeologico. Obiettivo di questa campagna di ricerche era ottenere una prima documentazione anche fotografica delle condizioni del sito. Le ricerche sono proseguite nel 2008 e nel 2009, e nel 2010 è iniziata la cooperazione con gli archeologi italiani, sotto il coordinamento di Carlo Beltrame, del Dipartimento di Studi Umanistici dell'Università Ca' Foscari di Venezia. Nel 2011 le indagini si sono concentrate sulla documentazione dei resti dello scafo e sono continuate nel 2012 con la documentazione delle ancore.*

*Zahvaljujući osiguranim financijskim sredstvima Ministarstva kulture Republike Hrvatske prvo je istraživanje nalazišta kod Plićine Sv. Pavao proveo 2007. godine Odjel za podvodnu arheologiju pri Hrvatskom restauratorskom zavodu. Cilj je prve kampanje istraživanja bio izrada trenutnog plana nalazišta i fotografiranje stanja nalazišta i popratnih nalaza. Istraživanje je nastavljeno u 2008. i 2009. godini, a u 2010. je godini ostvarena suradnja s podvodnim arheolozima iz Dipartimento di Studi Umanistici, Università Ca' Foscari iz Venecije. U 2011. godini naglasak je bio na dokumentiranju ostataka brodske konstrukcije. U posljednjem su istraživanju u 2012. godini dokumentirana sidra koja su pronađena na nalazištu.*

More than 400 underwater archaeological and historical sites are evidenced in Croatian inner waters and territorial sea. Around 25% of these sites are protected as cultural heritage. That implies that the Ministry of Culture brought in laws about legal protection for such sites, the so-called decisions on preventive protection and decisions on registration of underwater cultural assets. The number of protected sites is growing every year, considering the discovery of various new sites and revalorizing already recorded sites. Apart from such individual protected sites, there are protected archaeological zones that embrace a wider area, mostly the area of outer islands where most archaeological sites are located. The zones around the islands usually encompass a belt 300 m from the shore, and all other islets and shallows which are 2000 m away from the island coast. A total of 110 sites is currently protected as cultural heritage, 12 sites are individual

preventively protected cultural heritage sites, and eight are preventively protected zones, five of which are very interesting for diving:

1. underwater archaeological zone around islands Vis, Brusnik, Svetac and Biševo;
2. zone around island Palagruža;
3. zone in front of Cavtat;
4. zone of islands Lastovo, Kopače, Sušac and other islands in the aquatorium;
5. zone of island Mljet;

Individual diving (Perkić, 2003: 78–81) in such zones is prohibited, and the only permitted type of diving is organised diving (in the sense of recreational, sport or touristic diving) with the approval of the Ministry of Culture or the authorised Conservation Department. The procedure for getting the approval which can be

issued to diving centres (commercial/touristic diving) and diving clubs (non-profit, sport and recreational diving) is regulated by the appropriate legal acts<sup>1</sup> and legislations<sup>2</sup> from the Ministry of Culture. Diving clubs which require the approval of the Ministry of Culture for diving in the protected zones need to attach a special programme, tied to the protection of the seabed (surveys, mapping the bottom etc), which contributes to the protection and preservation of cultural heritage. They must also report a new archaeological site to the authorised government institution if they find one during the carrying out of their programme. Diving clubs do not pay a fee for diving, but divers may only be members of the club. This possibility was instituted to aid local diving clubs on islands which are also protected zones and to allow the native inhabitants to dive, but also to allow diving for other clubs in which people do not dive commercially but for sport or recreation. In any case, most data about new sites comes from diving clubs, so it is in the best interest of the Ministry of Culture to enable them to dive.

The discovery of the underwater archaeological site near the Sv. Pavao shallow on Mljet was in the context of issuing the approval for diving in the zone of island Mljet to the diving club 'Sava-Medveščak' from Zagreb. The club held a diving camp on the southern part of Mljet during August 2006. The remains of the site were found during a dive guided by Jurica Bezak, at the time a diving instructor and student of archaeology, and now an active employee of the Department for Underwater Archaeology, Croatian Conservation Institute. He immediately informed the authorised Conservation Department in Dubrovnik and the inspector for the protection of underwater cultural heritage. First survey was carried out in May 2007 within the framework of the Regional coordination of work and protection of inland sea, territorial waters and *Ecological and Fisheries Protection Zone* of the Republic of Croatia (according to the Coast Guard Law), for the area of Harbour Authority Dubrovnik. There is a permanent coordination on local and state level of all state institutions whose work is tied to the sea, to protect the sea and the seabed. The aforementioned survey was carried out with help from the ship of Harbour Authority Dubrovnik. The survey also assembled a team of divers from the Special Police Force Dubrovnik, experts from the Department for Underwater Archaeology at the Croatian Conservation Institute and the inspector of protection of underwater cultural heritage from the Ministry of Culture.

The first immersion uncovered several visible parts of ship's structure, equipment and cargo: seven bronze artillery pieces, numerous fragments of and complete ceramic vessels (bowls, jugs and plates), glass vessel parts, part of a bronze candle holder and other small finds. Remains of the ship's hull and an iron anchor were visible 10 m to the south of the artillery pieces, and some wooden shell plating was visible over a larger area. According to the retrieved samples of ceramic vessels and the expert determination of the finds made by Liljana Kovačić from

the Dubrovnik Archaeological Museum, a few finds belonged to Ottoman pottery, manufactured in the territory of present-day Turkey at the workshops in Iznik, on the basis of which the complete shipwreck could be dated to the second half of the 16th century (Perkić, 2009: 319–338). The recognised value, both of the finds and the whole site, is undeniable. In fact, this is an exquisitely preserved site which was not devastated at all in any of its parts, which is a rarity in both a local and global framework. The first publications about the discovery of the site, and in bringing about appropriate legal acts – decisions on preventive protection of underwater cultural assets – the position of the wreck was assigned the name of shallow Preč, but a more precise toponym was then chosen and it is today still in use: Sv. Pavao shallow.

This method of law regulation on protected underwater cultural heritage, taking into account the consciences and awareness of certain divers, has shown to be useful and efficient. Divers in diving clubs and centres are the ones who dive almost every day on well known and unknown locations. They are the ones who usually have timely information about any change on existing sites or about new ones. Therefore, it is important not only to supervise divers, but to make them more sensible and open to the importance of the cultural heritage and encourage them to cooperate with proper authorised institutions. While doing that, one must not neglect the importance of coupling diving within diving clubs or centres with the development of tourism and touristic opportunities in Croatia. This way a contribution is made to the local diving centres and, on the other hand, strengthens the protection of cultural heritage since the divers and the diving centres are an "extended arm" of the Ministry of Culture, and it is also in their best interest to make certain that the cultural heritage remains preserved for posterity.

Thanks to the assured financial assets from the Ministry of Culture, first research on this valuable site began in October 2007, undertaken by the Department for Underwater Archaeology of the Croatian Conservation Institute.<sup>3</sup>

The goal of the first research campaign was to draw blueprints and take photographs of the situation on the site at that time. Because of the great value of the bronze artillery pieces and the other preserved objects, it was decided that all the objects that had been documented could be raised, in order to prevent possible devastation (Fig. 2.1). The sea bottom drops to the depth of 46 m, forming terraces. The rocks are overgrown with vegetation, and rocks are succeeded by the sandy bottom which forms a mild slope towards the depth. The biggest concentration of finds is visible on the last two cascades. The concentration of finds spreads across approximately 50 m<sup>2</sup>, at 40–42 m depth, apart from the two artillery pieces found 10 m away from the concentration to the east at a depth of 37 m. In order to precisely document the site it was necessary to place seven orientation points. They were assigned letters A–G (see Plan 1). These points were used to measure in the

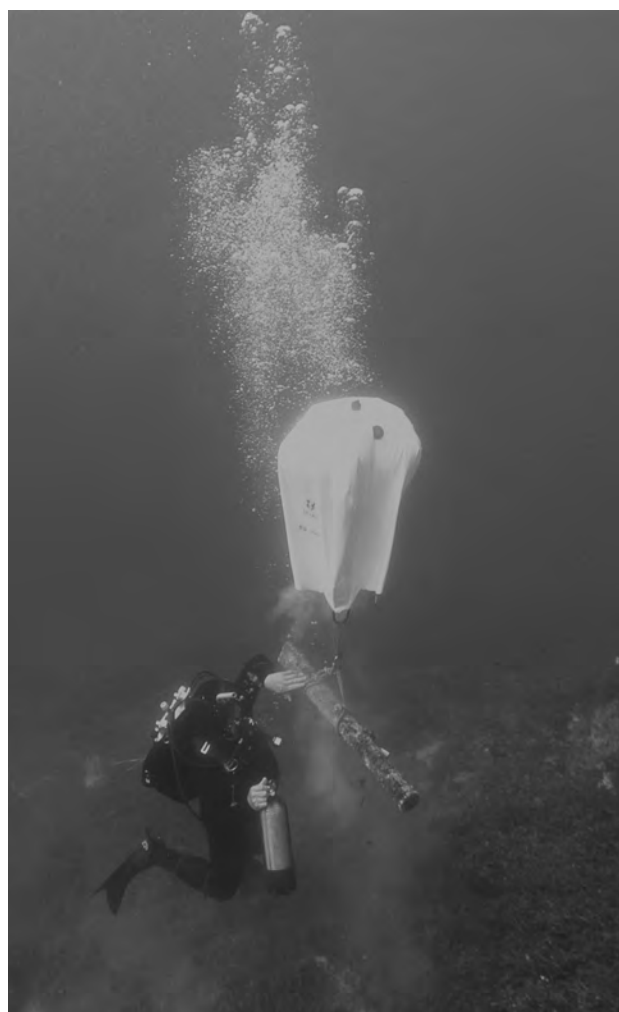


*Fig. 2.1. Documenting the condition of the site upon discovery (photo: I. Miholjek, HRZ archive)*

position of finds using the triangulation system, so each find received its exact position, depth and relation with other finds. After the finds were documented and photographed with their associated number, they were recovered to the surface so they could be individually documented and drawn. Smaller objects were put into nets and carefully taken to the surface, while the artillery pieces were taken out individually using an air lift (Fig. 2.2).

The first excavation lasted four days, during which 33 immersions were conducted, and 37 objects were documented and retrieved up to the surface. Such a field research requires experienced divers with appropriate certificates for deep dives. Divers used the Enriched Air Nitrox gas mixture with 26% oxygen which allowed them longer bottom time, and made the whole dive much safer (Figs 2.3 and 2.4). The gas mixture used during the decompression stops was again the Enriched Air Nitrox gas mixture with 80% oxygen, or in some cases pure oxygen ( $O_2$  100%). An additional safety factor was introduced by putting one spare diving tank on the bottom. Extensive briefing was carried out every day before the beginning of the diving operation, laying out general assignments for all divers and agreeing upon the diving plan, and smaller briefings were carried out before the dive with each diving group to confirm tasks (Fig. 2.5).

Because of the great value of this material and its intact condition, research was continued in 2008. Apart from the previous year, when the measuring technique used was triangulation, a documentation grid (Fig. 2.6) was placed in 2008, using the previously fixed points. This allowed precise measurement both of various finds and the site. The complete site was divided into quadrants of  $2 \times 2$  m, which could be subdivided into smaller sections. The whole excavation field was divided into 12 quadrants, or



*Fig. 2.2. Raising of one of the artillery pieces using an air lift (photo: I. Miholjek, HRZ archive)*



Fig. 2.3. Filling the diving tanks with the Enriched Air Nitrox gas mixture (photo: R. Mosković, HRZ archive)

12 archaeological trenches (Fig. 2.7). They were designated A–L and enclosed part of the research area from 2007. Archaeological trenches were excavated using a water dredge (Fig. 2.8). During this research phase 51 objects were documented and recovered up to the surface. Nine stone shot made of limestone were found (Fig. 2.9). One small lead shot was found inside the sand layer on the bottom of the trench. This shows the ship was armed not only with artillery pieces but also with arquebuses. Metal objects were also found on the sea bottom, including a copper food warmer with a horizontally hammered band in relief below the rim. Other items include a bronze, convex plate for a scale with three small holes used for hanging, with a diameter of 6.2 cm; a lock cartridge measuring 14×6 cm; a glass bead of diameter f 10 mm and a large number of animal bones. An iron anchor found at a depth of 37 m and 25 m to the north of Sector 1 (area with the highest concentration of finds, Plan 2) was also documented and named Sector 3 (Plan 1). It is 2.20 m long with the tilt on top having a diameter of 60 cm. The lower part of the anchor was buried in the sand and only one arm was barely seen protruding. Taking into consideration the site was found intact, it was necessary to preserve the conditions of the preserved ship's hull during all underwater investigations (digging, documentation etc) Therefore, additional care was given to the hull, paying special attention to the documentation of the wooden remains in order to get a better image of the ship itself, its function and details about the unfortunate capsizing of the vessel. The 2008 campaign lasted for six days during which 54 immersions



Fig. 2.4. Analysing the oxygen percentage of the gas mixture (photo: R. Mosković, HRZ archive)



Fig. 2.5. Briefing before the excavation (photo: R. Mosković, HRZ archive)

were conducted. It is important to mention seven large Iznik plates stacked on top of each other, and several bowls packed for transportation, confirmed the hypothesis that the ship contained oriental commercial cargo meant for the western market (Fig. 2.10).

The 2009 excavation continued towards the northern area of the excavation field, so the trenches from the previous year were completed (F, G, I, M and N) and new ones opened (P, R, S, T and U). An area of 11 quadrants or 44 m<sup>2</sup> was enclosed into the research. An additional orientation point H was placed to allow more precise measurement of the finds. In total 75 items were documented and retrieved up to the surface during this research phase. Three additional stone shots of a similar diameter of 9.5 cm were found. Fragments of at least five green glass bottles were recovered and, from the shape of rim and neck we can conclude there were at least three types of various sizes and shapes. One bilateral wooden comb was also found. Most finds were pottery, which can be divided into two categories: ship's simple shaped kitchenware of western and oriental origin, and luxurious, abundantly decorated Iznik pottery, forming part of the ship's cargo. Finds included parts of the ship's equipment, a brass square coak (part of a scarf joint) and a wooden "heart" (deadeye). Furthermore, an eighth bronze artillery piece with an iron breech holder and iron yoke and peg were found on the bottom in the sand below the stone cascade (Fig. 2.11). The campaign lasted six days with 54 immersions carried out.

The material that emerged in the 2010 campaign is related to that found in previous campaigns. One of the



Fig. 2.6. Documentation grid with archaeological trenches A–E (photo: I. Miholjek, HRZ archive)



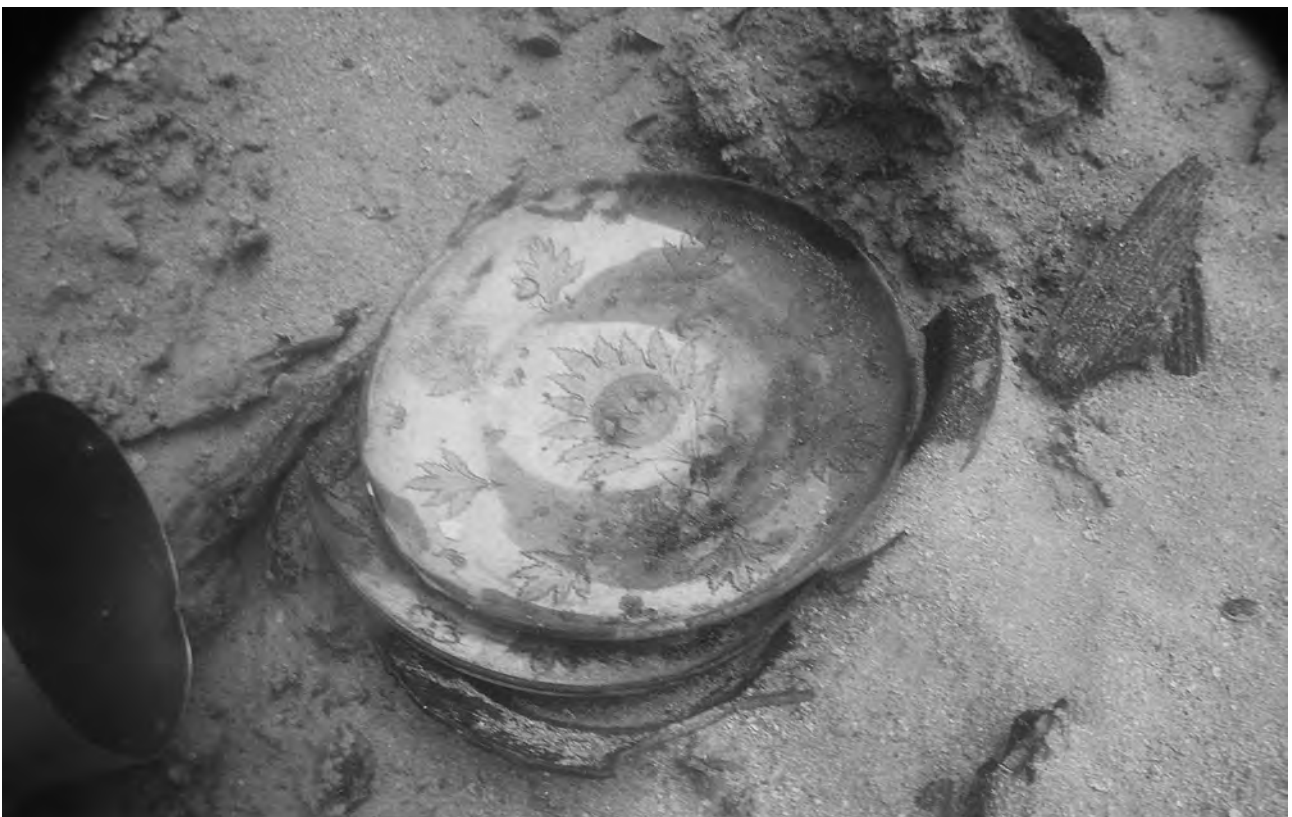
*Fig. 2.7. Documentation within the grid (inside the trench) (photo: R. Mosković, HRZ archive)*



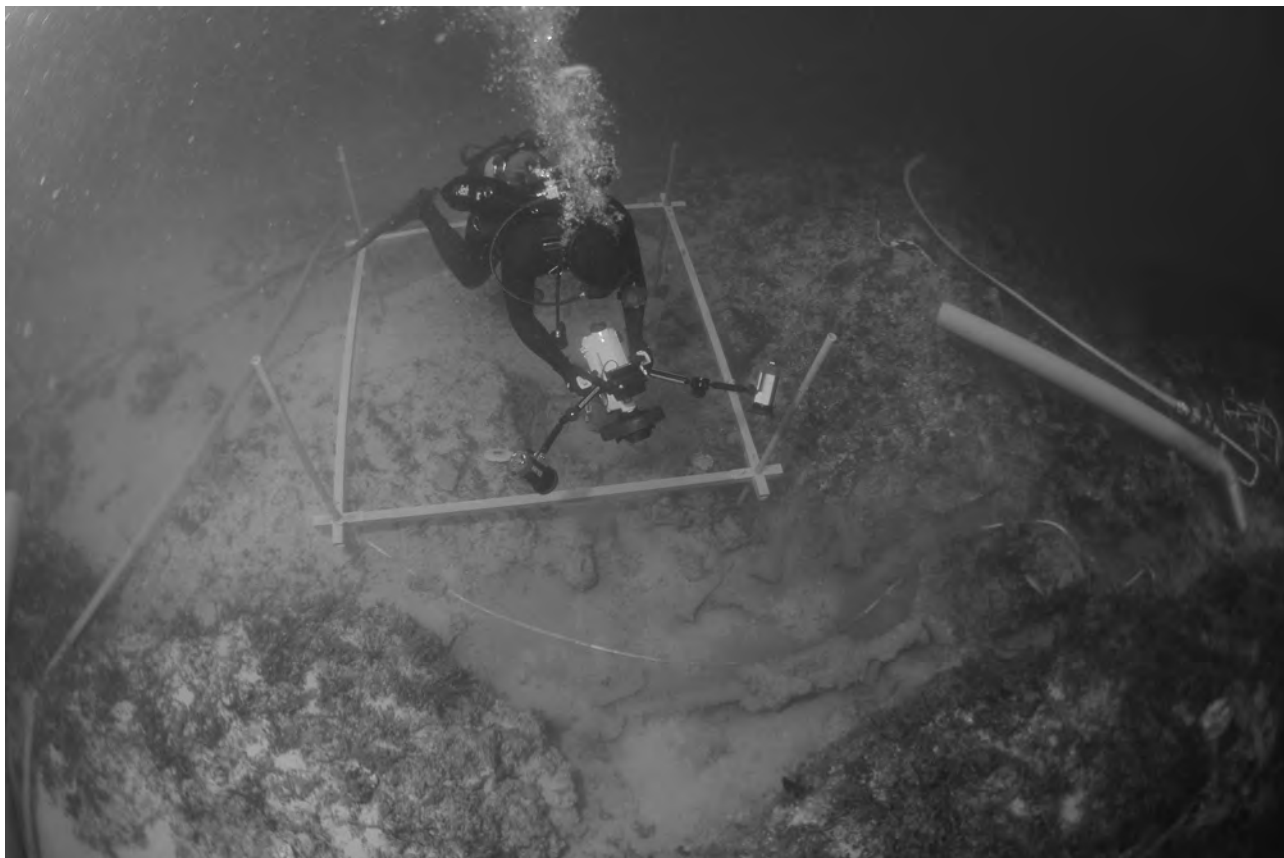
*Fig. 2.8. Excavation was conducted using a water dredge (photo: I. Miholjek, HRZ archive)*



*Fig. 2.9. Taking photographs of the shots in situ (photo: R. Mosковиć, HRZ archive)*



*Fig. 2.10. Iznik pottery in situ (photo: HRZ archive)*



*Fig. 2.11. Documenting the artillery piece using an underwater video camera (photo: R. Mosković, HRZ archive)*



*Fig. 2.12. The team from 2010 consisting of Croatian and Italian members (photo: R. Mosković, HRZ archive)*



Fig. 2.13. The view of the site – Sector 2 and the remains of the ship's hull and Sector 1 with the ship's cargo (photo: I. Miholjek, HRZ archive)

more interesting objects is a small bronze ship's bell with the year MDLXVII (1567) in relief. Two silver *talers* together with 40 *akches* were also found. The Ottoman *akches* are extremely important for dating this shipwreck. In fact, those recovered belong to four different sultans: Sultan Selim I (1512–1520), Sultan Süleyman I (1520–1566), Sultan Selim II (1566–1574) and Sultan Murad III (1574–1595). Since Sultan Murat III began minting these coins in 1574, we know the ship did not sink before that year.

Ten archaeological trenches were investigated, which correspond to an area of 40 m<sup>2</sup>. Additional reference points were placed to allow precise measurement of objects found outside of the grid. The position of each object was made using trilateration within the grid, or triangulation for objects outside the grid. Eighty-eight objects were uncovered and documented during this research stage. Most items are pottery finds: Iznik plates and vessels of various sizes, jugs and smaller luxurious pottery. Objects of glass and metal are represented in smaller numbers, as well as animal bones. The international cooperation with the team of underwater archaeologists from Italy, under the direction of Carlo Beltrame began in this year. The Italian team joined the campaign with the goal of making a complete documentation of the ship's wooden hull. Colleagues from Università Ca' Foscari made a photo mosaic and a ground

plan of part of the hull. They documented 16 planks and six frames (approximately 24 m<sup>2</sup>). The 2010 research stage lasted 13 days during which 147 immersions were conducted (Fig. 2.12).

The research in Sector 1 was continued in 2011. Sector 1 expanded to the east, west and south of trenches K and L, excavated in 2010. New trenches were named X, Y, Z, AA, AB, AC and were located at a depth of 42–44 m below the surface. Previous excavation in K and L areas uncovered the biggest concentration of the ship's cargo, consisting of small ceramic cups and larger plates which were laid one on top of the other, in the manner in which they were transported. A total of 46 finds was documented on the site. About a dozen larger fragments of small plates and a dozen fragments of larger plates were found within the layer of dark sand mixed with soot. The fragments of larger plates actually belong to plates found in previous research campaigns. These finds belong to the luxurious Iznik pottery. Sector 2, including the remains of the ship's hull, was located east of Sector 1. Documenting the wooden structure of the ship which began in 2010 was also continued in cooperation with the Italian colleagues (Fig. 2.13). Fifteen planks and six frames were documented using photogrammetry. During cleaning of the ship's remains the seventh frame was found as well as the mast step and new parts of the planking. The hull

was thoroughly photographed as well as every important detail of it. One frame with a futtock (No. 1) and one plank (No. 15) were air lifted to the surface. Plank No. 15 was returned to its original position immediately after taking a sample for dendrochronological analysis. The frame with the futtock was carried to the bottom where it was drawn at 1:1 scale, taking great care in documenting the connection of frame and futtock. It was also returned to its original position after the documenting process was finished. The campaign lasted ten days with 94 immersions carried out.

Four new trenches AE, AF, AH and AJ were placed in the western part of Sector 1 during the excavation campaign in 2012. Only four objects were recovered from the layer of dark sand mixed with soot in trenches AE and AF, situated at the depth of 42–44 m below the sea surface. Extremely bad weather conditions and a strong southerly wind made further research impossible, so the campaign lasted only four days, in which 29 immersions were carried out. The deeper part of the site, at around 46 m depth, was surveyed with a small Remotely Operated Vehicle (ROV). Video Ray belonging to the Italian team caught sight of two iron anchors. The position of the anchors has been known since 2006, when the site was discovered, but they were not documented or visible until the 2012 campaign. The first anchor was placed perpendicularly across the second one, partially buried in the sand. This part of the site received the designation of Sector 4. Since the anchors were found around 20 m to the south of Sector 1 and 10 m to the west of Sector 2, four additional orientation points were placed: M, N, O and P. These points created a new documentation area for future finds. In the same sector, a stone cylinder, length 160 cm and diameter 50 cm, was found just a few meters above

the anchors, at a depth of 44 m. It has a rectangular slot on the sides (the two holes of the slots follow the axle of the cylinder). A similar object, although smaller, was found during the 2010 campaign, also at a depth of 44 m, but closer to Sector 2. The function of these items is not yet known.

Underwater archaeological excavations are extremely complex and demanding in organisational terms. The great depth of the shipwreck additionally makes the research more complicated. Considering the whole six campaigns (2007–2012), the total number of working days was only 43. The site spreads across approximately 200 m<sup>2</sup> (all four sectors), and the excavated and investigated area spreads across approximately 100 m<sup>2</sup>. Thirty-one divers participated in the research campaigns, and 411 immersions were carried out, with the average bottom time of 25 minutes. Although these deep research projects are extremely dangerous, not one diving incident happened in the duration of the research. Since around 300 objects were retrieved during all archaeological campaigns, we believe that future research and excavation on the site will reveal a larger amount of valuable finds and information.

### Notes

- 1 Zakon o zaštiti i očuvanju kulturnih dobara (*Narodne novine* broj 69/1999, 151/2001, 157/2003, 87/2009, 88/2010, 61/2011, 25/2012 i 136/2012); Croatian law published in the *Narodne novine*— the Official Newspaper of the Republic of Croatia (*author's comment*).
- 2 Zakon o zaštiti i očuvanju kulturnih dobara (*Narodne novine* broj 69/1999, 151/2001, 157/2003, 87/2009, 88/2010, 61/2011, 25/2012 i 136/2012).
- 3 About the activities of the Department: see also Perkić, 2006.

## 2.2. The photogrammetric documentation of the hull

*Cristiano Alfonso*

### Abstract

*L'ambiente del relitto di Mljet ha reso indispensabile la ricerca di un metodo speditivo, agevole e veloce di rilievo individuato nell'utilizzo della fotogrammetria digitale, tramite l'utilizzo di camera fotografica Sea&Sea 8000 G e software di restituzione PhotoModeler. Tale programma consente di ottenere, partendo da almeno due fotogrammi distinti, un modello metrico e tridimensionale dell'oggetto ripreso, senza necessariamente avvalersi della visione stereoscopica per l'elaborazione dell'immagine. Il sistema, già abbondantemente utilizzato sia a terra che su siti subacquei, si presenta, rispetto alla fotogrammetria tradizionale, molto più semplice con un risparmio notevole dei tempi di immersione e una notevole precisione. Tuttavia sono state riscontrate alcune difficoltà dovute per lo più alla profondità di lavoro e ad alcuni errori di tipo strumentale. L'applicazione della fotogrammetria su siti archeologici subacquei profondi si è rivelata molto utile e proficua poiché, nel complesso, la restituzione con PhotoModeler ha permesso di avere una accuratezza nell'ordine del millimetro e di ridurre notevolmente i tempi di lavoro in acqua.*

*Brodolom je na Mljetu zbog specifične dubine i položaja zahtijevao jednostavnu metodu čiji bi cilj bio dokumentiranje prostornih odnosa na nalazištu kao i uspoređivanje dobivenih podataka. Kao optimalna metoda izabrana je fotogrametrija uz upotrebu podvodnog fotoaparata i programa za renderiranje PhotoModeler. Taj je program omogućio stvaranje metričkog modela i 3D modela fotografiranog objekta tako da su u obzir uzete najmanje dvije različite fotografije koje se nisu trebale nužno stereoskopski procesirati. Ta je metoda, ranije upotrebljavana na kopnenim i podvodnim nalazištima, u usporedbi s tradicionalnom fotogrametrijom puno jednostavnija te točnija a ujedno štedi i vrijeme urona. Ipak, postojale su poteškoće prilikom snimanja zbog dubine samog nalazišta i određene greške na instrumentima. Upotreba se fotogrametrije, unatoč tomu, pokazala korisnom i isplativom na dubokim arheološkim nalazištima poradi preciznosti programa Photomodeler i do nekoliko milimetara što uvelike smanjuje trajanje urona.*

### Introduction

During the 2010 campaign, a portion of the hull of the Mljet wreck, already identified in 2009 (Mihajlovic *et al.*, 2012), was revealed on the seabed, sloping at about 25°, at a depth ranging from 38 to 41 m. Fifteen strakes with planks approximately 3 m long were identified. Part of the hull was cleared from the sediments and cleaned over an area of 5.20×3.50 m, even though it continues to a greater depth on its long side.

Because of the considerable depth, the photogrammetric

method was adopted in order to optimise the documentation and survey of the shipwreck. The photogrammetric survey was carried out using a Sea & Sea 8000 G camera and PhotoModeler software ([www.photomodeler.com](http://www.photomodeler.com)). This program provides a 3-D representation of the object, starting from at least two separate frames, without necessarily using the stereoscopic vision of the image processing. The work had four phases: calibration, field preparation, picture acquisition, and photogrammetric processing.

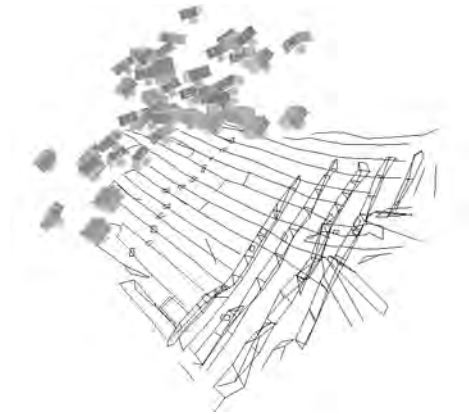


Fig. 2.14. Three-dimensional map of the photogrammetric survey (drawing: C. Alfonso)

## Work phases

### Calibration

The calibration of the camera, on which the success of the entire interpretation process depends, was made following the “calibration module”, using the reference grid supplied with the program. It consists in making two shoots for each side of the grid (for a total of eight) and four shoots at a fixed angle, with an easel. Data on the focal length of the lens (shooting parameters) are recognised by entering the pictures in the program. Perspective distortions are corrected according to the orientation of the camera that is recognised and positioned in the exact spatial location. As for the optics, the focal length was fixed at 35 mm.

### Preparation of the area

The preparation of the area by the marine archaeologist highlighted the individual elements of the hull and provided orientation. Small yellow target markers (plastic diskettes skewered by a needle) were placed at nearly regular intervals, mostly along the edges of the planks and along the seams, to create planimetric references. Sub-surface buoys, attached to a white wire and inserted at random, were used as vertical references in order to orient the three-dimensional model with respect to its actual position in space in the image processing stage (Fig. 2.14). During the photogrammetric survey, the team took measurements of some elements of the hull to make corrections to the final drawing.

### Picture acquisition

This phase consisted of the acquisition of a useful number of frames suitable for achieving the full coverage of the small portion of the hull (85 frames were sufficient), in a total of three dives. It was necessary to organise a work plan and respect the photographs programmed in order to cover the site completely because some areas were hidden and

not always visible in photos. The photographs were taken from the best angles for showing elements of the structure not usually visible. The camera orientation was preferably at approximately 45° and 90° to the seabed (Fig. 2.15).

### Photogrammetric processing

The processing was performed semi-automatically in the PhotoModeler program. The orientation of the photographs was done in pairs by referencing at least seven common points in each pair. It was possible to obtain the three-dimensional representation of the wreck through the acquisition of two frames at a time (Fig. 2.16). It was then necessary to identify, semi-automatically, all the common points present on two or more frames, and to process them with the software in order to illustrate the object in three-dimensional space. Additional information, provided by underwater archaeologists, was integrated into the 3-D model by Elisa Costa (see Chapter 2.4 below).

## Discussion

The underwater environment of the Mljet shipwreck required a quick and easy survey method, and digital photogrammetry was chosen. This method, already widely used both on land and in underwater sites (Drap *et al.*, 2002; Green *et al.*, 2002; Canciani *et al.*, 2003; Drap *et al.*, 2005; 2007), was found to be much easier than the traditional photogrammetry, enabling a substantial saving of diving time and giving considerable accuracy. However, there were two different kinds of complications, one concerning the depth of the shipwreck, and the other concerning the calibration of the camera.

The first was linked to various factors, mostly due to the position of the hull at a considerable depth, that conditioned diving modes, maximum dive times, the systematic programming of pictures, and the use of flash to compensate for light absorption.

The second problem was in the calibration of the camera, due to the light beam refraction through the different media (water, glass, air) (Drap *et al.*, 2008; Bass and Rosencrantz, 1973; Maas, 1995). The standard photogrammetric calibration software was used to perform the calibration of the ‘housing + digital camera’ setting. This approach can indeed largely correct the refraction distortion. However, it is strongly dependent on the optical characteristics of the water-glass interface of the housing.

### Data analysis, accuracy and conclusions

The application of photogrammetry to deep underwater archaeological sites proved to be very useful and fruitful (Drap *et al.*, 2002). The advantages of the digital survey can reduce the time required for survey in the water, and allow analysis to be performed with more accuracy. On the other hand this method requires the need of additional



Fig. 2.15. Vertical and horizontal references placed on the hull (photo: C. Alfonso)

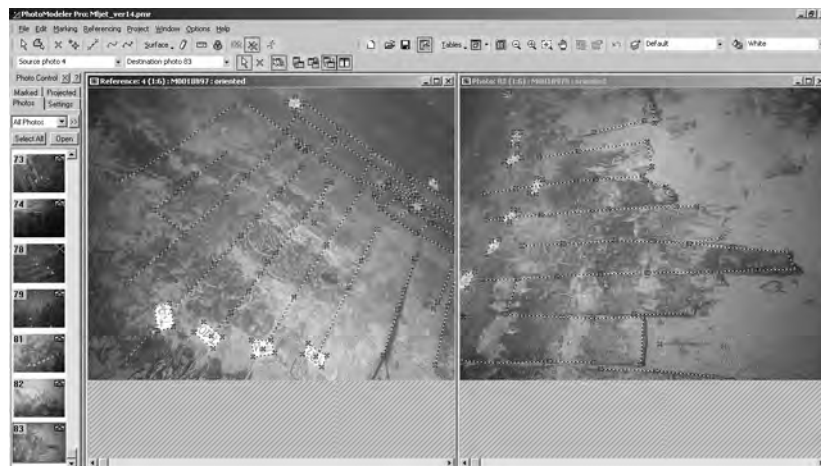


Fig. 2.16. Identification of relevant points on the wreck with PhotoModeler (photo: C. Alfonso)

sources of light and the detailed planning of the shots. Overall, the semi-automatic output of PhotoModeler allows an accuracy of the order of millimetres.<sup>1</sup>

### Note

- 1 The help of the Croatian team, Prof. Carlo Beltrame and his collaborators is acknowledged.

## 2.3. The photographical documentation

*Robert Mosковиć*

### **Abstract**

*La fotografia ha avuto molteplici ruoli nel corso degli scavi archeologici subacquei del relitto presso lo scoglio di San Paolo. Sebbene principalmente utilizzata per documentare la situazione sul sito e lo svolgersi delle ricerche, attraverso l'applicazione di metodi fotografici si è ottenuta una sorta di base scientifica che ha agevolato l'analisi e l'interpretazione dei reperti archeologici.*

*Fotografija je imala brojne uloge u podvodnom arheološkom istraživanju brodoloma kod Plićine Sv. Pavla. Iako je primarno upotrijebljena za dokumentaciju situacije na nalazištu i cjelokupan tijek istraživanja, primjena fotografskih metoda dala je svojevrsnu znanstvenu podlogu budući da je pomogla u analizi i definiranju arheološkog materijala.*

Photography undertaken during archaeological research at the Sv. Pavao site has an extremely important and diverse role. We used photography to monitor and record the condition of the site and to follow and record the research process. We can roughly divide photography according to its function as archaeological documentary, reportage and scientific photography.

Every underwater archaeological excavation consists of many phases. It is necessary to photograph and record the condition of the site before the beginning of the research, following the complete course of the research with its corresponding stratigraphy and the final stage of the excavation and protection of the site. Such photographic records will give us full visual insight about all actions and procedures conducted on and around the site and enable us to subsequently reconstruct the site in its various research phases. This recording method also allows the reconstruction of a site following the recorded depths of the stratigraphic units as a reference to the periods of time through which a site passed.<sup>1</sup>

Photographs of the Sv. Pavao site were taken immediately after it was reported to us, in order to assess the spread of the site and the configuration of the terrain. Subsequent analyses of the photo material and other data enabled the researchers to plan ahead the next step in the

research; where and how to place the documentation grid or reference points, where to start excavating with the dredges or how to choose and define the research priorities.

Throughout the research of the ship remains on the Sv. Pavao wreck, photographic techniques were used every day to record the course and progress of research, along with everyday status of archaeological probes and various finds *in situ*. Photogrammetry, as an additional method of scientific photography, and photo mosaics to record a detailed situation for current and future analysis of the site and material were used (see C. Alfonso and E. Costa in this volume).

The photographs were taken using a Nikon SLR digital camera with wide lens in the underwater Seacam camera housing, equipped with calibrated glass dome port, which allowed a wide angle of recording with optical correction of light refraction that occurs underwater. The same setup was used through the rest of the excavation, along with ultra wide (fish eye) and normal focal distance lenses with corresponding ports on the other underwater housings.

Next, there is a photographical documentation of the finds. Photography has a diverse role here, too. First, a precise display of the finds, along with their surface texture and structure of the material is achieved. Secondly, the condition of the finds after retrieval from the site

or in various phases of conservation and restoration is documented, followed by the presentation of the finds in various publications, web pages and posters – in all places available to the wider audience which are not in immediate contact with the finds.

It is important to document the finds before the process of desalinisation because they will not be available during the implementation of the process and they need to be catalogued. It is important also to take photographs of the finds just extracted from the sea while they are still wet in order to preserve their form before the restoration process. This is especially true with the wooden remains. Photographs are taken using a measuring scale and the signature of the item, so by just taking a look at the picture it is possible to distinguish the origin of the item, the time of retrieval, inventory number, actual size and proportions.

After the find has been restored and conserved, it is ready to be presented to the wider public. This time it is important to address the quality of the process of taking the photographs and to adjust the visual impression to the find itself, having in mind its true appearance and the emphasis we want to make. Taking the photographs for publication is best done in a controlled environment, with controlled lighting and adequate background or improvising within an adequate ambient. It is important to take care of the

structure, colour and the surface of the item and to try and capture its plasticity as well as we can, therefore reproducing its characteristics within the photograph and accentuating the features it carries. On the excavation we used studio strobes with various diffuser attachments, reflectors and table top setup, sometimes improvising on the location and later on, after the restoration of the finds, comfortably in the studio with more equipment and better conditions.

Data which we can distinguish using modern methodology of excavation satisfy some criteria necessary for making the plans and 3D models of the site, but with the future development of technology we will be able to gain new insights from already existing databases and photographs. Following that idea, all data recorded are kept in full quality, what in practice means that the maximum of available technology and equipment is used to take the photographs and store them in full quality as raw sensor data suitable for future editing and analysis (NEF, RAW, DNG).

### ***Note***

- 1 To read more on this subject: Green and Gainsford, 2003; Green, 2004; Jurišić, 2006.

## 2.4. 3-D reconstruction of the hull

*Elisa Costa*

### **Abstract**

*Il lavoro consiste nella rielaborazione dei rilievi bidimensionali del relitto, pianta e sezioni, eseguiti per mezzo della fotogrammetria. L'obiettivo è quello di illustrare e comprovare le potenzialità della ricostruzione 3D per la documentazione di un sito archeologico. Il prodotto ottenuto attraverso questo sistema risulta essere molto vicino alla realtà ed è per questo importante non solo per usi didattici ma anche per affinare la qualità della documentazione.*

*U ovom se radu prikazuje postupak 3D rekonstrukcije olupine a koja je načinjena upotrebom fotogrametrijske tehnike te 2D crteža (planovi i presjeci). Demonstrira se i objašnjava potencijal 3D dokumentacije na arheološkom nalazištu ne samo kao korisnog istraživačkog alata, već i kao nove vrste dokumentiranja arheološkog nalazišta.*

At the end of the excavation of the wreck of the Venetian ship at Mljet, we decided to produce a three-dimensional model of part of the hull to create a new kind of representation (Fig. 2.17). The 3-D reconstruction resulted from the study of the wreck and analysis of technical documents. In fact 3-D was the final step of the documentation, based on other techniques, such as photogrammetry, used during the underwater excavations by Cristiano Alfonso to produce the final plan and section drawings (see Section 2.2 above) (Drap *et al.*, 2002). Transverse sections were made on three of the ten frames uncovered; the thickness of the other frames and the longitudinal elements such as keelson, mast step and *cosce* (mast step components) is not shown (Del Vais *et al.*, 2012). To recreate the correct shape and position of these absent elements (Fig. 2.18), we needed to use, in addition to the two-dimensional drawings, the photographic documentation and measurements made underwater by a marine archaeologist. The combination of these different types of information allowed us to illustrate all the construction elements of the wooden ship, modelled on actual dimensions of the shipwreck (Del Vais *et al.*, 2012; Demesticha, 2011).

The 3-D reconstruction was produced with Rhinoceros software, an application used to create solid figures, to which it is possible to apply photographic textures. These, with different wood grain and colour, are important to recreate realistic features of wood. Rendering also allowed us to analyse, study and appreciate technical details of the construction of the ship from different perspectives, and to measure any construction element any time after excavation, without reopening the underwater site (Figs 2.19 and 2.20).

During excavation and documentation of a site, many factors, including the characteristics of the archaeological material, seabed properties, and the depth of the shipwreck, influence the project timetable and affect the choice of technical documentation (Robert *et al.*, 2012).

Considering the set of problems in the excavation of different kinds of shipwreck, such as the necessity of protecting the wood by covering it with sand to recreate anaerobic conditions, and taking into account that archaeology is a destructive operation, we finally concluded that three-dimensional reconstruction was the most complete documentation that could be utilised, because it allowed us to optimise time and work during

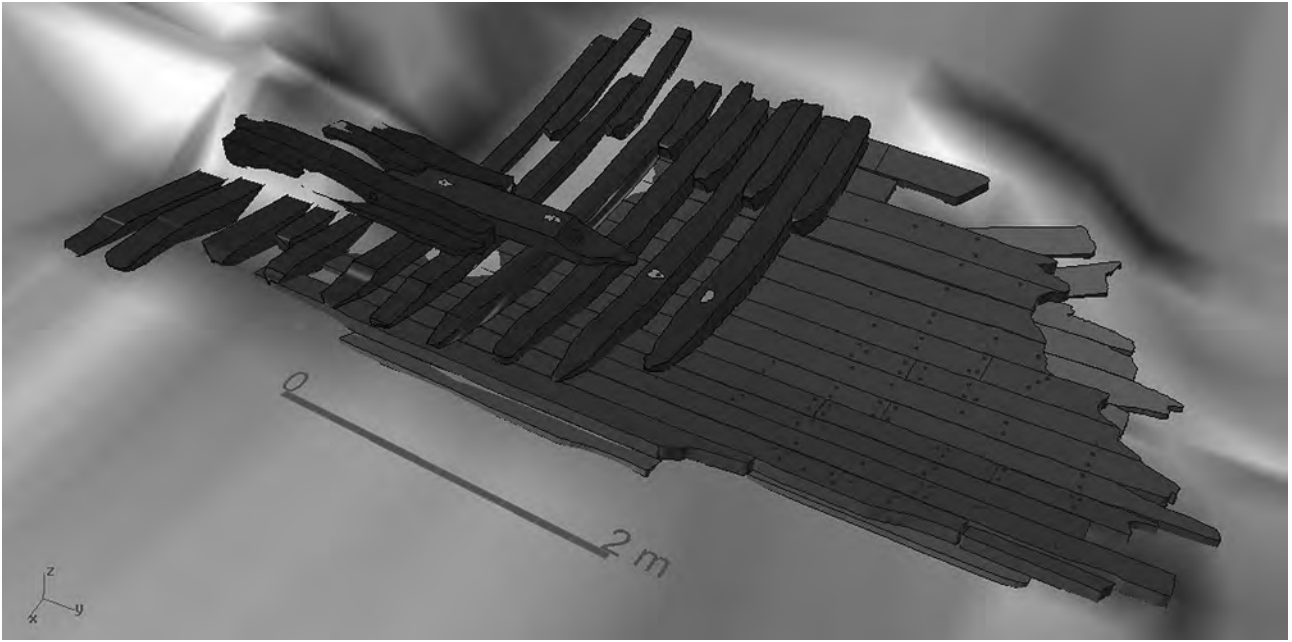


Fig. 2.17. 3-D reconstruction with Rhinoceros software (drawing: E. Costa)

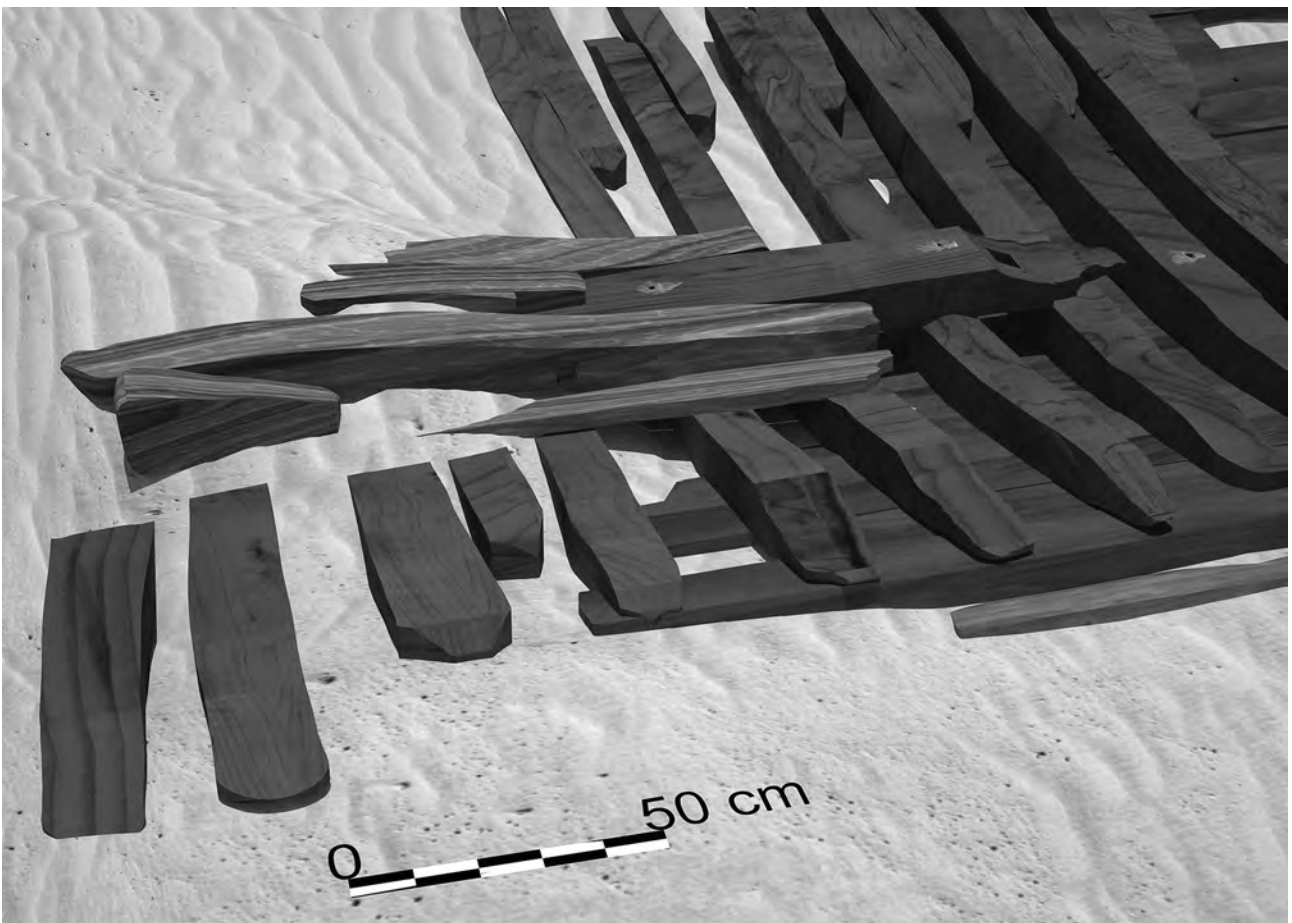
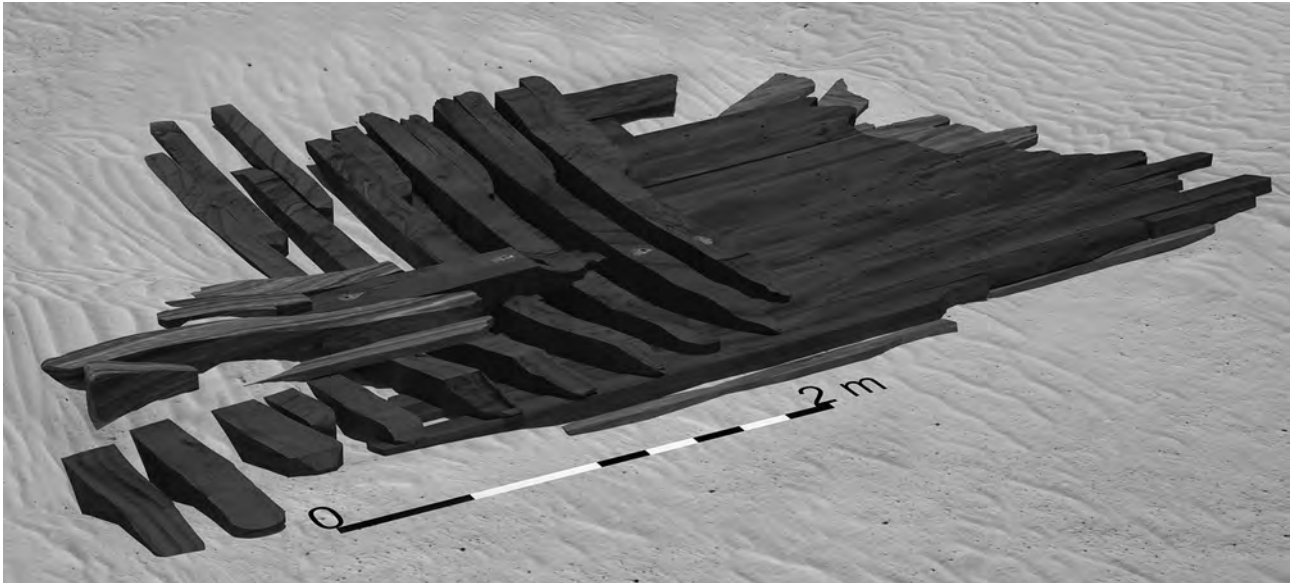
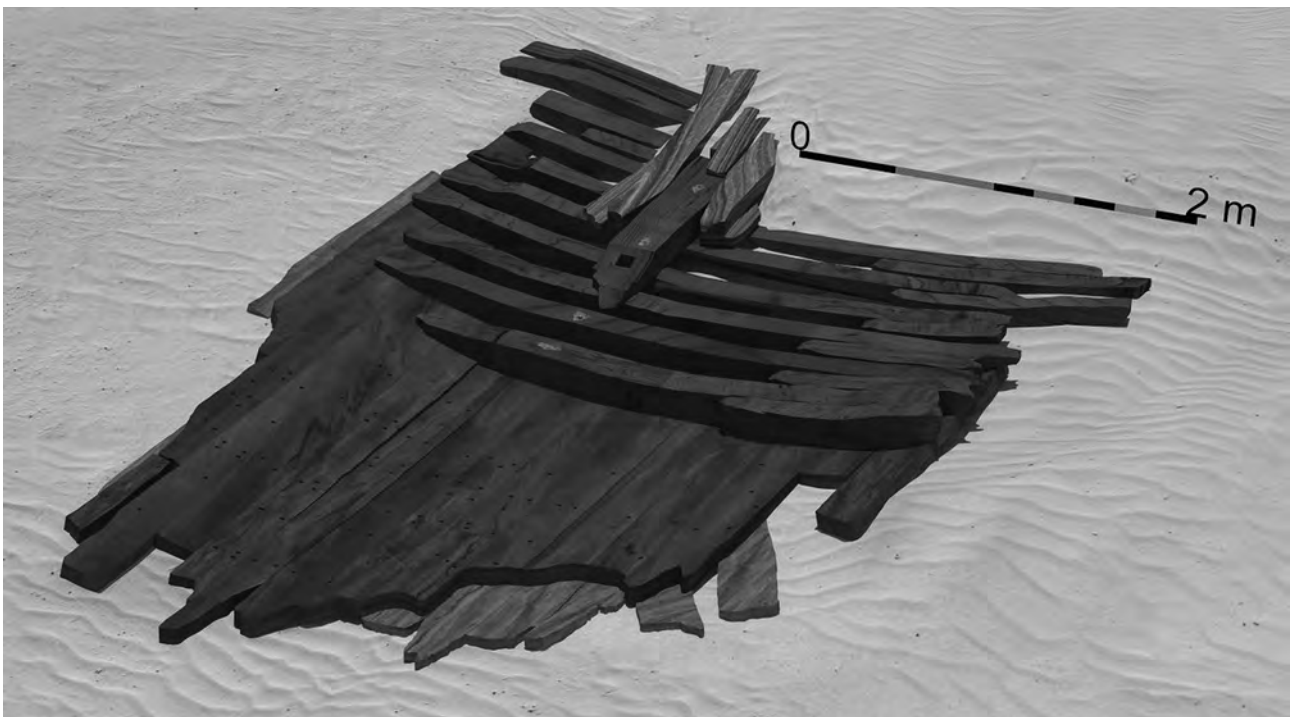


Fig. 2.18. Detail of longitudinal elements, keelson, mast step and cosce (drawing: E. Costa)



*Fig. 2.19. Complete reconstruction of the shipwreck from two different perspectives (drawing: E. Costa)*



*Fig. 2.20. Complete reconstruction of the shipwreck from two different perspectives (drawing: E. Costa)*

the excavation, decreasing bottom dive-time (Drap 2012). We also obtained more complete data than two-dimensional documentation would have given, permitting flexibility during the software simulation of the data acquired. Furthermore, it offers new prospects for research and study in the final stage of the post-excavation work (Drap, 2012; Gianolio, 2012).

Three-dimensional reconstruction served as an innovative tool for the interpretation of the complete Sv. Pavao

(Mljet) shipwreck, and allowed us to present, better than in a two-dimensional drawing, the layout and construction of the hull. At the same time, it offered a good picture with great appeal for the general public, who, with this kind of perspective, can better appreciate the archaeological evidence (Lefebvre and Galmiche, 2012). We have to evaluate the potential of 3-D drawing for technical archaeology and surveying, as well as a providing display meant for the general public.

### 3.1. The Adriatic Sea, pottery and shipwrecks in the late and post-Medieval period: an archaeological perspective

Sauro Gelichi

#### Abstract

*La ceramica che si rinviene nei relitti di età post-antica può appartenere al carico oppure all'uso di bordo. La distinzione tra queste due categorie non è però sempre facile, data anche la relativa omogeneità della ceramica. I relitti di età post-antica dell'Adriatico (più numerosi quelli della costa dalmata che non quelli della costa italiana) sono stati studiati e pubblicati, fino ad oggi, in maniera abbastanza preliminare. Raramente poi essi conservano ceramica, soprattutto relativa al carico. Quella che è stata rinvenuta sul relitto di Gnalić, del 1583, doveva appartenere alla dotazione di bordo. La stessa interpretazione può essere proposta per la ceramica recuperata dal relitto di Koločep, databile nella prima metà del XVII secolo e piuttosto eterogenea, con produzioni perlopiù provenzali e comunque, solo per pochi oggetti, venete. Poteva essere commercializzata invece la porcellana cinese del relitto del XVIII secolo di Bisaga e quella di Iznik del relitto di Mljet. Guardando ai risultati degli scavi sulla terraferma possiamo notare come, lungo la costa dalmata, non siano al momento documentati centri produttivi di ceramica fine da mensa e, nello stesso tempo, come quella documentata sia tutta di importazione e in prevelenza di origine Veneta. Malgrado i dati siano ancora scarsi e piuttosto preliminari, possiamo notare come, a differenza di quello che ci si aspetterebbe, i relitti di navi non attestano quasi mai carichi di ceramica destinata alla commercializzazione e quando essa è presente è costituita da carichi esotici provenienti dall'Oriente. La spiegazione di questa mancanza di evidenza archeologica dai relitti potrebbe essere riconosciuta nel sistema di trasporto della ceramica su piccole imbarcazioni, di cui ad oggi non è stata trovata traccia.*

*Keramika pronađena na brodolomima koji potječu iz perioda srednjeg i novog vijeka može pripadati brodskom teretu ili keramici koja je upotrebljavana na brodu. Nije uvijek jednostavno razlikovati navedene kategorije zbog relativne homogenosti keramičkog materijala. Brodolomi su u hrvatskom Jadranskom moru, iako mnogobrojniji od brodoloma na talijanskoj strani Jadrana, do sada uglavnom djelomično istraživani. Rijetko su sadržavali keramiku koja je pripadala brodskom teretu. Keramika pronađena na brodolomu iz 1583. godine pronađenom kod Gnalića upotrebljavala se za svakodnevni život na brodu. Ista se interpretacija može predložiti i za keramiku nađenu na brodolomu kod Koločepa, koju možemo datirati u prvu polovicu 17. stoljeća i koja je vrlo heterogena, s centrima proizvodnje u Provansi te, u samo rijetkim slučajevima, u Veneciji. Keramika kao trgovačka roba nađena je na brodolomu iz 18. stoljeća kod Bisaga (teret kineskog porculana) i na brodolomu kod Mljeta (teret Iznik keramike). Uzmemo li se u obzir rezultati kopnenih istraživanja vidljivo je da uz obalu ne postoje proizvodni centri keramike te da su keramički nalazi uglavnom uvoz iz inozemstva, najčešće iz Venecije. Iako su informacije o brodskim teretima oskudne i preliminarne, također možemo naglasiti kako brodolomi gotovo nikad ne sadržavaju teret keramike u svojstvu trgovačke robe, a kad keramika i jest prisutna na brodolomu, sastoji se od egzotičnog tereta s Istoka. Objašnjenje za ovaj manjak arheoloških dokaza s brodoloma možemo naći u načinu transporta keramičke robe na brodovima o kojima, dosad, nismo imali nikakvih tragova.*

### Pottery and shipwrecks in the post-Medieval Adriatic Sea: an introduction

Maritime archaeology in late and post-Medieval contexts is a relatively recent development, probably in part due to advances in the discipline of historical archaeology (Flatman and Staniforth, 2006): such approaches are also now being developed in Italy (Gelichi and Librenti, 2011). However, it should be stressed that this phenomenon, as demonstrated by a few important case studies, is limited by the relatively small data-set and cannot therefore be used to present general reconstructions. Despite this, the results which have emerged from new research help to clarify a number of key issues: the structures of ships or their armament, and the more refined categorisation

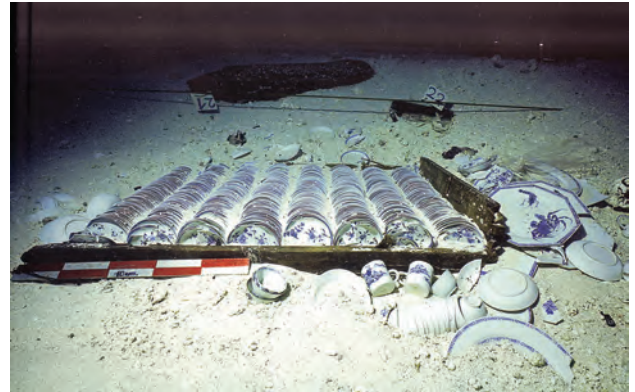


Fig. 3.1. Chest of porcelain from the Griffin Wreck (1761) (after Goddio, 1999: 53, photo 31).

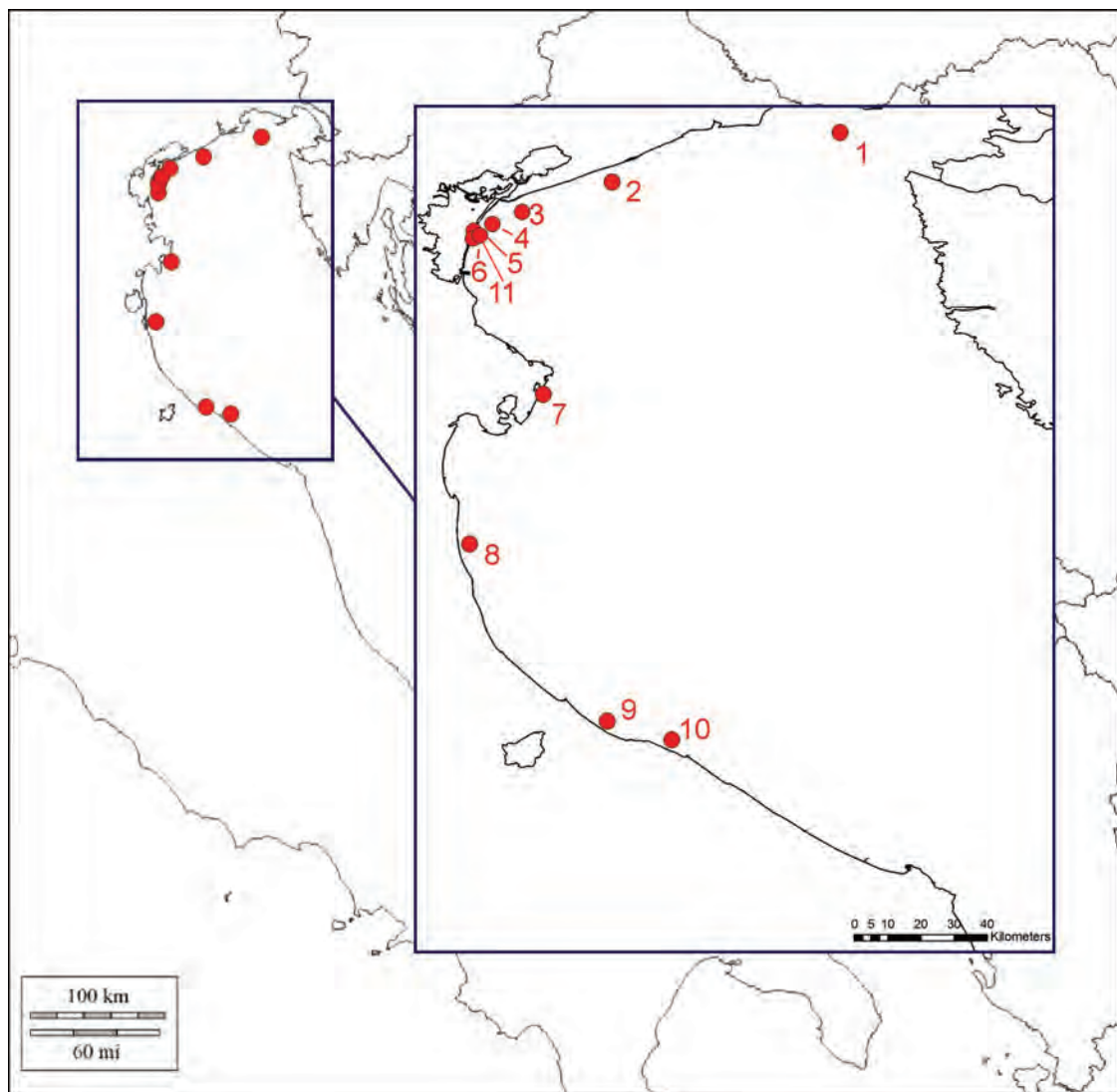


Fig. 3.2. Map of the late and post medieval northern Adriatic shipwrecks mentioned in the text: 1. Mercurio (military, 1812) (Lignano – Udine). 2. Rocchetta 1 shipwreck (Bocca di Porto di Malamocco – Venice). 3. Shipwreck of the ‘diga delle Ceppe’ (Bocca di Porto di Malamocco – Venice). 4. ‘Relitto del vetro’ (1) (Venice). 5. ‘Relitto dei mattoni’ (Venice). 6. Relitto di Eraclea (military, 19th century) (North of Venice). 7. Contarina shipwreck of the Po delta (Ferrara). 8. Presumed shipwreck of Porto Corsini (Ravenna) (called shipwreck ‘delle Erme’). 9. Presumed shipwreck in front of Cattolica (Rimini). 10. Shipwreck nearby Pesaro, defined incorrectly as ‘il galeone’. 11. ‘Relitto dei cannoni’ (Venice).

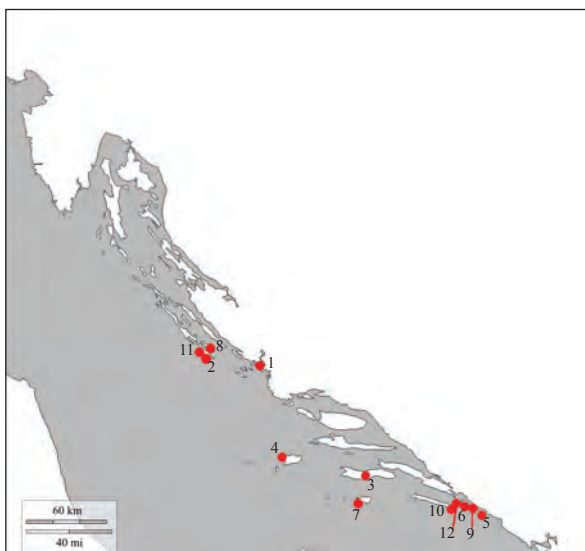


Fig. 3.3. Map of the late- and post-medieval shipwrecks of the Dalmatian coast mentioned in the text: 1. Mijoka. 2. Smokvica. 3. Otočac. 4. Saladinac. 5. Drevine. 6. Brsečine Cove. 7. Lastovo. 8. Gnalić. 9. Koločep. 10. Šipan. 11. Bisaga. 12. Mljet.



Fig. 3.4. Gnalić, monochrome sgraffito vessels (after Mileusnić, 2006: 106, fig. 5)



Fig. 3.5. Gnalić, set of majolica vessels with polychrome decorations (after Mileusnić, 2006: 107, fig. 8).

of some classes of well-represented materials, including pottery and glass. In this paper, pottery and late- and post-Medieval shipwrecks in the Adriatic Sea will be discussed, in comparison with the other archaeological evidence. However, a number of difficulties with the evidence must first be explained.

The first issue concerns the contexts. It is difficult to provide a precise history, as maritime archaeology is not sufficiently developed to offer a full picture of the pottery circulating between the 16th and 19th centuries. The main problem is that very little pottery has been recovered from the shipwrecks and published.

The second issue finds its origins in the first: no shipwrecks have been completely investigated and comprehensively published, so the available information is patchy. This makes dating the shipwrecks and reconstructing their history difficult, and further limits the interpretation of the items present within those ships.

The third aspect involves the pottery circulating in this period around the Adriatic area, which must be related to the contents of the ships. However, this analysis is hampered by a general lack of understanding of the pottery types produced in this area, to some extent due to a lack of research on Italian production centres.

Furthermore, finds on one coast generally differ from those on the other; and on the Italian coastline, which has been better studied, finds in the north (Veneto, Friuli) differ from those in the south (Apulia, Calabria). Nevertheless, it is worthwhile analysing the evidence of the pottery recovered in the little-known shipwrecks in an attempt to explain its relationship with the pottery evidence from the mainland (essentially for coastal sites).

## Pottery and shipwrecks

Pottery recovered from shipwrecks is studied by archaeologists for different reasons. First, because finds from accurately dated shipwrecks provide unique closed, uncontaminated contexts that are seldom found on land (Marchen, 1994: 1). Secondly, in many cases, pottery and storage vessels were transported for trade. A study of the pottery from shipwrecks can therefore help us to understand the relationships between different locations, and patterns of consumption. Scholars have long highlighted the utility of pottery studies for reconstructing trade networks (Davey and Hodges, 1983), and this is absolutely true for Antiquity and later periods.

The third point is the analysis of the pottery *per se*, that is, as a social expression. The ship is a microcosm inhabited by a diverse and stratified community of people. The pottery (along with other artefacts) may well represent the communities which decide to adopt it, not only for its mere practical purpose but also for its intrinsic significance through which they can identity themselves.

We can distinguish two main types of pottery which are generally recovered from the ships:

1. Pottery which was part of the cargo, and
2. Pottery which was used on board for domestic functions: vessels used to store food for the crew, cooking ware and tableware (for the officers and the crew), and finally
3. Personal items (often single pieces).

Pottery which formed part of the cargo may have included transport vessels (traded for their contents) and/or items which were bought and sold in their own right. The transport/storage vessels (amphorae, jars, *dolia*) are easily recognised, and their quantity and location (when it is known) within the hull can help to determine their function

(that is, whether they were part of the cargo or the crew's equipment). This is also valid for the utilitarian ware.

When the identity of the ship is known (and perhaps also the composition of the crew) it is possible to establish whether a relationship exists between the tableware and the crew (Dąbal, 2008). But when this information is not available (and often it is not), or the archaeological evidence of the contents of the ships is not complete, it is difficult to decide whether these items are cargo or equipment.

The homogeneity of the pottery types does not help, as a complete set of the same product could be part of the crew's equipment (as may have been the case on the Gnalić shipwreck, see below), and furthermore, within the same ship, pottery of varying quality can be found as ship's equipment, personal items, or goods for trade (Martin, 1995: 355–356).

In brief, we need to look at the volume of the pottery in association with the homogeneity of the assemblage and its location in the ship all together in order to better understand the evidence (Fig. 3.1).<sup>1</sup> Generally it is believed that cooking wares on ships are part of the ship's equipment for food preparation. However, cooking pots were also traded (Amouric *et al.*, 1999: 105–108), as confirmed by modern documents (Cvikel, 2011).

For the personal items, these were often acquired *en route* by the members of the crew. It is therefore clear that the evidence of pottery present on the ships, when it lacks associated archaeological data, must be used with caution, both for studies of trade and consumption, and for assessing the origins of the ship. The “origin” of a merchant ship may mean different things: the place where the ship was constructed (the “*constructive*” place of origin), or the place where the ship was registered, or where the owner was living (the “*legal*” place of origin), and finally the place where “the ship was fitted out for a voyage, where the crew embarked, and where it would eventually have to return to unload its cargo (the ‘*economic*’ place of origin)” (Kleij, 1997: 181).

Defining the “economic” place of origin of a merchant ship through the materials that have been recovered is, however, quite complex: it requires an assemblage composed of many different categories of data. Among these categories the pottery which forms part of the “galley utensils” has a moderate rate of circulation (Kleij, 1997: 183, 185). The artillery, however, has a low rate of circulation, due to its high cost and long use: we cannot therefore be sure that a merchant ship is Venetian because the artillery pieces recovered on board were manufactured in Venice. Further categories of items need, therefore, to be considered when determining the origin of a ship, as the pottery evidence is really very difficult to interpret, especially when only a part of it has been recovered.

## Shipwrecks in the Adriatic Sea

The number of post-Medieval shipwrecks which we know

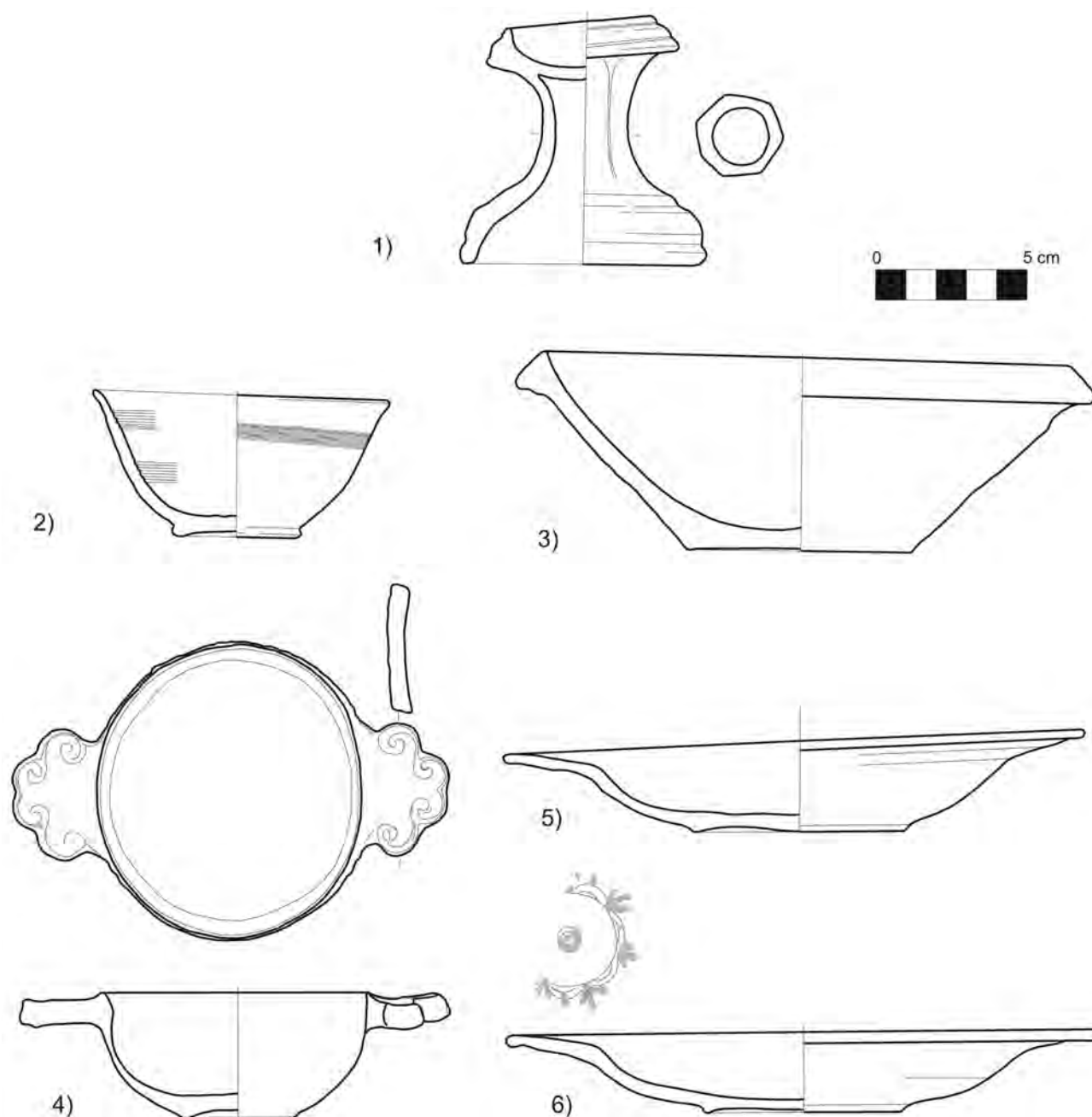


Fig. 3.6. Koločep. Pottery: 1. Marbled salt cellar (?) (ST 20). 2. Fine Sgraffito Ware (ST 34). 3. Marbled Ware (ST 23). 4. Monochrome Slip Ware (ST 38). 5–6. Majolica (ST 29 e 26) (Courtesy of I. Radić Rossi – drawings by S. Cadamuro).

in the Adriatic Sea is modest, particularly along the Italian coast. This may be due to the particular conditions of the sandy seabed, and also to the previous lack of interest in this type of archaeology. Furthermore, the few known shipwrecks have been poorly investigated (apart from the *Mercurio*, which nevertheless was a naval ship, not a merchant ship: Beltrame and Gaddi, 2002; Beltrame, 2009a; 2010), and have provided very poor pottery evidence (Fig. 3.2).

Among the shipwrecks recovered close to or within the Venice lagoon are the 19th century ‘Rocchetta 1’ in the port of Malamocco (Capulli, 2008), and the shipwreck at the

Ceppe dam (Beltrame, 2008), which is dated to the same period. Other shipwrecks, all discovered in the vicinity of the lagoon area, are: the ‘Glass Shipwreck’ (D’Agostino, 1998: 93; 2008) and the ‘Bricks’ Shipwreck’ (*ibid.*: 93–95). A third is the ‘Eraclea’ (D’Agostino, 1997: 64–68). The second shipwreck is dated on the basis of some pottery finds to the 17th–18th centuries, and the third, a naval ship, to the 19th century. However, the majority of these ships did not contain pottery, or at least very little, both from the typological and functional points of view. Finally, it is important to include the so-called “Cannon Wreck” of Malamocco, dated to the beginning of the 18th century,



Fig. 3.7. Koločep. Fine Sgraffito Polychrome Ware (Courtesy of I. Radić Rossi).



Fig. 3.10. Koločep. Marbled Ware dish (Courtesy of I. Radić Rossi).

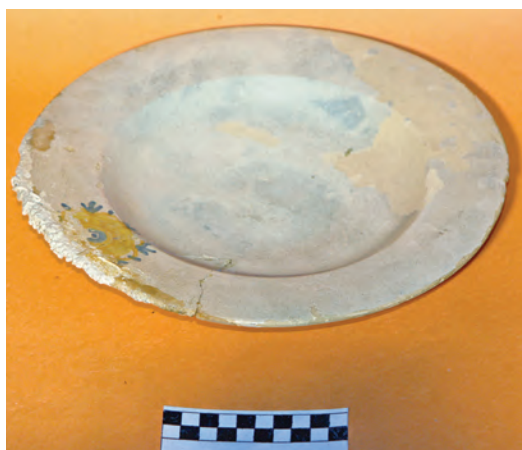


Fig. 3.8. Koločep. Stile compendario majolica plate (Courtesy of I. Radić Rossi).



Fig. 3.11. Koločep. Marbled salt cellar (?) (Courtesy of I. Radić Rossi).



Fig. 3.9. Koločep. Marbled Ware bowl (Courtesy of I. Radić Rossi).



Fig. 3.12. Koločep. Monochrome Slip Ware bowl 'à oreille' (Courtesy of I. Radić Rossi).



Fig. 3.13. Koločep. Slip painted jug with a straight spout (Courtesy of I. Radić Rossi).



Fig. 3.15. Koločep. Oil jar (Courtesy of I. Radić Rossi).

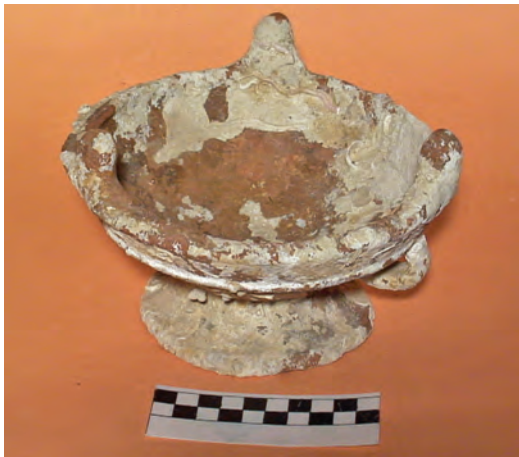


Fig. 3.14. Koločep. Chafing dish (Courtesy of I. Radić Rossi).



Fig. 3.16. Koločep. Oil jar, detail of the marks impressed on the shoulders (Courtesy of I. Radić Rossi).



Fig. 3.17. Bisaga. Chinese and Kūthaya coffee-cup (after Brusić, 2006: 83, fig. 16).



Fig. 3.18. Bisaga. Terracotta pipes (after Brusić, 2006: 82, fig. 15).

and identified with the Venetian *Croce Rossa*. This wreck has produced much material, of which very little is known (D'Agostino *et al.*, 2010).

Towards the southern coast, the scenario remains the same. Around the Po Delta, at Contarina, is a shipwreck which revealed pottery datable to the second half of the 15th century (Beltrame, 2009b: 412). Another presumed ship is attested close by at Porto Corsini, in Ravenna: this is the so-called "Wreck of the Herms", wrecked in 1553 while it was transporting a series of marble herms dated to the Classical period, recovered in excavations undertaken in Rome directed by Cardinal Ippolito d'Este (Arias, 1953; Bermond Montanari, 1986: 3).

From the shore opposite at Cattolica (Rimini) a group of 17th century jugs was found, which probably (considering the number) formed part of the cargo of a ship, as yet unidentified (Gelichi, 1986). Close to Pesaro, a ship dated to the early 18th century, known as the "Galleon", has been recorded (Profumo, 1986: 40–41, fig. 2; Profumo *et al.* (a cura di), 1995), from which several pottery sherds have been recovered, which are not easy to identify. Finally, several shipwrecks have also been recorded along the coast of Salento (Auriemma, 2004: 10–50).

On the other Adriatic shore the situation is different. The number of identified shipwrecks is 15 on the Dalmatian coast and three on the Slovenian one (Scordato, 2009), perhaps due to the different nature of the seabeds, but certainly due to a lack of attention to ships of this period (Orlić, 2006). These ships have not been completely investigated, and the information is patchy; however, nine of the 15 ships mentioned contained pottery finds which can be used here for the analysis.

### Pottery from the Dalmatian coast wrecks

Analysis of the contents of the known and published Croatian post-Antique shipwrecks (even if they are never completely published) reveals uneven documentation and a prevalence of 16th and 17th century wrecks (Fig. 3.3). One group does not show evidence of pottery (or at least the available information is incomplete and therefore unusable): this is the case for the Mijoka shipwreck close to the island of Murter (Brusić, 2006: 81–83; Zmaić, 2009), for the shipwreck near Otočac, for another close to Korčula (Glušćević, 2006: 75), for one close to Smokvica in the Kornati archipelago (Brusić, 2001), for a shipwreck in Saladinac Bay on the island of Biševo (Glušćević, 2006: 75) and finally for the Drevine shipwreck (Glušćević, 2006: 75). Together with these sites it is worth considering the ships with less secure documentation, such as the one identified near the Elafiti islands on the west of Brsečine Cove (Perkić, 2009: 328–329) and others close to the island of Greben, near Vis, and near the promontory of Cuf on Lastovo (Scordato, 2009).

A second group of shipwrecks can be identified from the pottery that probably formed an integral part of the ship's

equipment. This seems to be the case for the most famous shipwreck on the Dalmatian coast: the Gnalić (Biograd-Zaravecchia), investigated several times between 1967 and 1968, and in 2005 (*The Venetian Shipwreck at Gnalić*, 2004). The identification with *Gagliana Grossa* (which sank in 1583) has been recently supported by additional historical evidence (Radić Rossi *et al.*, 2013). This shipwreck is famous because a very rich and heterogeneous cargo was recovered, including a large quantity of superior quality glass (Lazar and Willmott, 2006; *Glass from the Sea Depth. Gnalić Shipwreck*, 2011). The pottery recovered however "does not represent a numerous group of finds" (Mileusnić, 2006: 104). In total today we have "62 complete vessels or pottery fragments", to which we have to add 30 sherds recovered in the excavations of 1996 (Mileusnić, 2006: 104).

Some of this pottery is clearly domestic (such as glazed pots for cooking: Mileusnić, 2006: fig. 3), but lamps, such as candlesticks, are also present (Mileusnić, 2006: fig. 1). However, most of the pottery is represented by *sgraffito* or tin-glazed wares (Mileusnić, 2006: figs 4–8) (Fig. 3.4), whose chronology is compatible with the artillery (1582) and the sinking of the ship (if it really was the *Gagliana* as it would seem). There are two series of reasonably homogeneous table sets: one is composed of polychrome majolica dishes with fruit and flower decorations, and the other of dishes (and small bowls) in majolica, but with a blue decoration on a grey-blue background (Fig. 3.5). As is the case with the *sgraffito*, these are certainly Venetian majolica; but it is difficult to conclude that this was part of a significant cargo when considering the quantity. Analysing the type of finds, these objects probably represent part of the ship's equipment.

In the case of the Koločep wreck (Radić Rossi, 2006), the small amount of pottery (38 whole or very badly damaged pieces) suggests it was "daily-use pottery on the same ship" (Radić Rossi, 2006: 87). However, unlike the Gnalić, the pottery is not homogeneous, from what we can understand from this rather poor excavation. The composition of these objects, however, is very interesting and worth describing below.

A pottery sherd with a central *sgraffito* inscription (*Rosto*) must be from Veneto (Cozza, 1989: 55, figs 65–67), but the remaining vessels are of a different origin. A *sgraffito* bowl with a central flower is of Pisan manufacture (Figs 3.6: 2 and Fig. 3.7): a type which is well dated to the first half of the 17th century (Berti, 1994: 363, Types Ab 2 and fig. 18), which was popular despite its inferior quality, and it can be found across the Mediterranean and in northern Europe, and even in North America. This type of pottery also had a wide diffusion in Provence (Amouric, 1993), and it was actually imitated there (for instance by the workshops in the Vallée de l'Huveaune: Abel, 1993).

A set of monochrome dishes (with a simplified decoration in yellow and blue on the rim: '*stile compendionario*') (Figs 3.6: 5–6 and Fig. 3.8) could be from central southern Italy (perhaps Castelli, in Abruzzo: see Zglav-Martinac,

2004: 80–81 and 166, no. 314). The remaining pottery is represented by: a number of monochrome glazed wares (which are difficult to identify); a group of Marbled Wares (Mannoni, 1975: 70–71, Type 56), with a two-coloured decoration in white-red (which was obtained by using red and white slips) and green splashes (Fig. 3.6: 1 and 3 and Fig. 3.9–11); a small monochrome slipped bowl with the rims ‘à oreille’ (Figs 3.6: 4 and Fig. 3.12); a small jug with a straight spout decorated in painted slip (Fig. 3.13); and a chafing-dish (Fig. 3.14).

The marbled wares were made by mixing white and red slips (and sometimes by adding pigments), to imitate ornamental stone. It is a technique, which between the 16th and the 17th century, was largely used on Italian vases (particularly in northern Italy), but also was used in Pisa and on the Tuscan island of Valdarno. However, from the 17th century this technique (and also the fine *sgraffito* wares) was adopted by the potters of Provence (Amouric *et al.*, 1999: 98). Our specimens are very similar to the vessels of these Italian workshops (Figs 3.6: 3 and Fig. 3.9–10), both in the shapes and for the marbled decoration (Amouric *et al.*, 1999: 98–100, figs 212–213).

It is also important to highlight objects whose function is not clear. One such is probably a salt cellar (Figs 3.6: 1 and Fig. 3.11), which has parallels only with versions produced in the rue du Limas in Avignon (Carru, 1995a: 97, no. 8, figs 4 and 7). Also a small monochrome bowl with handles “à oreille” (Figs 3.6: 4 and Fig. 3.12) constitutes a quite common form in the workshops of Provence and Languedoc in this period, where it is applied on two marbled slip painted monochrome vessels, which bear fine *sgraffito* decorations. However, looking at the form of the handles, better comparisons can be made with *sgraffito* vessels from Moustiers (Zérubia, 1995: fig. 96), or with a slip-painted decoration from the chapel of Mélan (Zérubia, 1995: fig. 126), where we find the typical relief clay strips which follow the shape of the handle (as in our item). Bowls of these slipped and monochrome wares are attested in Provence, in the workshop of rue du Limas (Carru, 1995b: fig. 1) or in Languedoc, in the workshop of the end of the 17th century in Saint-Quentin-la-Poterie (Thiriot, 1995: 123, figs 131–132). However, a close comparison comes from a vessel of the Lunek shipwreck, dated to 1664 (Dieulefet 2013: vol. 2, 127–128; on the wreck see Dieulefet 2013: vol. 1, 187–189), and attributed to the production of Huveaune (Provence) about the mid-17th century (Abel and Amouric, 1995).

The pottery with slip-painted decorations represents widespread production in the modern age area of Provence (from Lille to Marseille: Faure-Bouchalart and Vicard, 1990: 120). The decoration of our piece (Radić Rossi, 2006: 87, fig. 6) (Fig. 3.13) can be compared particularly with a type of small jar (*orciolo*) (again with a spout rim: *dourque*) recovered in the ancient chapel of the ‘Pénitents Blancs’ in Apt, datable to 1647 (Kaufmann, 1996: 89–90, fig. 2.2). The shape is more similar to monochrome vessels recovered in Cabrières (Schneider, 1995: 120, fig. 129, right), datable

to the 16th century, but a very similar vessel comes from the wreck of the *Lune* (Dieulefet 2013: vol. 2, 148; on the wreck see above). Associations between slip-painted wares and marbled wares (see above) are amply attested in Provence (for instance in the Couvent de la Visitation in Sisteron: Lemaire, 1995: 118, figs 100 and 140).

A chafing dish (Fig. 3.14) can be compared with Catalan productions, datable to the end of the 16th and the beginning of the 17th century (Amouric *et al.*, 1999: 108, fig. 232), but which seems also to be widespread and produced (also in an unglazed version) in the Lione and Vienna areas (Vicard, 1990: 149). A jar (Radić Rossi, 2006: 86, figs. 4 and 5) (Fig. 3.15), which is very similar to the oil jars of the Provence area, datable to the end of the 16th and the beginning of the 17th century (Amouric and Vallauri, 2005: 44–65), as the moulds with two Maltese crosses side by side in a circular scroll (Fig. 3.16) are similar to potters’ marks in Provence (Amouric and Vallauri, 2005: 54–55).

To sum up, the assemblage of the pottery recovered in the Koločep shipwreck provides two important types of information: the first concerns the ship’s dating which seems to be the first half of the 17th century (possibly the second quarter); the second concerns the composition of the pottery assemblage, which is too heterogeneous to allow an accurate assessment, but with little evidence from the Veneto region it casts doubt on the wreck’s origin.

The Ragusa ship, which sank in 1576 in Sudurad Bay on the island of Šipan, revealed 60 pottery sherds, identified as part of the ship’s equipment, and not the ship’s cargo (Kisić, 2006: 126, 140–21 pieces of *sgraffito* wares from Veneto). However, there exist cases where the pottery transported was traded in its own right, and not used on board. The Bisaga shipwreck, near the islands of Inoronata, for instance, has very specific pottery in association with a group of terracotta pipes (Brusić, 2006: 83, fig. 15) (Figs 3.17–18). This association is quite interesting, because if the pottery was (as shown in the image) represented by Küthaya coffee cups (from the Ottoman territory) Chinese porcelain (Brusić, 2006: fig. 16), it would correspond chronologically with the pipes (18th century). Furthermore, in this cargo, this would be a typical association of domestic supplies from the Ottoman world (Ward and Baram, 2006), of which we have ample evidence in settlement contexts on the mainland (e.g., Stari Bar excavations: Gelichi, 2006).

The last wreck which contained an appreciable amount of pottery was found near the Mljet (Sv Pavao), which is discussed in this volume. The ship was returning with a cargo of Iznik pottery and a fair amount of pottery associated with the equipment on board.

### Comparing pottery between land and sea: the Dalmatian – Albanian coast

The evidence from maritime archaeology (mainly shipwreck sites) reveals a report that would be interesting to compare with that from the sites of the mainland. This comparison is

interesting, in particular, for material relevant to the cargo, rather than to that assignable to the onboard equipment. Since I think that pottery was especially commercialized by sea, this comparison should yield similar results. However, it does not; in fact there are significant differences that we should try to explain.

A comparison between a recent and well excavated site (such as Stari Bar, Montenegro: Gelichi and Guštin, 2005; Gelichi, 2006; 2008) and the materials recovered from the Croatian shipwrecks represents a good example of these differences. In Stari Bar, the pottery imports from the 12th century to the Ottoman period represent the economic and commercial character of those areas over a long period. We see particular relationships with the area of Apulia (in the 13th and 14th centuries), then the Venetian area (14th–16th centuries), then the Balkans (17th–18th centuries), and finally international networks (19th century) (D'Amico, 2006; D'Amico and Fresia, 2008). The situation brought to light through the Stari Bar stratigraphy is not dissimilar from the pottery contexts of the Dalmatian–Albanian centres known today.

In the 13th century, Apulian *protomaioliche*, RMR (Ramina Manganese Rosso), archaic majolica from Marche and Romagna were circulating (Ratac, Montenegro: Zagarčanin, 2006; Split: Zglav-Martinac, 2004: 41–50). From the 14th century onwards, the pottery from Veneto (monochrome, painted and *sgraffito* wares: *spirale cerchio*, *San Bartolo*) started to be much more evident, while the Apulian imports of RMR and majolica from Marche and Romagna continued to circulate. From the 15th, and probably until the 17th and 18th centuries, the Venetian pottery (*sgraffito*, but also majolica) was the most common type (Butrint: Vroom, 2006; Durres: Metalla, 2006; Kotor, Montenegro: Križanac, 2006; Dubrovnik: Kovačić, 2006; Split: Grković and Lovrić, 2006; and Zglav-Martinac, 2004: 51–86; Zadar: Gusar, 2006). Contemporaneously, the majolica from Romagna, and a few products (in majolica) from central Italy (Deruta) or from southern Italian workshops (Abruzzo, Apulia) are well recorded. This trend in pottery consumption shows a political-economic framework, where Venice controlled the market, but imprinted its character at a social level. The tableware (glazed, tin-glazed and *sgraffito* vessels), which are documented along the entire eastern Adriatic coast (from Istria to Dalmatia), from the 13th century onwards, are in fact of Italian or Mediterranean manufacture.

At the moment we have a few scraps of evidence that some of these wares may have been produced in Istria and Dalmatia. This is testified, for example, by the presence of workshops producing *sgraffito* vessels during the 16th and 17th centuries in Pirano and S. Giovanni della Coronata near Umago (Guštin, 2004: 55–61), Capodistria (Cunja, 1989: 38, no. 77), Rovigno (Bradara, 2006a: 47–50; 2007), and finally on the island of Korčula, at the site of Curač-Goge in Žrnovska Banja (Zglav-Martinac 2006: 136).

In brief, the archaeological results at the moment seem to exclude the presence of potters on the Dalmatian–Albanian

coast producing fine tableware (glazed, slip and tin-glazed wares), even when this territory was controlled by Venice.

These coastal areas therefore did not develop pottery industries of any significance, if we exclude the coarseware and some types of *sgraffito* wares, except in a later phase in a small number of centres. If we compare the pottery recovered in the shipwrecks along the same coast with the evidence of the urban sites in the same territories it is evident that:

1. this comparison is impossible before the 16th century (in fact, no medieval shipwreck is currently known along the coasts of Dalmatia and Albania);
2. for the subsequent periods, when documentation appears, pottery is still rather rare in the ships, in particular that relevant to the cargoes, in contrast with the large quantities from archaeological sites;
3. the pottery types recovered in the shipwrecks do not always correspond with the pottery recovered in household contexts;
4. the pottery from the shipwrecks is generally for shipboard use, and not for trade (however this needs further verification from fully excavated and published cargoes).

We have demonstrated that it is unlikely that the same products were being produced on both shores of the Adriatic (due to the circulation of craftsmen rather than wares) except at specific a time (post-16th century), and in particular areas (Istria, Korčula). This is not surprising if we consider that certain craft activities are linked with specific conditions (in terms of economy, society, technology, resources), which are not reproduced automatically everywhere and over entire periods. Therefore, if in the late and post-medieval Adriatic the products circulated more than the craftsmen, it is instead strange to find little evidence of them in the known cargoes.

In conclusion I would like to provide some banal but useful observations. The first one refers to the research of the pottery in general; the second refers to the pottery from the shipwrecks.

The disparity, even if only in terms of quantity, of studies of the pottery of the western Adriatic, compared to the eastern side, is so evident that further comment is unnecessary.

This disparity makes a direct comparison between the two territories difficult. It needs to be considered in terms of both the quantitative and qualitative evidence. Good sequences and well-dated contexts exist; and we have qualitative data for the pottery from each site, so presenting selected vessels only is not sufficient.

The shipwreck pottery can be considered in the same way as the mainland finds. This stresses the point that there is no link between the evidence recovered from the shipwrecks and the material used on the mainland. Very few of the ships analysed seem to have transported pottery cargoes, or at least their cargoes were unremarkable in terms of quantity. In the shipwrecks with substantial

cargoes these are of eastern origin, which is not so evident on the mainland.

The study of the transport of pottery at present therefore seems to be addressed towards the commerce of rare exotic products, and not the more common 'Italian' pottery. However, it is premature to generalise this model, as the archaeological data are still quite scarce, and not sufficient to completely clarify the mechanisms through which the most common products (widespread along the coast) were circulating. A clearer example can be seen in Provence, where the pottery, even if in modest qualities, was transported and traded in its own right, and therefore the link between the contents of the shipwrecks and the archaeological contexts on the mainland is coherent. It may therefore not be the case that only exotic ceramics have been found as part of the ship's cargo. Their presence could be

related to the type of vessel, as in the case of *Mljet*, a ship of large tonnage and intended for international maritime trade (which is easier to detect archaeologically). It is very likely, however, that these Italian ceramics, so common along the coast, circulated through 'short' coastal navigation and, after all, in more limited quantities. This could make it more difficult, if not almost impossible at this time, to detect their presence in the evidence of underwater archaeology.

### *Note*

- 1 For depositional processes in shipwrecks and their correct interpretation see Beltrame, 1997; on the distinction between pottery as part of the crew's equipment or cargo, see Beltrame, 2002: 42; on stacking for transportation see Goddio *et al.*, 2002: 28–38.

## 3.2. Archaeological traces of Venetian navigation in the Mediterranean and Atlantic from the 16th and 18th centuries

Carlo Beltrame

### Abstract

*Dall'analisi dei relitti di navi veneziane emergono una serie di dati interessanti. Innanzitutto il numero di questi è nettamente superiore rispetto ai relitti di navi di altri stati italiani pre-unitari. La distribuzione dei naufragi inoltre è concentrata lungo la costa dalmata a differenza di quello che emerge dai documenti notarili relativi a questi disastri; questo dato può essere giustificato, almeno in parte, con le condizioni ambientali della costa italiana che possono aver sottratto i giacimenti alla vista. La ricorrente presenza di armi, anche in navi commerciali, può essere spiegata con la necessità di difesa dai pirati. I relitti si dimostrano spesso delle fonti più oggettive e di migliore qualità delle fonti scritte: ne è un esempio eccezionale il relitto di Gnalić. Questa considerazione però non può essere generalizzata; se osserviamo infatti gli altri relitti che hanno conservato, a differenza di questo, quasi esclusivamente oggetti in materiale poco deperibile, notiamo come la fonte archeologia sia piuttosto parziale e selettiva rispetto a quella scritta. Di tutte le merci deperibili menzionate negli atti notarili infatti non vi è traccia nei relitti che invece restituiscono perlopiù vetro e metalli semilavorati. Caso particolare poi è quello della ceramica che non è quasi mai presente nei relitti come carico e che d'altronde (anche se potrà apparire strano) non è neppure menzionata nei documenti.*

*Iz analiza mletačkih brodoloma doznajemo mnoštvo zanimljivih podataka. Kao prvo, njihov je broj puno veći od broja ostalih brodoloma u periodu prije ujedinjenja talijanskih država. Pozicije brodoloma koji se nalaze duž hrvatske obale uvelike se razlikuju od pozicija koju navode pisani dokumenti o brodskim nesrećama. Ova se činjenica može objasniti ambijentalnim uvjetima na talijanskoj obali koji otežavaju pronalazak nalazišta. Čest nalaz broskog naoružanja, pa i na trgovačkim brodovima, može se objasniti potrebom za obranom od gusara. Brodolomi su češće mnogo objektivniji i bolji izvori informacija od pisanih dokumenata kao što se vidi iz brodoloma kod Gnalića. Ipak, takvo se razmatranje ne može generalizirati. Ako pogledamo druge brodolome na kojima su očuvani samo predmeti koji nisu podložni propadanju možemo reći da je arheološki izvor nepotpun i nemjerljiv s kvalitetom pisanog izvora. Materijalna dobra podložna propadanju a koja su navedena u pisanim izvorima ponekad nije moguće naći na olupinama brodova. Na njima uglavnom možemo pronaći staklo te metalne poluproizvode. Nalazi keramike predstavljaju poseban slučaj budući da su rijetko bili dio broskog tereta te jer nisu navedeni u pisanim izvorima, što je vrlo zanimljiva činjenica.*

### Introduction

An investigation of the evidence for Venetian shipwrecks, both from publications and from unpublished new discoveries, has allowed us to identify 18 sites.<sup>1</sup> They are distributed along the trading routes of the Serenissima Republic (Fig. 3.19). Starting from Venice, where we

find the Malamocco 1 and Malamocco 2 shipwrecks in the central harbour entrance of the lagoon, we move to the Dalmatian coast where we find the Gnalić shipwreck. Continuing along the Croatian coast we come to the Mljet, Koločep and Palagruža island shipwrecks.

In the eastern Mediterranean, we have recorded

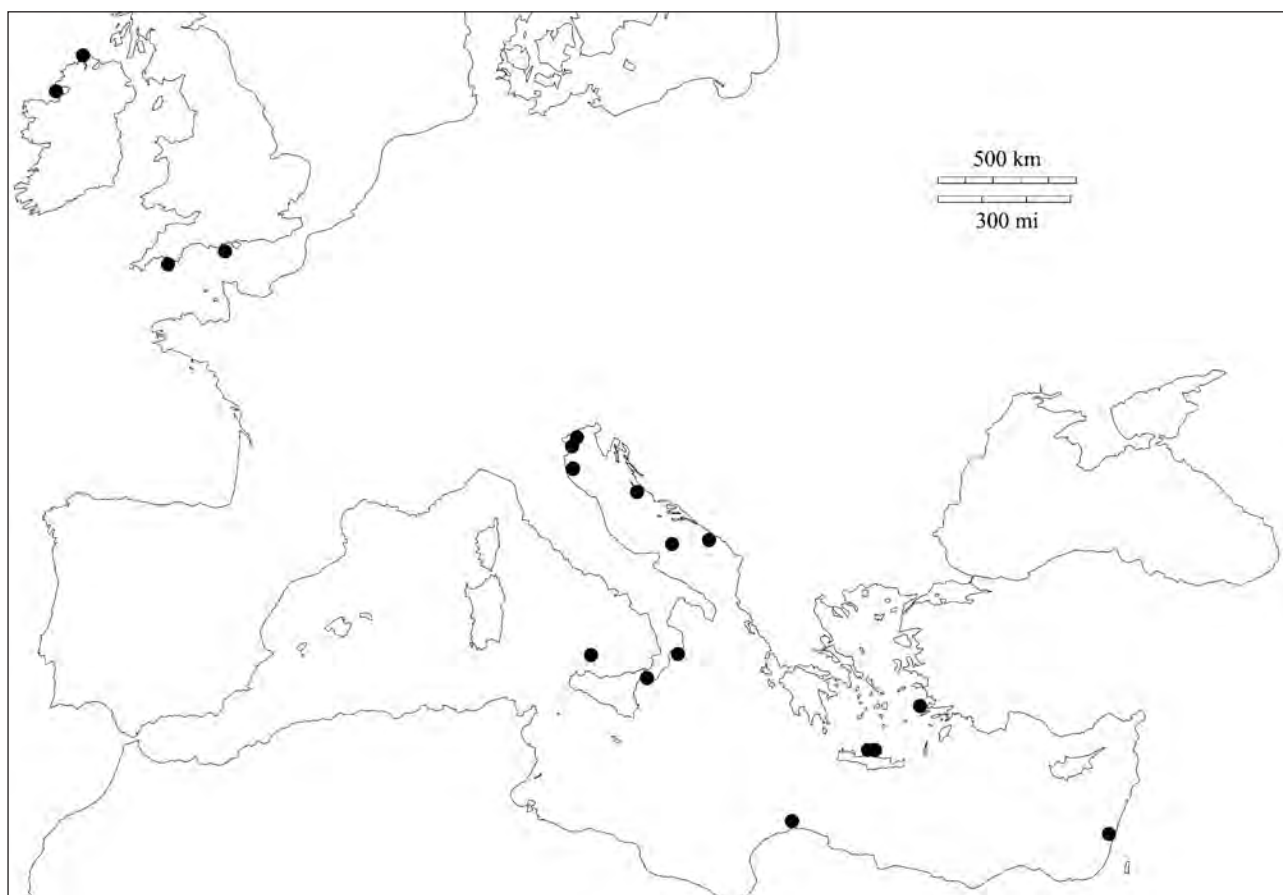


Fig. 3.19. Locations of shipwrecks of Venetian ships



Fig. 3.20. Wooden and iron chest from the Gnalić wreck in the museum of Biograd (photo: the author)

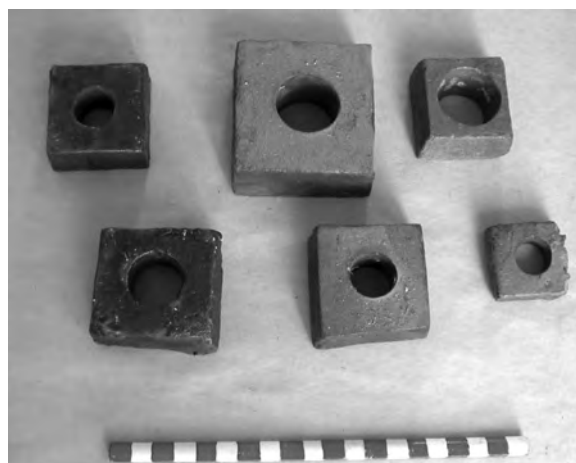


Fig. 3.21. Brass coaks of various sizes from wooden pulleys of blocks from the shipwreck of Gnalić (photo: the author)

presumed shipwrecks off Haifa in Israel, Dia island and Candia in Crete, and Symi island in Greece. However, if we go back along the Italian coast, we may add as evidence the guns found near Crotone in Calabria, the wreck of Torre Faro of Messina and the wreck of Capo Graziano on Filicudi island in Sicily. Along the Libyan coast of Cyrene, an Italian team has also documented the shipwreck of what

was presumed to be the Venetian vessel *Tigre*, sunk in 1705 (see further in this contribution).

It is curious how many shipwrecks of Venetian ships are present in the Atlantic Ocean, along the coasts of Great Britain and Ireland. In the south of England we can mention the Teignmouth and the (presumed) Isle of Wight shipwrecks while, further north, there are more shipwrecks



Fig. 3.22. Stem glasses in the Koločep wreck (photo: D. Della Libera)



Fig. 3.25. Window panels still loaded in lines, in the Koločep wreck (photo: D. Della Libera)



Fig. 3.23. Glass lid with solid finial and dome decorated from the Koločep wreck (photo: D. Della Libera)



Fig. 3.26. Window panels still loaded in lines, in the Koločep wreck (photo: D. Della Libera)



Fig. 3.24. Glass bottle from the Koločep wreck (photo: D. Della Libera)



Fig. 3.27. Copper sheets in the Koločep wreck (photo: D. Della Libera)

associated with the Spanish Armada. These include the *Balancera*, better known as *Trinidad Valencera*, which was wrecked in Kinnagoe Bay, and the *Labia*, sunk in the Sligo bay, both in Ireland. It must be clear, as we shall see, that not all of these wrecks can be identified with certainty as being Venetian, and not all the discoveries, which often



Fig. 3.28. Copper wire in the Koločep wreck (photo: D. Della Libera)



Fig. 3.29. Copper sheet reel in the Koločep wreck (photo: D. Della Libera)



Fig. 3.30. Copper sheet roll in the Koločep wreck (photo: D. Della Libera)



Fig. 3.31. Cluster of completely concreted iron shovels (photo: D. Della Libera)

consist only of isolated guns, can be linked with certainty to shipwrecks (Beltrame, 2011).<sup>2</sup>

## Venetian shipwrecks

### *Malamocco wreck 1 (“Glass wreck”)*

The so-called “Glass wreck” was found in the 1980s just north of the entrance of the harbour of Malamocco; amateur divers made the first surveys and recoveries (Molino *et al.*, 1986). Other surveys, organised by the Archaeological Soprintendenza of the Veneto Region, allowed the recovery of many objects belonging to at least two overlapping

wrecks (D’Agostino, 1995–1996). One of the wrecks contained many raw glass blocks made using natron, a raw material for glass in Roman times. Close by were a number of tubs of iron slag, a stone weight for a scale similar to other weights of the Roman period, a small iron anchor, a small bronze statue of Hercules, a base of another statue, and a fragment of cornice made with limestone from Istria (Beltrame, 1993: 42; 2002: 39).<sup>3</sup>

Other objects, such as many iron tools, axes (and not “adzes” as has been written), two iron anchors, two very similar hammered iron swivel breech-loader guns (*petriere da mascolo*) – which, because of the recovery of a *cugno* belonging to a *petriera da braga*, had to be at least three

items (Beltrame, 2011)<sup>4</sup> – fragments of unrecognised pottery indeed would belong to another wreck dating to the 16th or the beginning of the 17th century.

### ***Malamocco wreck 2 (“Gun wreck”)***

The so called “Gun wreck” was found to the south of the harbour entrance of Malamocco. It was discovered and investigated, in 2005 and 2006, by a team from the *Consorzio Venezia Nuova* during the building of the MOSE system. The vessel sank on a sandbank while attempting to enter the harbour (D’Agostino *et al.*, 2010).<sup>5</sup>

The shipwreck can be dated between the end of the 17th and the beginning of the 18th century. It contained four cast iron guns of English and Venetian production, a bronze *mascolo*, decorated with a lion, of a Venetian *petriera*, and many precious objects, such as 94 pewter plates, three bronze mortars, a bell, and a miniature gun. Other items found are carpenter’s tools, various objects from the galley, portable arms, cannonballs, objects belonging to the crew, and many items of naval equipment. These finds were contained in a quite well-preserved hull more than 40 m long (D’Agostino *et al.*, 2010; Morin, 2011). Probably, as demonstrated by archival research by M. Minini (pers. inf. Martina Minini), this is the shipwreck of the *Croce Rossa*, a First Rate vessel built in the *Arsenale* and sunk off *S. Piero* (the entrance of the harbour of Malamocco) in 1715.

### **Gnalić shipwreck**

The site excavated near the small island of Gnalić, south of Biograd, is one of the most impressive shipwrecks of the Mediterranean, both in the number and quality of the objects, and also the well-preserved condition of the artefacts. Although it has been interpreted as a Venetian galley, we have demonstrated that it must have been a round ship, about 40 m long. The type of anchors, the type of cargo, the thickness of the frames, together with the types of artillery recovered, are all proof of this identification (Beltrame, 2006).

The cargo was composed mainly of thousands of beautiful glass vessels, window panes, mirrors and partially worked metals (Lazar and Willmott, 2006). The ship also carried brass sheet, brass wire and lead ingots in wooden barrels. Hundreds of pairs of spectacles, razors and parts of chandeliers, perhaps made in Lubeck, were also part of the cargo (Stadler, 2006). Damask and linen shirts were found in a chest (Fig. 3.20) (Davanzo Poli, 2006). The rich list of artefacts recovered included objects from the ship’s equipment (Fig. 3.21) and other items illustrating commercial activities and life aboard.

The artillery consisted of eight pieces. There are two bronze culverin-sakers (*sacri colubrinati*) cast in 1582 by Zuane Alberghetti II. The ship carried also three bronze *petriere da braga* and a bronze *moschetto* with a curious coat of arms. The last two pieces are two bronze minions

of possible French origin (Petricioli, 1970; Morin, 2006a; Beltrame and Morin, 2014).

All the artillery from Gnalić had to be for private customers because of the absence of the winged lion and the ‘X’ symbol of the *Consiglio dei Dieci* magistracy, symbols usually found on guns cast for the state until 1588–1589. The ordnance would suggest that the ship sank at the end of the 16th century.

### **Mljet (Sveti Pavao shallow) shipwreck**

This shipwreck is fully presented in this volume.

### **Koločep-Dubrovnik shipwreck**

The ship wrecked near the small island of Koločep was probably trying to enter the harbour of Ragusa, the ancient port of Dubrovnik. It carried many types of vessels and objects of glass of possible Venetian production (Figs 3.22–24; Radić Rossi, 2006). These items were found together with various kinds of pottery from the western Mediterranean, and some pieces of Venetian production, which now belong to a private collection, and which date the site to the beginning of the 17th century (see Gelichi’s contribution in this volume).

On the site, we have documented the presence of hundreds of window panels still loaded in at least seven lines (Figs 3.25–26), copper sheets (Fig. 3.27), copper wire matters (Fig. 3.28), copper sheet in reels (Fig. 3.29) and rolls (Fig. 3.30), and a cluster of completely concreted iron shovels (Figs 3.31–32).<sup>6</sup> Three iron guns lie on the seabed, but, because they are encased in concretion, it has been not possible to identify them.<sup>7</sup>

*Amateur* divers have recovered some metal objects, such as a candelabrum, and a bronze *petriera da mascolo* of a possible Venetian type (Beltrame, 2011). Some glass grenades have also been found. Although both part of the goods and the *petriera* could be Venetian, we cannot be sure that the ship also belonged to the *Serenissima* because most of the pottery did not.

### **Palagruža wreck**

In the water of the island of Palagruža, near the isle of Vis, two bronze guns have been recovered from an unexplored shipwreck. One gun bears a coat of arms of the Gritti family of Venice and the initials “AL” and “G”. The other initials “CA”, together with the style of decoration, would indicate that the gun was made by the founder Camillo Alberghetti, who died in Venice before 1528.

The second gun bears the same coat of arms of the Gritti family, but the initials “TC” of Tomaso di Conti who produced artillery in Venice till 1540. Because of the period of activity of the two founders, the initials “AL” and “G” could belong to the famous and wealthy merchant Alvise Gritti, son of the Doge Andrea (Beltrame, 2011).

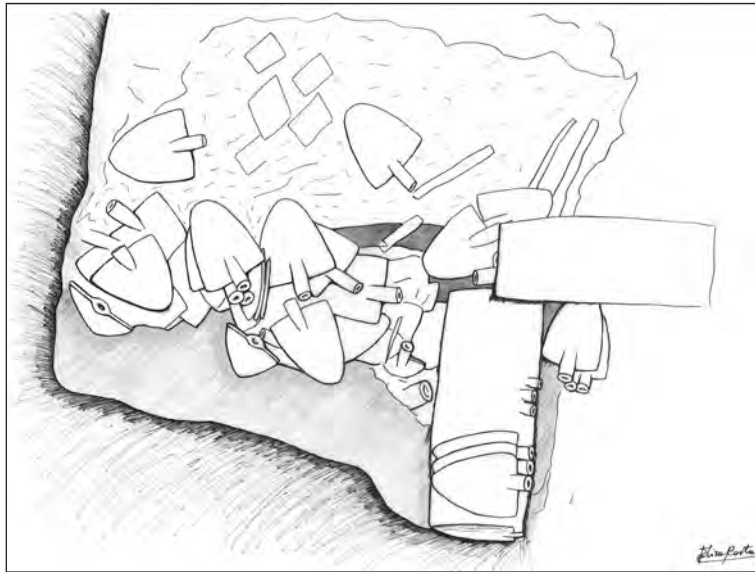


Fig. 3.32. Cluster of completely concreted iron shovels (drawing: E. Costa)

### Haifa shipwreck

In 1973, on the beach of Haifa, a fisherman recovered two bronze sakers (Roth, 1989a). The initials “ZA”, and the style of the decorations allow us to attribute one of them to Zuane Alberghetti II, who was active till 1586 when he was sent to the galleys (Beltrame, 2011; Morin, 1983).<sup>8</sup> The second cannon presents almost all Venetian characteristics (morphology, decorations, style of the engraved numbers indicating the weight in *libbre grosse alla veneziana*), but also two details which are not Venetian: these are the two dolphins, which are never present on ordnance produced by the Serenissima, and a coat of arms which, apparently, does not represent a known Venetian family. It is possible that this second gun, which when recovered conserved traces of the wooden carriage, was produced by a Venetian founder for a foreign merchant, or for a Venetian merchant of the eastern Mediterranean (Crete, Cyprus?). Recently, the site of discovery of the two cannons has yielded another, probably a falcon, which clearly shows Venetian morphology (pers. comm. E. Galili and R.G. Ridella, 2013).

### Symi wreck

In the 1860s, off the island of Symi, some bronze guns (*aspidi* and possibly a *colubrina*) and some bronze *petriere da mascolo* were recovered by sponge divers (Hewitt, 1871). An *aspide* and three *petriere* are now conserved in the Woolwich Military Museum in England. The Venetian state production is indicated by the winged lion in *moeca* (that is in frontal position). This detail and the possible presence of a *colubrina* suggest that the ship could have been a Venetian galley, which the aspect of the *aspide* would date perhaps to the first half of 17th century (Beltrame, 2011).

### Dia wreck

In 1976, a French mission directed by A. Falco, recovered two bronze *petriere da mascolo* near the isle of Dia, north of Candia, which probably belonged to a private cargo ship. They are no longer available (Grousset, 1994).

### Candia falconi

Off Candia (Heraklion), in Crete, we have evidence of the presence of a galley of the 16th century documented by three bronze *falconi* (Beltrame, 2013).

### Crotone wreck

On the bottom of the sea off the Tonnara site, between Capo Colonna and the city of Crotone, two bronze *falconetti*, one *petriera da mascolo* and an exploded Ottoman gun have been recovered. The pieces are now displayed in the civic museum of Crotone.

On the chase the *falconetti* show the Lion in *moeca*, the X belonging to the Council of the Ten and the monogram “MC” is of Marco di Conti I, active in the Arsenale between 1524 and 1567.

The long *petriera da mascolo* with the *mascolo* is not Venetian. The Ottoman bronze gun with an Arabic inscription could be evidence of a fight between a Christian and an Ottoman ship west of Capo Colonna. The lion and the “X” suggest that the two *falconetti* could have belonged to a galley (Beltrame, 2011).

### Torre Faro of Messina wreck

Along the coast of Torre Faro near Messina, many objects

belonging to a shipwreck of the 16th or 17th century have been recovered (Musolino, 1994).

The artillery was composed of two bronze and iron *petriere da braga*, one bronze *mascolo* and 15 pieces of stone and iron shot. The presence of other finds of probable Venetian origin, such as a stiletto handle in the shape of one of the two columns of Saint Mark's Square in Venice, suggest that this was a Venetian ship. A fragment of a helm, a steelyard, an Ottoman coin, a sounding lead, and some nails are among the other finds recovered from the site (Scordato, 2011).

### Capo Graziano, Filicudi wreck

Some objects recovered from the site of Capo Graziano, in the island of Filicudi, have been attributed to the shipwreck of a Spanish ship of the 18th century (Kapitän, 1985). The assemblage consisted of common pottery, a copper cauldron, some bricks and a millstone, but it is possible that some anchors were left *in situ*.

The bronze *falconetto* and two bronze *petriere da braga*, on display at the Archaeological Museum of Lipari, were cast by the founder Niccolò II di Conti, who was active in the second half of the 16th century (Beltrame, 2011).

### The wreck of the *Tigre* (in Cyrenaica)

The *Tigre* was intentionally sunk by her captain on 7th April 1705 to avoid being captured by enemies along the coast of Cyrene, in Libya. According to the written sources, the ship carried 48 bronze guns, 12 swivel guns and 22 iron guns. Venetian iron guns and a bronze *mascolo* found at the site of a shipwreck off Ras al-Hilal, in Cyrenaica, convinced Tusa that this is the site of the sinking of the *Tigre*. A few other objects were recovered, among them items worthy of note, including scissors, pewter dishes, a teapot, candelabra, objects connected with the rigging, a steelyard, and fragments of at least two bronze bells with Christian iconography (Tusa, 2011). We can say that this interpretation is wrong because one of the iron cannons, recovered and cleaned, is marked "CB", which means that it was made by the well-known founder Carlo Camozzi of Bergamo who began his activity for the Republic at Clanezzo not before 1714 (Lanfranchi, 1958: 296), at least nine years after the shipwreck (Beltrame and Morin, 2014).

### Teignmouth (Devon, UK), Church Rocks wreck

In the south of England, at Teignmouth, from 1975 to 1995, a group of sports divers excavated a site and recovered hundreds of artefacts relating to life aboard the ship and the equipment of the vessel. A fragment of majolica pottery, two fragments of china, a steelyard weight with an engraved Venetian lion, various elements of naval equipment, and

some metal items are among the objects from the site. Evidence of the ship, such as elements for the defence of the ship, was also present. The artillery was composed of a bronze *saker* with the monogram "SA" and a shield showing a lion rampant and a wheel. While of course the wheel must belong to the Venetian Molin family, we can only suppose that the lion belonged to the Badoer family (Preece and Burton, 1993; Wilson, 1993; Preece, 2004).

The same monogram "SA", belonging to the founder Sigismondo Alberghetti, is on two bronze *falconetti*, one of which was still attached to a fragment of the carriage. It is probable that the guns were made by Sigismondo II, active perhaps from 1566 to 1610. A bronze *petriera da braga* was also recovered from the site (Beltrame, 2011).

### Isle of Wight (Yarmouth Roads) presumed wreck

Another bronze *falconetto*, with a fragment of its carriage still preserved, has been found off the Isle of Wight, at Yarmouth Roads (Tomalin *et al.*, 1988; Watson and Gale, 1990). The monograms "ZA" and the style suggest it was more likely to have been cast by Zuane Alberghetti II than Zuane Alberghetti I (Beltrame, 2011). The gun could be associated with a shipwreck under preliminary investigation, which also contains northern Italian pottery (Advisory Committee on Historic Wreck Sites, 2005).

### The shipwreck of the *Balancera* (Donegal, North Ireland)

The *Balancera* or *Balanzera* took part in the expedition of the Spanish Armada in the Levant Squadron after Phillip II commandeered it at Lisbon, along with the *Labia*, and the *Ragazzona*, which sank off Corunna in December 1588. The *Balancera*, rated 1100 tons, was possibly owned by Alvise Balancer, a merchant who was active at the end of the 16th century. The ship was re-named *Trinidad Valencera* by the Spaniards (Beltrame, 2011).

The *Balancera*, which was probably wrecked on 14 September 1588 in Kinnagoe Bay in Ireland, was excavated in the 1970s by Martin, who published some preliminary reports on these investigations (Martin, 1979).

When she was at Lisbon, the ship was completely emptied of cargo in order to accommodate Spanish guns and soldiers, and for this reason the majority of the finds recovered during the excavation were of Spanish origin. These included a goatskin wine-bag, Merida type glazed earthenware, and a wooden lantern.

Elements of the ship's equipment (such as two iron anchors and some parts of the rigging), objects related to life aboard, a wooden gunner's rule, and four pieces of ordnance were the only Venetian finds. The ordnance was composed of a bronze *saker*, a bronze *culverin*, a bronze *falcon* and a bronze *petriera da braga* (Martin, 1979; 1997).

### The wreck of the *Labia* (Sligo bay, Ireland)

Rated 728 tons, the *Lavia* or *Labia*, which was named after the family of the rich merchant Paolo Antonio Labia, sank in Sligo Bay in Ireland on 25 September 1588. The wreck has been the subject of a non-disturbance survey by an English team. From the site, a bronze *petriera da braga* has been recovered. The eagle on its coat of arms is the symbol of the Labia family. Two probably bronze guns with their carriages, perfectly preserved, have been left *in situ*, and are waiting for research to resume on this very promising site (Birch and McElvogue, 1999; McElvogue, 2002; Birch, 2004). The results of the non-disturbance survey show that the wreck probably lies under 1 m of sand in only 2 m of water (Birch, 2004).

\*\*\*

Finally, we want to include in this list other two pieces of evidence.

A bronze 12-pound *aspide* of Venetian manufacture, 206 cm long, which, because of the absence of the winged lion, we can say was owned by a privateer, and, because of the morphology could be dated to the second half of the 16th or the beginning of the 17th centuries.<sup>9</sup> The gun, which was recovered in 2009 off Porto Garibaldi (Ferrara) by a fishing trawler, seems still to be loaded.

A possible shipwreck lies in the shallow waters at Torre Santa Sabina (Brindisi), where a preliminary investigation has recovered a Venetian coin of 1585–1595 and some iron helmets (*morioni*) in the Venetian style.<sup>10</sup>

### Conclusions

Summarising this brief overview of the available documentation of Venetian shipwrecks, the first observation we can make is about the impressive quantity of evidence compared to the information available about the shipwrecks of other Italian states. This result can only be partially explained by the comparatively greater attention that the Venetian shipwrecks have recently received in research, and is of course archaeological evidence of the widespread presence of the ships of the Serenissima in the Mediterranean – and also in the Atlantic Ocean – which is well known thanks to rich written documentation.

The second observation we can make is that Venetian ships are attested in the Adriatic, in the central Mediterranean, and in the Atlantic during a quite limited period: between the second half of the 16th century and the first 20 years of the 17th century. The shipwrecks found in Libya and that of the *Croce Rossa*, sunk in the 18th century, are the only exceptions.

Considering that much of the ordnance from the shipwrecks does not bear the image of the lion, the symbol of Venetian government ownership, it seems that more than half of the Venetian shipwrecks fall into the category of private round ships. Among the shipwrecks, evidence of guns made for the State – that is, with the image of the

lion – comes from Candia, Crotone, Symi, Libya and the *Croce Rossa* ship. The ordnance suggests identifying the first three shipwrecks as *galee*; that is, military ships.

The relatively limited number of commercial cargoes could be caused by the processes of degradation of organic goods and wooden containers: the only shipwrecks conserving many finds that could be identified as cargo have been found off the Croatian coast. If we compare Tenenti's (1959, pl. v) map of the localities of the shipwrecks documented by the notary sources, between 1592 and 1609, we can recognise a balanced distribution among the Italian and the Croatian littorals. The almost total absence – registered till now – of Venetian shipwrecks along the Italian coast, except in the area off Venice (and the isolated find "fished" off Porto Garibaldi) can easily be explained by the sandy morphology and the dark colour of the sea, which do not offer much chance for the discovery of shipwrecks of any period. In any case, the sites located off Venice are relatively few in comparison to the great number which Tenenti indicates in this zone.

The absence of finds off the western coasts of Greece can be explained by the rarity of reports of shipwrecks of any period (Parker, 1992).

The presence of ordnance in all the wrecks of private ships can be justified both by the survival and the visibility of these objects under water, and by the danger of attacks by pirates. We must consider indeed that, at least at the end of the 16th century, one loss of Venetian ships in every four was due to pirates (Tenenti, 1959: 27–45).

Of course, these are only preliminary considerations, which must be strengthened by much more archaeological information. Actually, the data are still limited and the evidence is often of quite poor quality. Indeed only in a few cases these maritime contexts have been investigated in a scientific way. Often, in fact, they have been compromised by treasure hunters or *amateur* 'archaeologists', while the complete excavation of a site is very rare.

A new and scientific approach to this kind of archaeological evidence would allow us to write new stories about all the aspects of navigation in the late Middle Ages and beyond: aspects which, until now, are known only from written and iconographic sources. Both the remains of the hulls and the elements of equipment and ordnance are precious evidence for writing a history of the construction of these vessels, and of contemporary navigation and military technology.

The archaeological information from a shipwreck is of course less selective than from a land site, which often forms as a result of dumping refuse. This characteristic puts the maritime archaeological source in a stronger position, both compared to the traditional archaeological source, and especially to the written source. When we analyse a shipwreck, in contrast to maritime archaeological sites, written sources can often be very incomplete, less objective, and on some issues, completely uninformative. Written documents often consist of official documents that, as well demonstrated by Martin (2001), did not always correspond

to reality because, for example, of undeclared merchandise. More often, the written records give us only partial and generic information about the goods carried aboard.

Sometimes maritime archaeology can offer us complete and frozen naval contexts with a minimum process of selection caused by natural formation processes. The Gnalić shipwreck and the Mljet site are wonderful examples. These sites have preserved a good part of the hull, part of the equipment, many personal belongings of the crew, a good part of the cargo, and also organic material (at least in the case of the Gnalić shipwreck). Sites like these are able to offer us information that probably no written document could give. What in the best 16th century index of goods conserved in the archives would consist of a generic list of the main goods “officially” carried in the ship (which, in this case, would be described generically as “glass, window panels and metal”) here is an almost complete panorama of the objects carried in a vessel of that period.

We must consider that this qualitative superiority of the archaeological approach over the traditional sources, in the analysis of a shipwreck, may not, at least until now, be transferred to a generic scale. This is evident when reviewing Tenenti’s work, which, although limited to a period of 17 years, can offer a sample of the potential of the archival documents for the knowledge of trade. The typologies of the main goods carried on the Venetian ships do not match the items found in the shipwrecks in the sea off Croatia. The great quantities of glass vessels, mirrors, glass panels<sup>11</sup> and raw metals (especially copper sheet and wire) found in these sites are of course only a selection of the goods transported which, according to the notary acts, were composed mainly of perishable goods, such as barrels of wine, sacks of wheat, cotton and clothes.<sup>12</sup> The items from the shipwrecks indeed are not the goods most frequently appearing in the documents. On the contrary, it is interesting to note that the discovery under the sea of very few pottery items quite well reflects the almost total absence of these objects in the notary documents. This inclines the author to support Sauro Gelichi’s opinion both that the pottery found in these shipwrecks belonged to the galley and not to the cargo; and that the only listed cargo, also if relatively small, of Iznik pottery of Mljet, was perhaps not the main cargo of the ship.

In conclusion, the potential of an archaeological approach for the reconstruction of the navigation and routes of Venetian ships is obvious, and will be of course improved by future investigations. However, aspects such as the geographical distribution of the shipwrecks and the commerce of perishable goods will still have to be supported by archival documents to arrive at an objective reconstruction.

## Notes

- 1 From this index we exclude military ships, such as the Venetian galleys from Lake Garda (Capulli, 2003) and the lagoon of Venice (*La galea ritrovata*, 2002), because only their hulls and a few elements of their equipment are preserved. These two long ships are indeed interesting mainly for the study of ship construction, since they represent unique examples for the knowledge of the methods of building galleys during the Middle Ages and Renaissance. We exclude also the flat-bottom boat of the *rascona* type, reused near the galley in the site of San Marco in Boccalama, in the Venetian lagoon. In the case of this vessel, only the hull is present, and it belongs to the history of inland navigation in the 14th century; a very interesting subject, but beyond the scope of our theme of maritime navigation.
- 2 Recently a team of Spanish archaeologists has reported the discovery of the shipwreck of the *Ragazzona*, the large Venetian merchant ship which commanded, with the other two vessels, the eastern squadron of the *Armada*, and which sank off Corunna (in *Il Venerdì di Repubblica*, 3 May 2013). Unfortunately this is another mistake because the iron cannon, which have been discovered in the site, are not compatible with the Venetian ship.
- 3 Recently D’Agostino (2008) has moved the dating of a brass emblem of a spear from the Ottoman period to the Roman period. The dating of the statue of Hercules to the 2nd–3rd century AD, as proposed by first excavators of the site (Molino *et al.*, 1986: 188–189), coincides with the probable date of the iron anchor, and so of the entire context.
- 4 One of the *petriere da mascolo* has been restored and is now displayed in the Museo della Laguna di Chioggia, while the second *petriera*, after restoration, is now abandoned in critical condition in a storehouse of the local Soprintendenza in the island of the Lazzareto Nuovo in the lagoon of Venice.
- 5 Despite the great importance of this shipwreck its study and its publication are still at a very preliminary level, and no plan of the site is available.
- 6 The site, which has been looted over a long time in 2009, has been surveyed by the author and Irena Radić during the Unesco project “Educational Programme in Nautical Archaeology and History of Navigation”.
- 7 Against our advice, one of the cannon has been recovered and transported to Dubrovnik. Because its process of conservation and cleaning from the concretions has not still begun, this weapon cannot yet tell us more than when it was underwater in its safe environment.
- 8 The cannon is still in private possession.
- 9 On the base ring the numbers 1235, indicating the Venetian *libbre grosse*, are engraved. A description of the gun, hosted in the official web site of the *Soprintendenza per i Beni Archeologici dell’Emilia Romagna* contains many mistakes which have been reviewed by R.G. Ridella in [www.daringtodo.com/lang/it/2011/09/08/porto-garibaldi-uncannone-veneziano-in-capitaneria/](http://www.daringtodo.com/lang/it/2011/09/08/porto-garibaldi-uncannone-veneziano-in-capitaneria/).
- 10 Pers. comm. Maurizio di Bartolo.
- 11 Glass panels have been found in the Gnalić, Koločep and Drevine shipwrecks. This last lies north of Koločep island. Glass panels, copper sheet and copper wire have been found also in the Korčula island and in the Studenac bay (Biševo island) shipwrecks (Gluščević, 2006 and references), which we do not know if they were Venetian.
- 12 The other main goods transported included: biscuits, wax, iron nails, ropes, leather, damask, cheese, oil, raisins, soap, silk and sugar (Tenenti, 1959: 633–641), almost all of which are perishable.

### 4.1. The ship, its equipment and the crew's personal possessions

Carlo Beltrame

#### Abstract

*I resti dello scafo messi in luce e documentati, da una batimetria che va dai 39 m in giù, sono lunghi 6 m e larghi 3,7 m. Lo scavo ha messo a nudo la sentina della nave con buona parte della scassa per l'alloggiamento dell'albero. Lo scafo è costituito da un doppio strato di fasciame esterno di pino sicuramente non interpretabile come "fasciame sacrificale" bensì come componente strutturale. Si tratta di una soluzione tecnica tipica delle navi impegnate in lunghe traversate in mari caldi quali quelle che compiva la flotta della Compagnia delle Indie. Questo ritrovamento dimostra quindi per la prima volta il suo uso anche all'interno del Mediterraneo. Il sistema di giunzione tra corbe e forcami e l'uso di legni, quali il pino e l'olmo, sono indizi, anche se non prove, a sostegno dell'ipotesi di un'origine veneziana della nave. La lunghezza ipotizzabile dello scafo completo è di oltre 24 m. Dell'attrezzatura sono state rinvenute tre ancore in ferro, tre bigotte in legno con foro quadrato, due lande in ferro ed una boccola in lega di rame proveniente da una puleggia di bozzello, nonché la campana in bronzo. I soli effetti personali dell'equipaggio sono rappresentati da un pettine, una cote, due manici di coltelli ed una perla di vetro.*

*Ostaci brodskog trupa otkriveni i dokumentirani na dubini od 39 metara dugački su 6 metara i široki 3.7 metara. Istraživanje je otkrilo dno broda i veći dio postolja jarbola. Trup je sastavljen od dvostrukog sloja vanjske oplata od borovine koji ne treba interpretirati kao "sacrificial planking" nego kao strukturalnu komponentu broda. Takva se dodatna oplata stavljala na trup broda kako bi ga zaštitila od propadanja budući da je vanjsku oplatu bilo lakše zamijeniti. Riječ je o tehničkom rješenju tipičnom za brodove duge plovidbe u toplim morima koje se može vidjeti i na brodovima Nizozemske istočno-indijske kompanije (VOC). Ovaj je pronalazak prvi put pokazao upotrebu ove tehnike i u vodama Mediterana. Tehnika spajanja rebra i rebra s uzvojnim dijelom i upotreba drva kao što su borovina, jasen ili grab pokazuju da je moguća, ali ne ujedno i dokazana, pretpostavka o mletačkom porijeklu broda. Pretpostavljena dužina cjelokupnog trupa iznosi 24 metra. Brodska je oprema zastupljena nalazom triju sidara, triju drvenih kolotura s kvadratnom rupom, željezne šipke, mjedenog kvadratnog dosjeda koji pripada koloturu te brončanog zvona. Jedini nalazi kojima se može pripisati osobni predznak su češalj, kameni brus, dvije drške noža i staklena perla.*

#### The hull

The wooden remains lie a few metres east of the scattered cargo, on the sloping seabed, 38.5–41 m deep (Plan 1). In the upper part they are covered by a thin layer of sand which, at the depth of 39.5 m, becomes thicker and mixed with ballast stones (Fig. 4.1). According to analysis by Lorenzo Lazzarini, of the *Laboratorio di Analisi dei Materiali Antichi* of the *Università IUAV di Architettura* of

Venice, the ballast was composed of pebbles of calcarenite and blocks of sandstone. After exposure of the upper part in 2010, the excavation was extended deeper in 2011, revealing the hull over a length of 6 m and a width of 3.7 m (Fig. 4.2). Actually we do not know how much of the hull is preserved to the south in deeper water, although it probably continues for some metres.

Because of the limited time allowed on the seabed

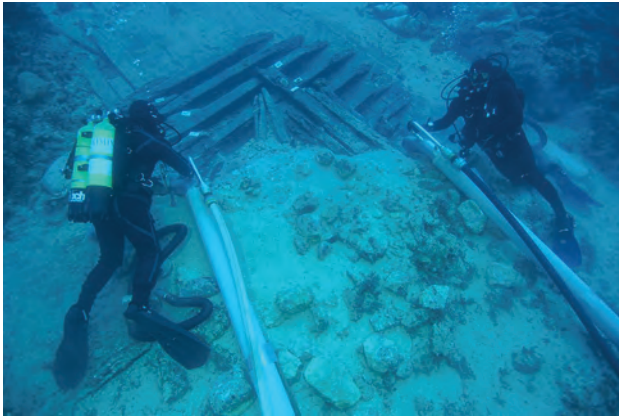


Fig. 4.1. Excavating the hull. The ballast stone is at the bottom (photo: R. Moskovčić, HRZ archive)

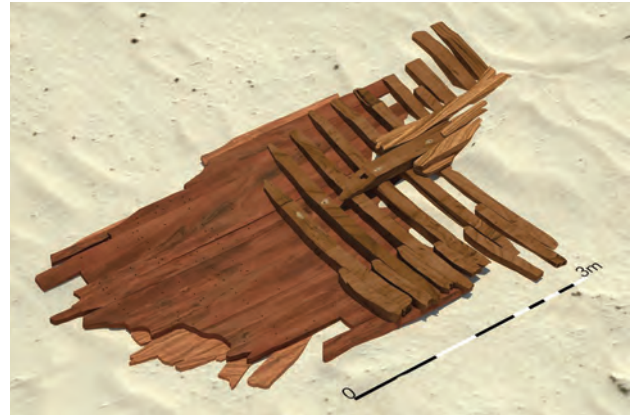


Fig. 4.4. 3-D model of the hull (drawing by E. Costa)

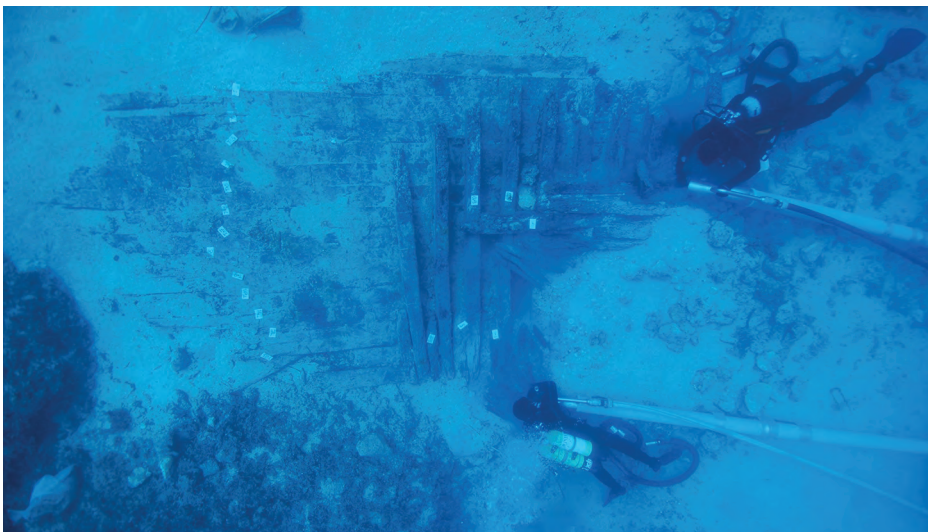


Fig. 4.2. (left) Excavating the hull. The ballast stone is at the bottom (photo: R. Moskovčić, HRZ archive)

Fig. 4.3. (below) Plan of the hull (drawing by C. Alfonso and C. Beltrame)

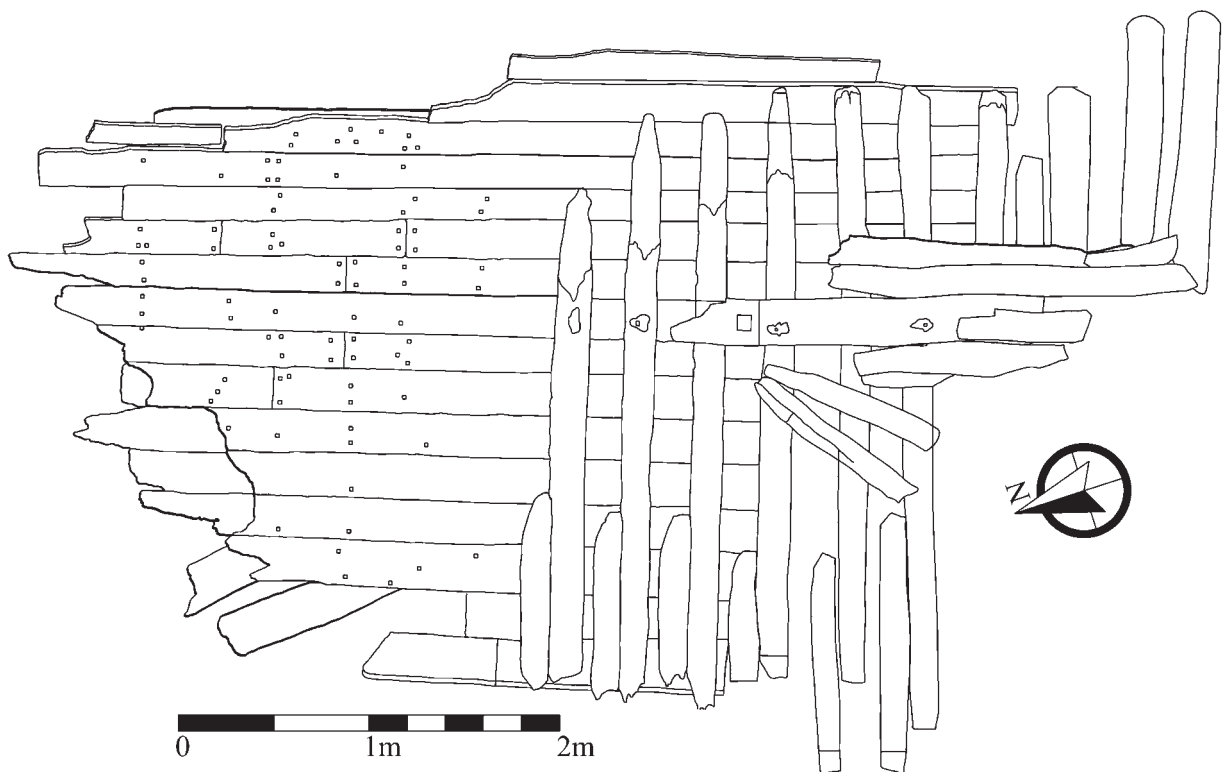




Fig. 4.5. Detail of the double external planking (photo: D. Della Libera)



Fig. 4.6. Floor timbers and futtocks on the western side (photo: R. Mosković, HRZ archive)



Fig. 4.7. Detail of the joint between floor timber 1 (corba) and its futtock (forcame) (photo: C. Beltrame)



Fig. 4.8. The keelson from the eastern side (photo: R. Mosković, HRZ archive)

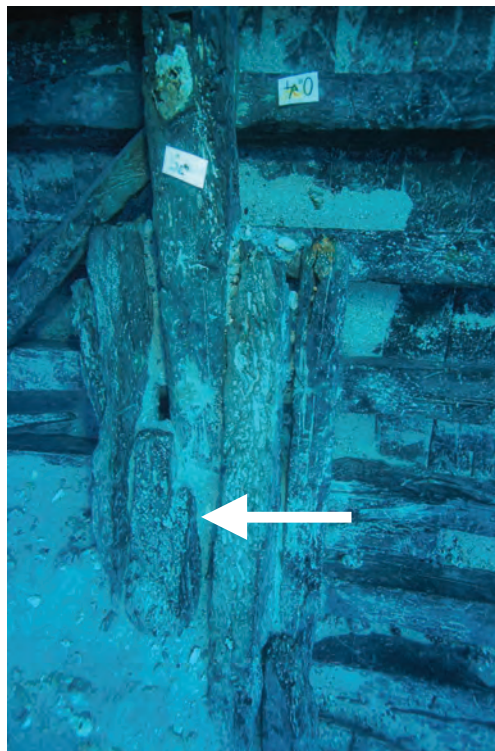


Fig. 4.9. The keelson from the top (photo: R. Mosković, HRZ archive)



Fig. 4.10. Anchor No. 1 (photo: R. Mosković, HRZ archive)



Fig. 4.11. Anchors Nos 2 and 3 (photo: R. Mosković, HRZ archive)

(no more than 18 minutes per diver per day) for the documentation of the hull, in 2010 we decided to use an unconventional photogrammetric technique which does not require photogrammetric cameras or metal frames (see C. Alfonso, Chapter 2.2).

In 2011, during a three-day investigation, it proved possible to uncover the area of the mast step, which had been documented only by photographs and measurements. These data were used to trace a plan which allowed us to complete the photogrammetry (Fig. 4.3). The photogrammetric documentation and other data were processed by Elisa Costa, using Rhinoceros software, to create a precise 3-D image of the preserved hull (Fig. 4.4) (see E. Costa, Chapter 2.4).

The hull's axis is oriented at 65°. About 15 strakes of hull planking (T for *tavole* in the plan), of *Pinus pinea* (Stone Pine), have been preserved. The planking is arranged in two distinct layers (Fig. 4.5).<sup>1</sup> The planks of both layers are about 19 cm wide, but plank No. 15, in contact with the frames, is 2.3 cm wide. The planking in contact with the frames is 7.8 cm thick, while the outer planking 5 cm thick.

We can say, without doubt, that the outer layer of planking is not sacrificial planking used to protect the hull from *Teredo* (naval shipworm), as has been documented in various shipwrecks of the Dutch East Indian Company (VOC) (Van Duivenvoorde, 2012) and in the Venetian shipwreck of the beginning of the 18th century investigated off the harbour of Malamocco (Venice), probably that of the 1st-rate ship *Croce Rossa* sunk in 1715 (D'Agostino *et al.*, 2010). This assertion is proved, both by the thickness of the outer planking of the Mljet shipwreck and by evidence from other sites, such as the *Batavia* shipwreck, which sank in 1629 (Van Duivenvoorde, 2012: 242), and the *Mauritius* shipwreck, sunk in 1609 off Cape Lopez in Gabon.

The external layer of planking documented on the presumed *Croce Rossa* is only 2 cm thick, although the ship was more than 40 m long. It is made of *Larix* (larch), while the internal layer of planking is of *Quercus* sp. sez. *Robur* (common oak) (D'Agostino *et al.*, 2010: 68). Similar situation has been documented on some of the VOC ships where sacrificial planking was made of pine while 'structural' external planking was of oak (Van Duivenvoorde, 2012). This indeed testifies that the sacrificial planking was usually made of less noble and much thinner wood than the structural planking.

The *Batavia* and *Mauritius* shipwrecks, on the contrary, had real double structural planking: the *Mauritius*, in particular, had double planking of oak, 15 cm thick in total. The double planking of the *Mauritius* was protected by a (third) thinner sacrificial layer of pine which could be replaced if degraded by *Teredo*. Between the two layers of structural planking there was also lead sheathing which is not present in the Mljet shipwreck (L'Hour *et al.*, 1989: 207–216).

According to Rieth, there is no evidence of the double planking technique in documents, and because both the *Mauritius* and the *Batavia* belonged to the VOC and were

found outside the Mediterranean, this technical solution could be explained by the necessity of building a strong hull to sail for many months in both tropical and Atlantic seas, without the possibility of extensive repairs (L'Hour *et al.*, 1989: 209). The recent discovery made by M. P. Jézégou of the DRASSM of the Listel 1 shipwreck off the southern coast of France, together with the evidence from the wreck of Mljet, requires a partial review of this theory.<sup>2</sup> The Listel 1 shipwreck, which is inverted, presents double planking with 5 cm-thick planks, which demonstrates that this technique was also used in the Mediterranean, and not only in tropical seas.

Preliminary observations suggest that the Venetian ship probably did not have a keel (*colomba*), and that the central element of the hull was a simple plank. Future investigations will have to confirm this assertion, and verify if this central plank was thicker than the others.

The framing has at least ten floor timbers (*corbe*) of *Quercus robur* which, at their western extremities, are joined to futtocks (*forcami*).<sup>3</sup> The floor timbers are 12.5–15 cm wide and 16 cm thick. The space between these components is 24–25 cm (Fig. 4.6). The floor timbers are 12.5–15 cm wide, and have pairs of rectangular limber holes spaced at about 47 cm. The futtocks are 12–15 cm wide and 14.5 cm thick, and their inner extremities are rounded.

The temporary removal from the seabed of one floor timber and one futtock allowed the documentation on land of some details of their junction (Fig. 4.7). The contact surface between these two elements is at least 85 cm long, and the futtocks are fixed on the north face of the floor timbers with iron nails which have disappeared. On the contact surface there is only a very superficial scarf consisting of a step less than 1 cm high. The scarf is 44 cm from the extremity of the futtock. The junction is fastened by at least two iron nails, which have disappeared, driven from the futtock.

In the Ottoman shipwrecks of Yassı Ada (Pulak, 2005: 141) and *Kadirga* (Arcak, 2003: fig. 36.6), in the eastern Mediterranean, the scarfs at the junctions of the components of the frames are more evident than on this hull, while in the Genoese *Lomellina* (Guérout *et al.*, 1989: fig. 19a) and Sardinian shipwrecks (Joncheray, 1988: 42–43, 50, 52), in the western Mediterranean, they were double, as used in the 'Atlantic Iberian' ship construction technique.

These two distinct types of junction, and the one with a very light scarf found in the Mljet shipwreck, were used in the Mediterranean at the same period, but the latter could have been typical of the Venetian shipyards, as demonstrated by all the known shipwrecks: the San Marco in Boccalama galea – beginning of the 14th century; the Contarina ship – second half of the 15th century (Occioni Bonaffons, 1901: 24–25; Beltrame, 2009b); the *fusta* of Lake Garda – beginning of the 16th century (Capulli, 2003: 109); and the *Croce Rossa* shipwreck – beginning of the 18th century (D'Agostino *et al.*, 2010).

The keelson of *Quercus robur* is 18 cm wide and 13 cm thick. On the upper face it has a small square hole.

Along its sides there are degraded inner planks. Between these and the keelson there is one plank on each side, in a vertical position, forming a mast step. They are curved, 150 cm long, 13 cm thick and 25 cm high, and are made of *Fraxinus excelsior* (European ash) (Fig. 4.8).<sup>4</sup> Between these two planks, which in Venetian shipyards were called *cosce*, and over the keelson, there is an element which could be a wedge to hold the mast step (Fig. 4.9). On the side of the eastern plank, there is an element which could be a knee (*castagnola*) to support the mast step (Fig. 4.8), as is evident in the San Marco in Boccalama galley (Beltrame, 2012: 211) and in the Lake Garda *fusta* (Capulli, 2003: 109). Another small knee seems to be installed horizontally between the *castagnola* and the mast step.

Two floor timbers (Nos 9 and 10) are very close to the mast step, perhaps to strengthen this critical zone. This kind of mast step seems typical of the Mediterranean construction of the Middle Ages, but is still poorly documented. An example is that of the 14th century *galea* of Venice.

Because the western side of the hull is preserved for 2.4 m, and it could continue for about 1 m more, we can assume that the ship had a beam of more than 6 m. Multiplying this by a ratio of about 1:3.5 or 1:4, which seems reasonable for a cargo ship of this period and which is indicated in the Pre Teodoro de Nicolò manuscript of the mid-16th century, for the *nave* and for the *galeone grosso* respectively (Lane, 1983: 287), we can estimate that it was about 21–24 m long from bow to stern. Comparisons of the dimensions of this shipwreck with those of others, including the Contarina ship (Occioni Bonaffons, 1901: 23), would confirm a length of not less than 24 m. The location of the anchors in the deeper area (see below) suggests that the stern of the ship was at the opposite end, and that under these anchors, the remains of the bow could still lie under the sand.

## Equipment

The equipment is represented by three iron anchors. One lies isolated west of the wreck, and is 250 cm long and 140 cm wide (Plan 1) (Fig. 4.10). The other two lie south of the hull at a depth of 47 m and form a 90° angle; one is 345 cm long and about 225 cm wide; the other is 370 cm long (Fig. 4.11 and Table 4.1).<sup>5</sup> They are a little smaller than anchors found in other shipwrecks of Venetian ships of the same period, such as the *Balancera*, better known as *Trinidad Valencera* (Martin, 1979: 31–32), and that of Gnalić (Beltrame, 2006; 2012: fig. 6.14). The two anchors from the *Balancera* were 480 cm long and 274 cm wide, and 457 cm long and 244 cm wide;<sup>6</sup> while the two from the shipwreck of Gnalić were 486 cm long and 276 cm wide, and 384 cm long and 189 cm wide.<sup>7</sup> As with the anchors from the other shipwrecks of this period, those from Mljet have triangular palms (flukes) and circular shanks, while the stocks (which must have been of course of wood) are not preserved.

The location of the last two anchors (Mljet 2 and 3) of the shipwreck of Mljet, not far from the hull, and

Anchors	Length (cm)	Width (cm)	Diameter of ring (cm)
Mljet 1	250	140	<50
Mljet 2	345	225	
Mljet 3	370		
<i>Balancera</i> 1	480	274	76
<i>Balancera</i> 2	457	244	76
Gnalić 1	486	276	82
Gnalić 2	384	189	57

Table 4.1. Dimensions of anchors from Venetian shipwrecks

their disposition, suggests that they were not in use at the moment of the sinking, and that they sank while on the deck. The location of the third anchor (Mljet 1), quite far from the ship, and the presence of the cliff where, of course, the vessel struck, suggests that it was used to attempt, without success, to hold the ship during a storm.

A brass square coak (Fig. 4.12), with slightly tapering sides, 5–6 cm wide, has a central large perforation with a bearing set in the centre of a sheave (*ragli*) of a block (*taie*), to prevent its splitting and to reduce wear by the pin on which it turned, similar to the items from the Ragusa shipwreck of Sipan (Kisić, 2006: fig. 12; Beltrame, 2012: fig. 6.15). Similar objects have been found in the shipwrecks of the *Balancera* (Martin, 1979: fig. 19.5, 19.6), *Girona* (Sténuit, 1972; Rodriguez-Salgado, 1988: 166) and Gnalić (Beltrame, 2006),<sup>8</sup> but they were quite common in any ship of that period.

Three wooden, pear-shaped and with one square hole (Plan 2) ‘hearts’/deadeyes (*bigotte*) were found. Two are complete (180/2009, 120/2009), 25 cm long (Figs. 4.13, 4.14) and one broken (20/2011). The latter is a little shorter than the others (Figs 4.15a–b). These can be compared with objects found in the *Balancera* shipwreck (Martin, 1979: 31–33; Rodriguez-Salgado, 1988: 166) and in the *Mary Rose* (Marsden and Endsor, 2009). 180/2009 still preserves remains of the rope (*cao* or *sartia*) which encircled the items in the grooves (Fig. 4.14). Analysis of a sample from the broken item tells us that it was made of elm (*Ulmus campestris* L./*Ulmus* Mill.)<sup>9</sup> which was the wood preferred for rigging equipment in the 18th century, and which has always been largely used in Venetian shipbuilding. This may account for the widespread presence, at least in the past, of elm trees along the Venetian littoral. These objects were used for standing rigging for, among other things, securing forestays; and they were found near two iron bars (122/2009, 165/2009) and a chain plate (49/2007)<sup>10</sup> in a 3×2 m sector of the cargo area (Fig. 4.16).<sup>11</sup> This last find could be interpreted as an iron link with wooden deadeyes which have disappeared (Fig. 4.17).

A large (and heavy!) limestone roller, 83 cm long and 50 cm diameter, with small holes in the ends was recovered from the site. It presents small parallel grooves which could have been produced by a rope (Fig. 4.18). Its function is still a mystery, but it is not necessary to attribute it to the working of the ship.



Fig. 4.12. Brass coak (photo: R. Mosković, HRZ archive)



Fig. 4.13. Wooden heart 120/2009 (photo: R. Mosković, HRZ archive)

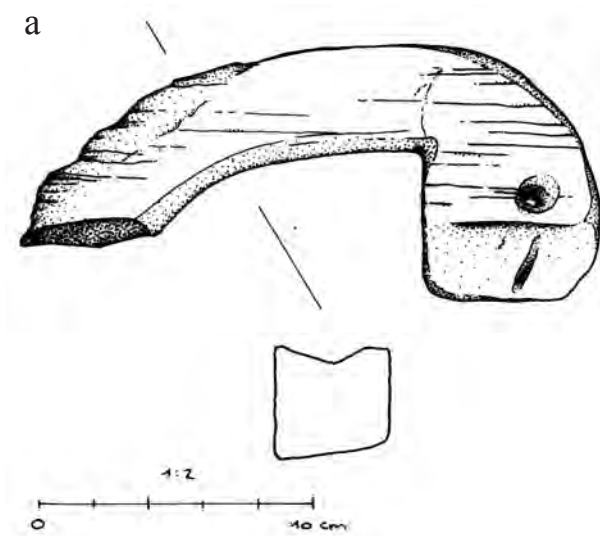


Fig. 4.15. Wooden heart 20/2011 (a: drawing by S. Zanetto; b: photo: C. Beltrame)



Fig. 4.14. Wooden heart 180/2009 (photo: R. Mosković, HRZ archive)

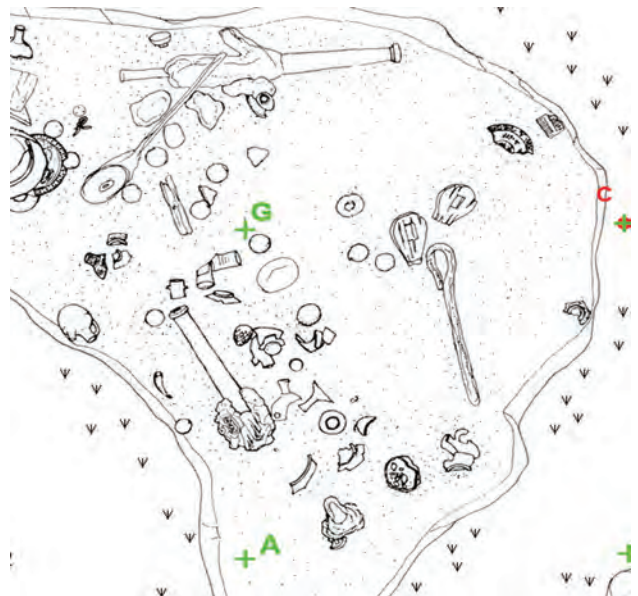


Fig. 4.16. Detail of the site plan with a group of equipment items (drawing: V. Zmaić Kralj, HRZ archive)



Fig. 4.17. Iron link (photo: C. Beltrame)



Fig. 4.18. Limestone roller (photo: C. Beltrame)



Fig. 4.22. Glass bead (66/2008) (photo: R. Mosковић, HRZ archive)



Fig. 4.23. Whetstone (156/2009) (photo: P. Dugonjić, HRZ archive)



Fig. 4.19. Bronze bell (photo: R. Mosковић, HRZ archive)



Fig. 4.24. Wooden handle tool (229/2010) (photo: P. Dugonjić, HRZ archive)



Fig. 4.25. Wooden handle tool (229/2010) (photo: P. Dugonjić, HRZ archive)



Fig. 4.20. Detail of the bell cast by Zuan Battista del Ton exposed in the Naval Museum of Venice (photo: the author)



Fig. 4.26. Wooden handle knife (204/2010) (photo: P. Dugonjić, HRZ archive)



Fig. 4.21. Wooden comb (No. 102/2009) (photo: R. Mosковић, HRZ archive)



Fig. 4.27. Wooden handle knife (204/2010) (photo: P. Dugonjić, HRZ archive)

A bronze ship-bell, 19.6 cm high, shows a profile and a mode of decoration which seems typical of the Venetian bells (Fig. 4.19). A comparison can be seen inside the Museo Storico Navale of Venice where a bronze ship-bell, made by Zuan Battista del Ton in the 1597, presents a similar style (Fig. 4.20). On the bell from the shipwreck, the dating in Latin characters 1567 is embossed.

### The crew's personal possessions

Evidence of life aboard and personal possessions is quite frequent in any shipwreck of every period. It is obvious that, especially aboard ships engaged in long voyages, such as that one sunk on Sv. Pavao's shoal, those aboard tried to continue everyday life, and possessed various personal items. Personal care was one of daily life's activities as a matter of hygiene.

Although objects in the shipwrecks, not related to the cargo, but to the categories which have been mentioned, have been studied in detail for the Roman period (Beltrame, 2002), and are quite numerous in shipwrecks of the 17th and especially later centuries, evidence from ships dated to the period of the sinking of the Sv. Pavao's ship is quite rare. This gap has been partially filled by the incredible window which has been opened on the history of life aboard the *Mary Rose*, a ship of the 16th century, by the study of the numerous items of various types (Gardiner (ed.), 2005).

Evidence of personal care aboard the shipwreck is a rectangular wooden comb (102/2009), 10 cm long and 6.5 cm wide, with densely packed teeth (some missing) along its two longer sides (Fig. 4.21). Its teeth are thicker on one side and thinner on the other, a feature common throughout the history of these objects. The widely spaced teeth would be used for disentangling hair, while the finer teeth would have been for grooming, or for removing fleas and pubic lice, which are likely to have been rife aboard ship. The comb represented the most common personal object recovered in the *Mary Rose* shipwreck, with 82 examples found (Richards, 2005).

A black glass bead (66/2008), with a diameter of 10 mm and a large hole (Fig. 4.22) could, because of its uniqueness, be classified as a typical personal object. Other personal possessions are Ottoman and European coinage (see Kurkman and Zmaić, Chapter 4.7 and 4.8, below).

Tools are represented by at least three items. A piece of stone, 21 cm long, 2 cm wide, and 2/2.5 cm thick, could be a whetstone (156/2009) (Fig. 4.23). The shape, which could not be easily handled, suggests that it had to be contained in a whetstone case, now missing, similar to those found in the *Mary Rose* (Gardiner, 2005: 340): this object could have been used to sharpen any kind of iron or steel tool.

A round turned wooden handle (229/2010), 8.2 cm long (with a maximum width of 2.2 cm and a maximum thickness of 1.2 cm), was part of a tool which could have been a whittle tang knife, where the tang was inserted into the handle (Figs 4.24 and 4.25). The inside is empty and the blade was not preserved.

A wooden handle of a scale tang knife (204/2010), 10 cm long and 2.2 cm wide, consists of two scales held together by four rivets (Figs 4.26 and 4.27). The blade was not preserved. A multi-purpose knife would have been an essential personal item for a sailor, and could have been used for many purposes, such as to cut ropes, in case of danger, and for eating. More than 50 examples of these two types of knives have been recovered in the *Mary Rose* shipwreck (Every and Richard, 2005).

### Conclusions

The use of pine (*pinus pinea*) and elm (*Ulmus*), the type of mast step and the technique of joining the components of the frames points to, if perhaps not exclusively, the Venetian shipyards and, of course, to a Mediterranean shipconstruction.

The extreme scarcity of archaeological information on ship construction and rigging of the 16th century make this shipwreck an important source of knowledge of ships of the Late Middle Ages in the Mediterranean Sea. Particularly interesting is the use of a double layer of planking, documented for the first time in a Mediterranean ship, and apparently not mentioned in the literature.

The nautical equipment and the crew's personal possessions from this shipwreck are rare sets of items of these categories in the Mediterranean from the Late Middle Ages.

### Notes

- 1 Wood analyses were made by Nili Liphshitz of the Botanical Laboratories of the Institute of Archaeology, Tel Aviv University. The planks sampled are Nos 12 and 15 of the planking in contact with the frames, and No. 12 of the outside planking.
- 2 I would like to thank Marie Pierre Jézégou for the personal information.
- 3 Only floor timber No. 1 (C 1) has been sampled.
- 4 Only the eastern element was sampled.
- 5 Measurements of these anchors are not precise, both because they were completely covered by concretions, and because they were partially covered by the sand.
- 6 They both had a ring with a diameter of 76 cm.
- 7 The first anchor, which has a ring with a diameter of 82 cm, was on display in front of the Museum of Biograd, the second one, which has a ring with a diameter of 57 cm, was conserved at the Archaeological Museum of Zadar. Both the anchors are now temporarily stored at Split waiting for conservation treatment.
- 8 The six brass coaks from the Gnalić shipwreck have the following dimensions in cm: 6 × 8 × 3.2 (hole: 2.8 in diam.), 5 × 5.3 × 2.5 (hole: 2 in diam.), 5.5 × 5 × 2.5 (hole: 2.5 in diam.), 4.2 × 4.4 × 2.5 (hole: 3.3/2.6 in diam.), 4.7 × 4.8 × 2.4 (hole: 2 in diam.) and 3.6 × 3.6 × 1.3 (hole: 1.8 in diam.).
- 9 Wood analysis was made by Stéphanie Wicha of the Archéobois Society.
- 10 The chain plate is 22 cm long and 13.5 cm wide.
- 11 Trench A-B-H-G.

## 4.2. The Ordnance

*Igor Mihajlović*

### Abstract

*Le prime sei fasi di scavo e documentazione del sito di San Paolo hanno messo in luce otto pezzi di artiglieria in bronzo. Sette sono petriere da braga a retrocarica, mentre uno è uno smeriglio in bronzo ad avancarica. Due petriere quasi identiche hanno un grosso calibro mentre le altre hanno un calibro più piccolo e appartengono alla tipologia del moschetto. Tutte e sette le petriere sono state fabbricate con due metalli. La volata in bronzo fuso e la braga di contenimento del mascolo in ferro battuto. Sfortunatamente, la maggior parte delle braghe era in avanzato stato di corrosione, e per questo motivo non sono state recuperate dal fondale. Solo il moschetto N. 08/2009, recuperato dal mare durante lo scavo del 2009, aveva la braga completa ancora collegata così come parte della forcilla usata per fissare il pezzo sulla fiancata della nave*

*Tijekom prvih šest faza istraživanja lokaliteta kod Plićine Sv. Pavao pronađeno je osam brončanih topova. Sedam ih ima sistem punjenja odostraga od kojih dva najveća topa pripadaju kategoriji pedrijera, a pet manjih kategoriji moschetto. Jedini top s punjenjem sprijeda pripada kategoriji smirilja. Svih sedam topova s punjenjem odostraga izrađeno je kombinacijom dvaju metala. Cijev je lijevana od bronce dok je zatvarač od željeza. Nažalost, svi zatvarači su pronađeni u uznapredovanom stupnju korozije te nisu izvađeni iz mora. Samo je moschetto 08/2009, izvađen tijekom istraživanja u 2009. godini, imao pričvršćen željezni zatvarač kao i vilicu pomoću koje je usađen u ogradu broda.*

### Introduction

Bronze artillery pieces started to be widely used in the 16th century, replacing the earlier made of wrought iron. At the time, bronze was not a new material, but the artillery manufacturers were attracted by the possibility of casting it in large pieces. New casting techniques had also been introduced in metal production, and they had greatly reduced the sponginess and appearance of bubbles in the material structure. One innovation in foundry techniques was the vertical casting of artillery, with their breech-chamber turned downwards. This technique resulted in the bronze being denser – and thus also stronger – in the lower part, closer to the breech-chamber, and this was the part of the cannon that had to sustain the highest stress.

In short, the casting process started by making the

exact model of the gun. This was done first by wrapping a rope around a wooden rod after which a sculptor added clay with all the details, reinforcing bands and muzzle mouldings. After the model was complete it was coated in a thick layer of wax. Now were added the wooden trunnions and, if needed, lifting dolphins. The model was again coated with layer of wax around which an outer mould was built, like a cocoon (Konstam, 2008: 134–135). The next step was to remove the wooden core and rope, as well as the clay until the moulders reached the wax. Then the mould was heated and the wax melted away. On the rear of the gun a new mould was added which closed one end and was modelled in the shape of the breech. The inside of the mould now looked like a mirror image of the finished gun. Before the pouring of metal, a iron bar



Fig. 4.28. Artillery pieces in situ, first campaign 2007 (photo: I. Miholjek, HRZ archive)



Fig. 4.31. Petriera da braga 03/2007 during recovery (photo: I. Miholjek, HRZ archive)



Fig. 4.29. (right) Recovery of moschetto 08/2009 during the 2009 campaign (photo: Igor Miholjek, HRZ archive)



Fig. 4.32. Ornamentation on the chase of Petriera da braga 02/2007 with comparison of coat of arms from Gnalić and Varna guns (photo: a, b: R. Mosković, HRZ archive; c: after Bishop-Smith, 2000: 6, fig. 5)



Fig. 4.30. Two perriers (classified as petriere da braga): 02/2007 and 03/2007 (photo: R. Mosković, HRZ archive)



Fig. 4.33. Five moschetti 01/2007, 04/2007, 05/2007, 07/2007, 08/2009 (photo: R. Mosković, HRZ archive)



Fig. 4.38. Muzzle-loading esmeril 06/2007 of probably French production (photo: R. Mosković, Croatian Conservation Institute)



Fig. 4.34. Four moschetti and an esmeril immediately after extraction, note the mascolo on the gun far right (photo: I. Miholjek, HRZ archive)



Fig. 4.39. Stone shot for petriere da braga (photo: J. Macura, HRZ archive)

Fig. 4.35. (right) Muzzle mouldings of moschetti 01/2007, 04/2007, 05/2007, 08/2009, note the signature of Tommaso di Conti on 05/2007 (photo: R. Mosković, HRZ archive)



Fig. 4.36. (left) Breech of gun 08/2009 with signature of founder 'L F' (photo: R. Mosković, HRZ archive)



Fig. 4.37. Tampion used for closing the powder chamber of moschetto 05/2007 (photo: J. Macura, HRZ archive)



Fig. 4.40. Types of projectiles found on the Sv. Pavao site (photo: J. Macura, HRZ archive)

with cord coated in clay (core) was inserted in the centre of the mould to form the bore (Kennard, 1986: 13–14). This early technique, which required moulds for both the bore and the gun, made each gun unique (Kennard, 1986). This is only a simplified description, making the mould and casting includes numerous details which are beyond the scope of this work.

Casting the gun solid without the bore, which was drilled later, was done from first half of 18th century (Kennard 1986: 19–22). One of the main advantages of a cast gun was the thickness of its wall, which allowed the use of stronger charges (Humble, 2004: 37). The 16th-century bronze artillery can be generally divided into two main groups: breech-loading and muzzle-loading guns.

Breech-loading guns were usually of swivel-gun type, which meant that they were mounted in the ship's rail. They had a loading device (removable powder chamber) that was fitted in a holder at the back of the barrel by which a relatively short firing interval was allowed, and the gunner could prepare one or more loaded chambers that included the charge. Venetian galleys, which were armed with breech-loading guns, had each one provided with three chambers (Morin, 2011: 4). For comparison, the 16th century, privately owned, merchant ships of Dubrovnik, which were mostly armed with breech-loading esmerils rented from the state, usually had two chambers (Beretić, 1960: 120–123). A major deficiency of this loading method was that the loading device had to be joined very closely to the barrel, or the gun would lose its power and present a great danger for the gunners. That was not a problem when firing at close range, but when the gunner had to hit a ship more than few hundred metres away, the loss of hitting power meant that it would not penetrate the hull. This meant that breech-loading guns were primarily used as close-range anti-personal weapons (Konstam, 2008: 127). Most breech-loading guns constructed to fire stone projectiles were called perriers (Italian: *petriere*; Spanish: *pedrero*). They were initially used to fire only stone shots, hence the name, but later in the 16th century they were loaded with grapeshot made of lead balls (Morin, 2011: 4).

Muzzle-loading artillery pieces had several significant advantages in comparison to the breech-loading guns. They were more reliable and much safer. Unless there was a problem with the gun casting, the chances of the barrel-chamber rupturing due to the expansion of gasses were greatly reduced. Thanks to the gradual improvement of melting and casting techniques, and an increase in the quality of metal used to produce naval artillery, this problem almost entirely disappeared in the late 16th century (Guilmartin, 1974). However, the loading itself was not as simple as in the case of guns with a loading device. It could be done in two ways, either from the ship or from outside the ship. In the latter case, the gunner would climb down from the deck and squeeze through the cannon opening to clean the barrel and load the gun. The other option was to retract the cannon so that the gunner could reach the barrel

muzzle (Konstam, 1988: 20). Both loading techniques were very dangerous for the gunners.

Guns, and especially bronze guns were much more durable than ships made of wood, so old guns remained in service and captured guns or those bought from various manufacturers were prevalent in the ordnance inventories (Glete, 2000: 24). The bronze used in gun founding was an alloy of approximately 90% copper and 10% tin, but founders all around Europe used their own recipes (Kennard, 1986: 14).

The first six phases of excavation and documentation of the site of Sv. Pavao revealed eight bronze artillery pieces (Fig. 4.28). Seven were breech-loading swivel guns, while one was a muzzle-loading esmeril. Two nearly identical swivel guns were of large calibre, belonging to the category of the *petriere* while the remaining five were of smaller calibre, representing the *moschetto* type (Fig. 4.29). All these seven pieces were made of a combination of two metals. The barrel was made of cast bronze, and the chamber-holder of wrought iron. All eight artillery pieces have been restored in the Department for Conservation of Underwater Archaeological finds of the Croatian Conservation Institute.

### ***Petriere da braga. Inv. Nos. 02/2007 and 03/2007***

The only difference between these two nearly identical perriers is in their weight mark (Fig. 4.30, plate 4.1). On perrier 02/2007 there is the engraved number 292, and on perrier 03/2007 the number 330. The corresponding stout iron plate holders, in which the removable chamber was inserted and forced against the rear part of the barrel through an iron wedge, were found, but due to an advanced stage of corrosion and decomposition they were not taken out of the sea (Fig. 4.31). The iron chamber holder was fixed to two rectangular ribs protruding from the barrel. Close to the breech the numbers 292 and 330 are engraved in the barrel, indicating their weight in libras. The length of the gun 02/2007 is 145 cm and its calibre is 10.7 cm (weight mark 292). The gun 03/2007 measures 147 cm with a calibre of 10.1 cm (weight mark 330). This is the length of the bronze part only, the barrel. Above the central reinforce ring, on the chase, there are four floral decorations in the shape of an acanthus leaf, with three five-petalled flowers among them. Similar Renaissance decoration in the shape of acanthus, widespread in the whole Mediterranean region, can be seen on two bronze sakers, casted by Zuane Albergegetti, recovered from the Gnalčić shipwreck (Petricioli, 1970: 9–16; Morin, 2006b: 95–97), as well as on three royal *canones de batir* from one of the wrecks of the Spanish Armada, *La Trinidad Valencera* (Martin, 1988: 57–73).

Venetian gun founders used foliate bands composed of delicate acanthus leaves or palmettes, which they frequently placed just behind the muzzle or just forward of the trunnions (Avery, 2011: 49). On the chase, under

the muzzle of both Sv. Pavao perriers there is an ornament of  $29 \times 20$  cm. The relief ornament is dominated by an empty coat of arms with sashes, and an attached wingless lion's head (Fig. 4.32). One perrier of the similar calibre discovered on a shipwreck in the vicinity of the isle of Gnalić, near Šibenik, displays the same coat of arms (Petricioli, 1970: 9–16). Only recently the shipwreck was positively identified as Venetian. The vessel itself was launched in 1569 in Venice, but from 1581 it was owned by the Gagliano family of Venice. The vessel named *Gagliana Grossa*, which was armed with at least eight bronze artillery pieces, sunk in late 1583 (Radić Rossi *et al.*, 2013: 78–79). The same coat of arms can be seen on perrier found in the 1980s in the Black Sea, close to the Bulgarian coast (Bishop-Smith, 2000: 6) and on another displayed at Naval Museum in Istanbul (Ridella, pers. comm.). The common features of all those perriers are the coat of arms, their calibre and the breech-chamber made of iron. It can be assumed that they were cast either in the same foundry or by the same founder.

The question arises: where were these perriers cast? Since the weight of a libra varied depending on the state (monarchy) in which the artillery was cast, one can establish the weight of the libra by weighing the artillery, and thus establishing the state in which particular artillery was cast (Roth, 1989b: 201). For the sake of comparison, the Venetian *libbra grossa* corresponded to 0.477 kg, the Italian libras ranged from 0.301 kg (Venetian *libbra sottile*) to 0.368 kg (*libbra* of Turin), and the libra used in Castile was equivalent to 0.460 kg (Roth, 1989a: 61–66). The Dubrovnik Republic, as an independent state, kept its libra unit of weight (0.358 kg) (Bašić, 2004: 79–100). The weight expressed in libras corresponded to the bronze part of the perriers only – in this case, the barrel. Perrier 02/2007 with the weight indication 292 weighs 139 kg, which best corresponds to the weight of a Venetian *libbra grossa*. More precisely, 292 Venetian libras equal 139.3 kg. Perrier 03/2007 with the weight indication 330 weighs 156 kg. Marked weight in libras equals 157.40 kg. The small difference in weight may be attributed to the wear of the guns. Previous measure stands incorrect since it was done during restoration (Mihajlović *et al.*, 2012: 49–57).

Both perriers were commercial weapons since the guns cast for the Venetian government are easily recognisable by the common features such as presence of the Lion of San Marco, both *in moleca* (head, torso and wings in round or oval background) or *andante* (complete body with the Gospel), presence of the roman digit X, logo of the Council of Ten, which was in charge of state artillery until 1586 (Morin, 2011: 10). Another feature of Venetian ordnance in general was the lack of lifting dolphins (handles on the dorsal part of artillery used for moving and lifting) and also the date of the founding is rarely present (Morin, 2009: 21). According to the classification of perriers cast and owned by the *Serenissima*, such artillery pieces, firing the 12 lb shot (measure for the shots was *libbra sottile* = 0.3012 kg), with a calibre of approximately 9.5 cm and a

barrel about 130 cm long, were called *petriere da braga*; if the chamber holder was made of bronze they were called *petriere da mascolo* (Morin, 2006b: 21). Dimensions and calibre of commercially cast pieces for private merchant ships could differ from the standards, depending on the client's wishes (Morin, 2009: 28–29). Another proof of Venetian provenance, besides the corresponding weight, could be the ornamentation with the motive of lion's head on the chase of both perriers, although not *in moleca* or *andante*. Muzzle mouldings (especially the 'teeth') seem quite atypical for Venetian artillery but these were commercial weapons which were, as said before, made by client's wishes, which could be the case for these guns (see Fig. 4.32). Their parallel position on the seabed (see Fig. 4.28 and Sector 1 on Plan 1) suggest that they were mounted at the stern, a tactically vulnerable location where armed merchantmen (and sailing warships) usually carried their biggest and best ordnance from the earliest days (Guilmartin, 1982: 143).

The Natural Science Laboratory of the Croatian Conservation Institute analysed the bronze from both perriers. Metal samples from prepared cross-cuts were analysed by X-ray fluorescent spectroscopy using the Artax device (Bruker AXS). The results for three samples from the perrier 03/2007 reveal that the bronze has a very high percentage of lead, more than 17% at the breech. The percentage of lead is the lowest at the muzzle, 4%. Given the fact that composition of long objects cast in vertical position is not homogeneous and that all samples were taken from superficial layer (lead has a lower temperature of solidification than copper and tin) this analysis does not contain any valid information for the whole mass of the artillery piece. We can also take into consideration that some gun founders added lead to lower the melting point. Others added latten, a brassy alloy composed of copper and zinc with heavy proportion of lead, which was taught by some founders to give the gun-metal a better colour (Kennard, 1986: 14).

### ***Moschetti. Inv. Nos 01/2007, 04/2007, 05/2007, 07/2007 and 08/2009***

The second artillery group consists of five similar swivel guns with a calibre ranging from 4.1 to 4.4 cm, so we cannot call them perriers but breech-loading esmerils (fig. 4.33, plates 4.2, 4.3, 4.4). All were composite guns made from bronze and iron. Construction is the same as with two larger perriers. All five guns have barrels made of bronze with two symmetrical ribs to which a stout iron plate holder (or *braga*) was attached (Fig. 4.34). The removable chamber (or *mascolo*, visible on the gun far right), swivel and tiller were all made from iron. Two of the guns bear signature of the founder. Gun 05/2007 bears the signature 'T C' on the chase which means that it was cast by Tommaso di Conti, member of the famous Venetian gunfounders family (Fig. 4.35). Tommaso died in 1540, so the gun, a *moschetto da braga* in the Venetian gun classification (Morin, 2006b:

21), could have been made in the 1520s or 1530s (Avery, 2011: 26).

*Moschetto da braga* was a gun with a calibre around 4.5 cm that fired 1 lb (0.45 g) shot and was usually 1 m in length (Morin, 2009: 28). The bronze part of the gun (the barrel) 05/2007 from Sv. Pavao wreck is 86 cm long with a calibre of 4.1 cm. Next to the slot for the *braga* is engraved the weight mark of 92 Venetian *libre grosse*. The marked weight equals 43.88 kg, and the real weight is 43.30 kg. Since it does not have signs of a state owned gun, it is obviously commercial. Another commercial gun of this founder was recovered in the waters of Palagruža archipelago in the 1988, along with a gun recovered a year earlier casted by Camillo Alberghetti (Orlić, 1988: 42–42; Radić Rossi, 2011: 68–70). Both guns bear the coat of arms of Gritti family of Venice (Beltrame, 2011: 14). In Askeri Museum in Istanbul there are five additional guns made by Tommaso di Conti, but made for Government use (Beltrame and Morin, 2014).

The Di Conti and Alberghetti families were the most respected gunfounders employed by the state, which often encouraged competition in order to insure the most quality products and best price. By the second quarter of the 16th century these two dynasties dominated the production of artillery in Venice, which lasted for 300 years (Avery, 2011: 46). Gun 08/2009 is the only one which (besides the muzzle-loading esmeril) does not have weight mark engraved. It bears the signature of one 'L F', a founder whose identity is not yet defined. The length of the bronze barrel is 86 cm, and the length of preserved stout iron plate holder another 30 cm (without the part of the tiller) (Fig. 4.36). Calibre is 4.2 cm. Part of the iron yoke and peg is also preserved. Gun 01/2007 has a length of the bronze barrel of 87 cm with a calibre of 4.3 cm. the marked weight is 72 libras, and if we use Venetian *libra grossa* it equals 34.34 kg. The real weight is 33.75 kg, which is again closest to the mentioned Venetian libra. Other two guns have also their real weight close to Venetian *libra grossa*. Gun 04/2007 (length of the barrel 89 cm, calibre 4.1 cm) has the real weight of 37.40 kg, with marked weight 77 which equals 36.73 kg. Gun 07/2007, with marked weight of 66 equalling 31.48 kg, has the real weight of 31.80 kg. the length of the barrel of the latter is 87 cm with a calibre of 4.4 cm. Since the real weight of these last three breech-loaders corresponds best to Venetian libra and since they are morphologically very similar, we can assume that their origin is Venetian. They can also be classified as *Moschetti da braga*. Determining the provenance of the perrier 08/2009 is more challenging. Although morphology suggests a Venetian origin, the absence of weight mark and signature of unknown founder suggests caution. Figure 4.35 shows a comparison of muzzle mouldings of all five perriers of this group.

During the restoration of gun 05/2007 a wooden tampion was found inside the breech chamber (Fig. 4.37). Wooden tampions in breech-loading guns were used to separate powder from shot and thus seal the chamber; later they

had the sole function of sealing the muzzle as a form of protection (Hildred *et al.*, 2011: 463–464). Material identified as linen was found in the barrel of gun 01/2007, close to the breech. This could be the part of the wad. Wads are described as any material such as a plug of tow, hay, and wood used to keep the powder and shot in position when charging the gun (Blackmore, 1976: 248). Only a few wads were found during the excavation of *Mary Rose* connected only to the breech-loading guns, none was recorded with excavation of muzzle-loading guns (Hildred *et al.*, 2011: 475–476). The suggested sequence for the wrought iron breech-loaders excavated from the *Mary Rose* shipwreck is: powder, wad, wooden tampion, fibres and then the shot (Hildred *et al.*, 2011: 463–465).

### Esmeril (inv. no. 06/2007)

*Question: "What is the name of this artillery piece which you need to use for shooting?"*

*Answer: "It seems to me, by the look of it, that this is an esmeril."*

*Question: "How can you recognize it as an esmeril?"*

*Answer: "I can distinguish him by many of his features, which are: he shoots iron balls weighing from a half to one libra of weight. The length of his barrel equals a measure of 30 to 32 diameters of his muzzle. At the touchhole the metal will be thick at least one measure of the diameter of his muzzle, and the remainder will have all those proportions found in other barrels of first class." (Vanini, 1666)*

This excerpt is taken from a manual (written in a form of an exam) for gunners who attended Artillery School in Republic of Dubrovnik, founded by Antonio Vanini in 1655. The manual holds all information needed for the young trainees who wanted the position of the state gunner. Vanini describes the kind of equipment that had to be used, different types of artillery and their ranges, different penetration at specific ranges (taking into account the type of shot and quantity of powder) and lot of other "need to know" information for young gunners (Beretić, 1960: 133–155). One question relates to this gun type. This kind of smallest piece of ordnance, which were used to fire shots of 0.5–1 libra, were called esmerils (Italian: *smeriglio*; Croatian: *smirily*). These weapons, which can be either muzzle- or breech-loaders, were often placed on a swivel mount and, as well as solid shot, fired lead shots containing an iron cube (Ridella, 2007: 8). The muzzle-loading esmeril is 120 cm long, with a bore diameter of 4.6 cm (Fig. 4.38, plate 4). The cross-section of the esmeril is polygonal with 12 edges. The edges run continuously from the base ring to the barrel muzzle, without any reinforces. The simple and unadorned fuse hole, cut by an astragal, is of a relatively large diameter (1.4 cm), suggesting that the gun was used for a long period, which caused the fuse hole to wear. The esmeril does not display any characteristic relief decorations that could be useful to identify its origin.

During restoration, a corroded iron shot of 4 cm in

diameter was discovered in the barrel. The available archaeological evidence indicates that keeping the cannon loaded while the ship was sailing was common practice at the time (Konstam, 1988: 17). It is almost impossible to determine the origin of this gun without the presence of the founder's mark, weight mark or coat of arms, but this commercial polygonal piece with 12 edges is definitely not Venetian. Main centres of production of polygonal artillery in Europe were France, Genoa and England. On the basis of some characteristics, such as the cylindrical button and astragal close to muzzle, it could be dated to the first few decades of 16th century (Ridella, 2007: 5–38).

## Projectiles

Eighteen stone shots were found in total next to perriers 02/2007 and 03/2007 in sector 1, and these correspond to the perriers' calibre (Fig. 4.39). Their weight varies between 1.10–1.25 kg. Since iron or lead shot were not found we could suggest that they used stone shot. The rest of the artillery pieces, including esmeril, used iron shot. Not one matching iron shot was preserved, except the one found in the esmeril. This was due to the advanced stage of corrosion of the breech chambers which, as described above, were loaded during the voyage. Iron shot as well as removable chambers collapsed soon after they were recovered from the sea. Interestingly, during the excavation in 2010, stone shot with average diameter of 14 cm was found in sector 4. It belongs to the yet undiscovered, piece of artillery (Fig. 4.40).

Another two shot were recently revealed from an incrustated piece of metal with no matching artillery piece. Both are made from cast iron, but there is large weight difference between them. The heavier shot displays rough a castline finish in comparison with the lighter shot. Their diameter is 6.7 cm. If we take into account the standard windage, roughly 1/20 of the shot (Hildred and Smith: 2011: 311), we should suppose that both shot belonged to a piece of artillery with calibre around 7 cm. This was the standard calibre for perriers between the smaller *moschetto* (around 4.5 cm) and larger *petriere da braga* (around 9.5 cm): of course, only in the Venetian military classification of state ordnance (Morin, 2009: 28). Two lead shot of 1.2 and 1.5 cm were recovered during the 2008 and 2009 campaigns. Shot can be connected to the two harquebuses which are still under conservation. The harquebus was a muzzle-loading firearm with matchlock used in the 15th–17th centuries. For comparison, a typical harquebus in the 16th century weighed 5 kg or less and had a bore diameter of around 1.5 cm (0.60 of an inch) (Guilmartin, 1974).

## Conclusions

This work encompasses the research conducted from 2007 to 2012. Eight artillery pieces were recovered in that period.

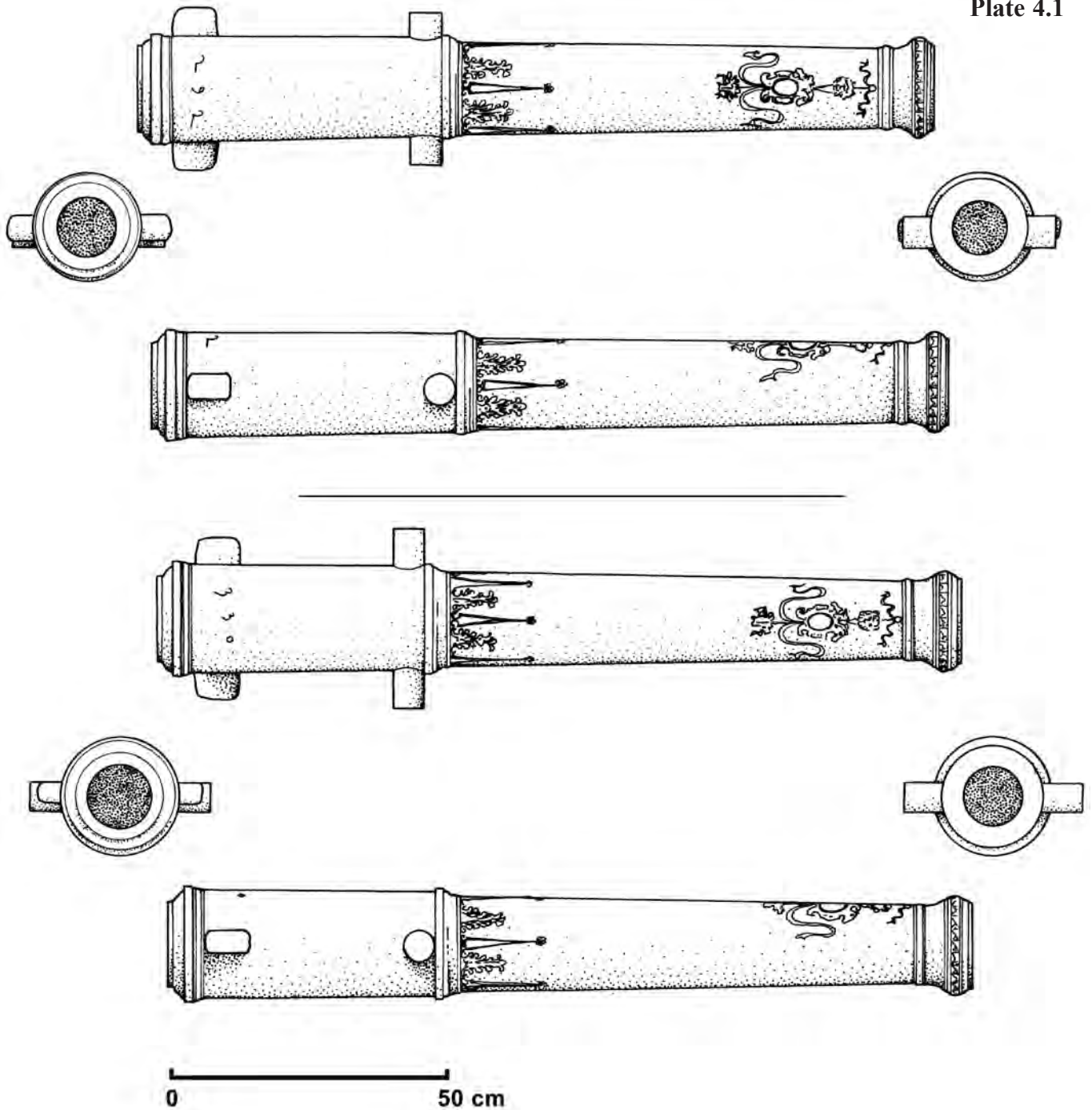
Two *petriere da braga* are most likely Venetian given that the marked weight equals best to Venetian *libbra grossa* (difference between marked and real weight is a mere 0.2% for 02/2007 to 1.1% for 03/2007). The presence of the lion's head on the chase as well as an empty coat of arms similar to two perriers at the Venetian wreck at *Gnalič*, suggests a Venetian origin. One of five smaller breech-loaders (05/2007) is marked with the initials of a known Venetian founder, Tommaso di Conti, who was active until 1540. Other three pieces (01/2007, 04/2007, 07/2007), which also have their weight closest to Venetian unit of measure, display similar morphological characteristics, such as muzzle mouldings similar to Tommaso's gun or other pieces from the di Conti family of Venice. Gun 08/2009 is a little problematic, although morphologically similar to Venetian pieces. It does not bear any weight mark but only a signature of unknown founder 'L F', so the provenance of this gun remains in question. The polygonal gun with 12 edges (06/2007) is definitely not Venetian; its origin could be France, which was mostly producing this type of artillery.

Artillery pieces with a polygonal cross-section were produced from the end of 15th century to roughly 1560s (Ridella, 2007: 5). Taking the morphology of this piece into consideration, it was cast in the early decades of the 16th century. Although the Sv. Pavao shipwreck is dated around 1580 it is not unusual to have 'old' artillery on the vessel, since the bronze guns lasted much longer than wooden ships. For comparison, the oldest bronze artillery piece found on the Swedish Royal ship *Kronan*, sunk in 1676, was produced in Germany in 1514 (Einarsson, 1990: 291). All artillery pieces found to date on the Sv. Pavao wreck are commercial, which means that they were privately owned and as such subjected to buying/selling or renting according to the need of the ship's owner. This depends, of course, on the value of the cargo, financial backing, the political situation and dangers the voyage would present. Venetian bronze artillery was considered to the best in the Mediterranean, second in Europe only to German production (Morin, 2011: 9). Guilmartin even suggested that Venetian gunners on galleys were probably the best naval gunners in the Mediterranean (Guilmartin, 1974). It remains to future excavations of the Sv. Pavao wreck site to reveal other pieces of artillery which probably exist since three shot found do not match recovered guns. Since the site was miraculously found undisturbed, hopefully future excavation will reveal gunners' equipment as well. This could shed new light on artillery of the most powerful merchant and military navy in the Mediterranean during the 16th century.

## Acknowledgements

I would like to thank Dr Renato G. Ridella and Dr Marco Morin for introducing me to fascinating subject of historic artillery and for all their help and guidance during the years.

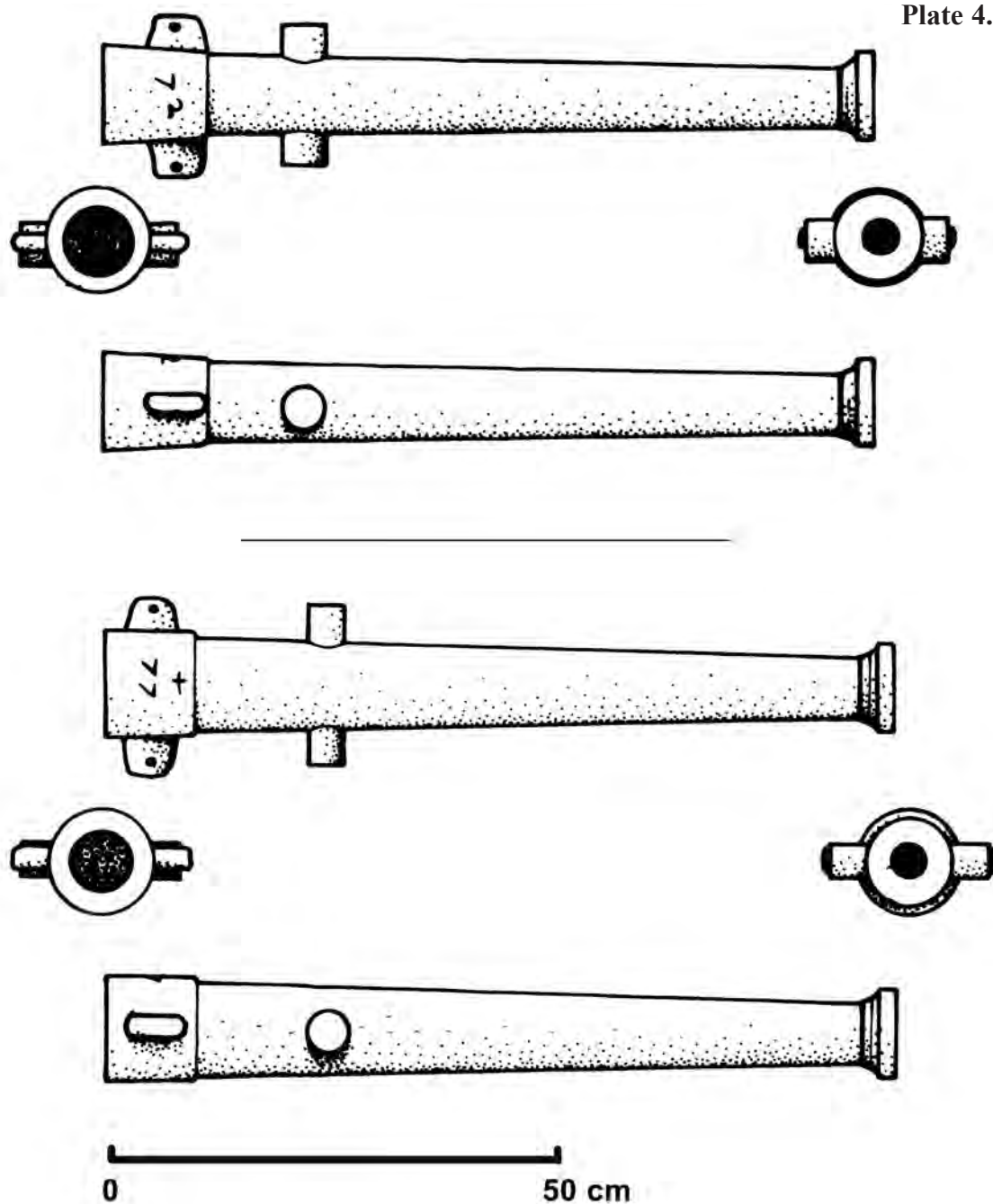
Plate 4.1



	02/2007 (top)	03/2007 (above)
Length	145.5 cm	147 cm
Bore	10.7 cm	10.1 cm
Max. diameter at the muzzle mouldings	18 cm	18 cm
Diameter under the muzzle mouldings	13.6 cm	13.8 cm
Max. diameter at the breech	19.5 cm	20.5 cm
Trunnion diameter and length	5.8/5.5 cm	5.3/6.6 cm
Stamped weight	292	330
Weight	139 kg	156 kg

Pl. 4.1. Petriere da braga 02/2007 and 03/2007 (drawing: S. Zanetto)

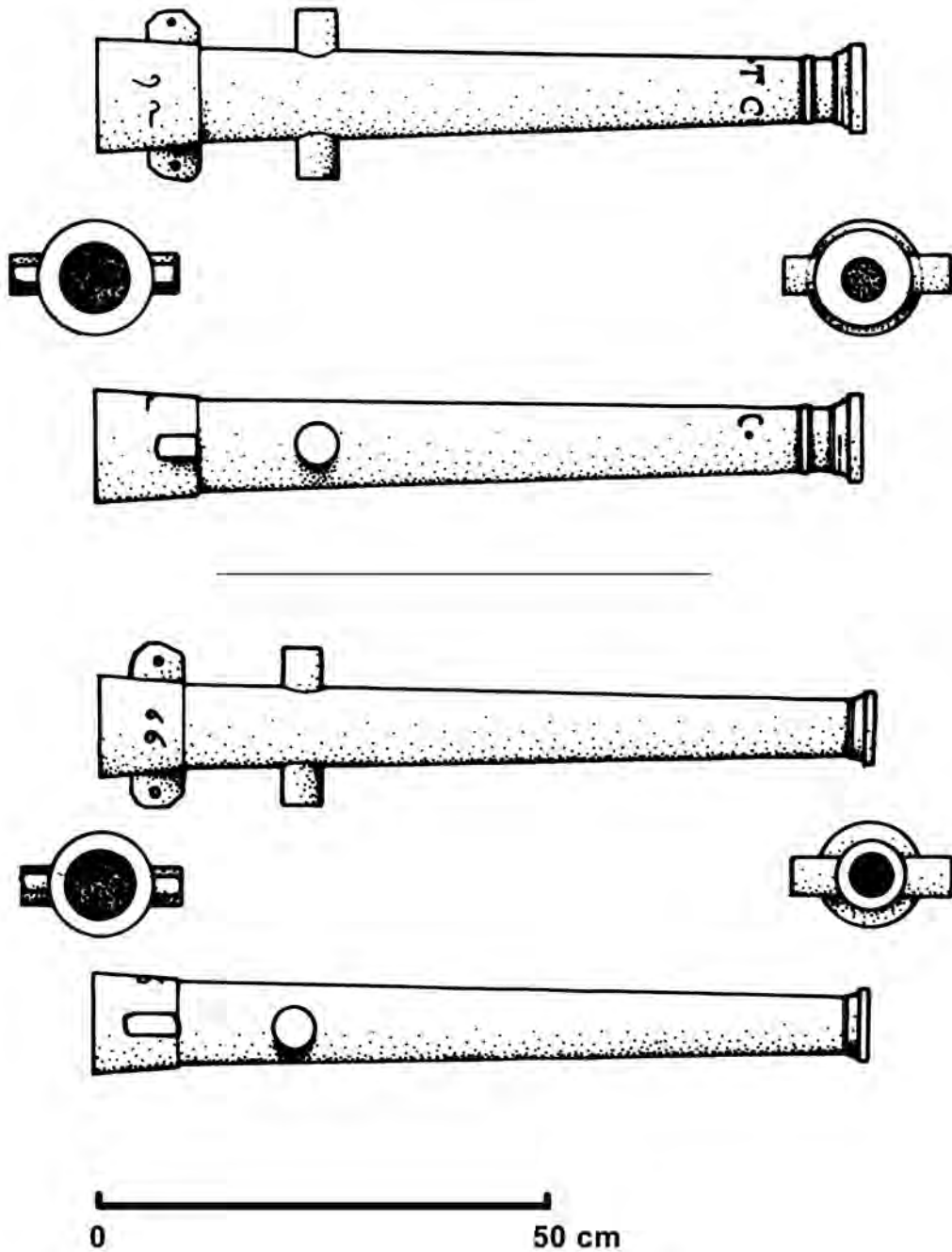
Plate 4.2



	01/2007 (top)	04/2007 (above)
Length	87 cm	89 cm
Bore	4.3 cm	4.1 cm
Max. diameter at the muzzle mouldings	9.5 cm	9.9 cm
Diameter under the muzzle mouldings	6.9 cm	7.1 cm
Max. diameter at the breech	11 cm	12 cm
Trunnion diameter and length	5/3.5 cm	4/4.4 cm
Stamped weight	72	77
Weight	33.75 kg	37.4 kg

Pl. 4.2. Moschetti 01/2007 and 04/2007 (drawing: S. Zanetto)

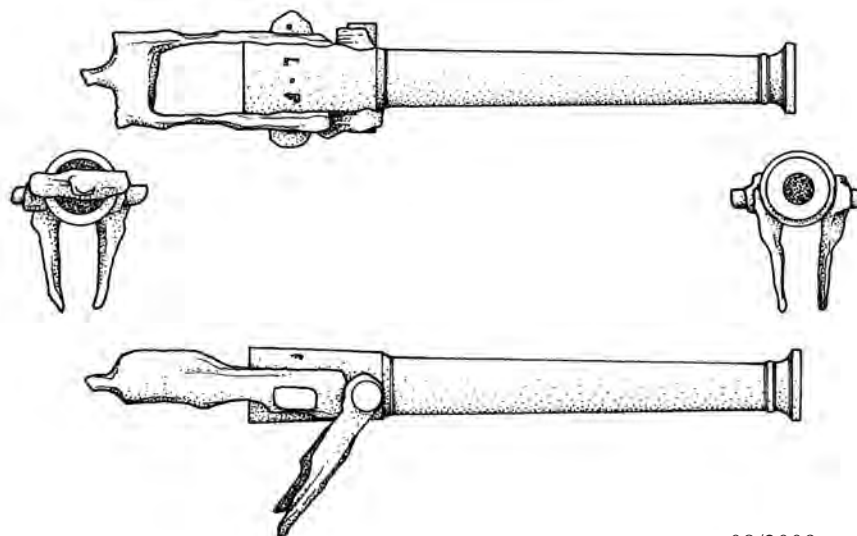
Plate 4.3



	05/2007 (top)	07/2007 (above)
Length	86 cm	87 cm
Bore	4.1 cm	4.4 cm
Max. diameter at the muzzle mouldings	10.2 cm	8.3 cm
Diameter under the muzzle mouldings	7.5 cm	6.2 cm
Max. diameter at the breech	12.5 cm	11 cm
Trunnion diameter and length	4.5/4.5 cm	4.5/4.5 cm
Stamped weight	92	66
Weight	43.3 kg	31.8 kg
Signature	T C	

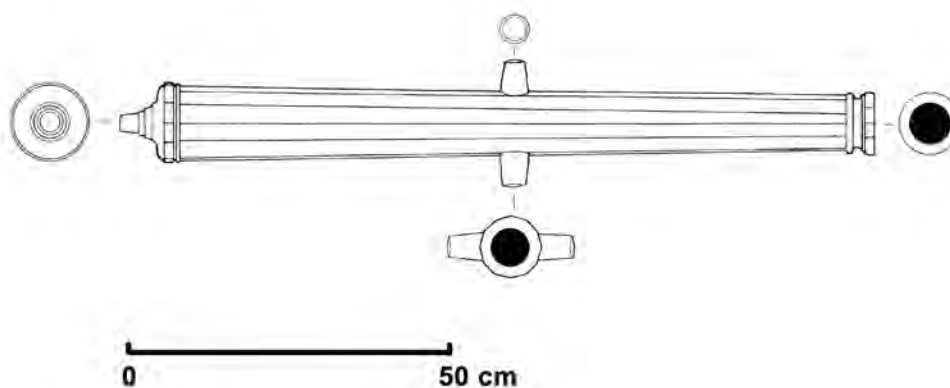
Pl. 4.3. Moschetti 05/2007 and 07/2007 (drawing: S. Zanetto)

Plate 4.4



08/2009

Lenght	86.5 cm
Lenght with preserved stout iron breech holder	116.5
Bore	4.2 cm
Max. diameter at the muzzle mouldings	10.6 cm
Diameter under the muzzle mouldings	7.5 cm
Max. diameter at the breech	12 cm
Trunnion diameter and lenght	4.5/3.5 cm
Stamped weight	/
Weight with preserved stout iron breech holder	40.75 kg
Signature	L F



06/2007

Lenght	120 cm
Bore	4.6 cm
Max. diameter at the muzzle mouldings	9.7 cm
Max. diameter at the touchhole	11.6 cm
Trunnion diameter and lenght	3.8/5 cm
Touch-hole diameter	1.4 cm
Weight	57.1 kg

## 4.3. A transport of Iznik pottery

*Vesna Zmaić Kralj*

### Abstract

*Il gruppo di reperti più rappresentativo ritrovato sul relitto era costituito da un carico orientale di ceramica di Iznik destinata al mercato occidentale. A giudicare dai motivi decorativi e dai colori di queste ceramiche si possono distinguere diverse fasi della produzione, dalle decorazioni più antiche, ispirate alle porcellane cinesi bianche e blu e agli arabeschi islamici, fino alle decorazioni floreali policrome che appaiono dalla metà del XVI fino alla fine del XVII secolo. Una tale quantità di ceramica, con un così ricco repertorio di stili, tra il carico di un relitto navale possiede un notevole valore cronologico per le produzioni di Iznik e per la storia economica e commerciale tra Oriente e Occidente nella seconda metà del XVI secolo.*

*Među najreprezentativnijim je nalazima s brodoloma svakako orijentalni trgovački teret luksuznog keramičkog posuda iz grada Iznika koji je bio namijenjen zapadnom tržištu. Prema motivima i bojama koje se pojavljuju na predmetima moguće je prepoznati nekoliko faza proizvodnje, od rane dekoracije inspirirane kineskim plavo-bijelim porculanom i islamskim arabeskama do kasnijeg višebojnog cvjetnog stila koji se javlja od sredine 16. do u 17. stoljeće. Tako široka lepeza predmeta pronađenih u zatvorenoj arheološkoj cjelini poput brodoloma ima izuzetnu vrijednost u dataciji i kronološkim odnosima proizvodnje keramike grada Iznika te odlično ilustrira gospodarstvo i trgovačke veze između Istoka i Zapada u drugoj polovici 16. stoljeća.*

### Introduction

The systematic investigation of the shipwreck at the Sv. Pavao shallow conducted from 2007 to 2012 resulted in more than 300 different artefacts being raised from the sea. The majority of items discovered is pottery, which can be divided into three groups: Italian glazed kitchen pottery, oriental kitchenware and luxury and richly decorated ceramic material from Iznik and other oriental workshops. While the Italian glazed pottery and the oriental kitchenware were parts of the kitchen equipment or belonged to the ship's crew, the luxurious oriental faience was part of the oriental commercial cargo intended for the western market. What other kinds of oriental goods besides the luxurious pottery the ship was carrying through the maritime trade route – that presumably ranged from the Bosphorus, along the eastern Adriatic coast line to Venice – has not yet been recovered.

Organic cargo probably disintegrated as a result of the destructive influence of seawater and other chemical and biological processes and some parts of the cargo still lie in the deeper parts of the site, and remain uninvestigated.

The most representative part of the cargo, a luxury faience originating from oriental ceramic workshops of the 16th century, can be divided into two main groups, according to their production centre. The first group, comprising the majority of the cargo (more than 53 specimens), came from the workshops of the Turkish town of Iznik, while the origin of the second group of six blue and white small bowls has not been ascertained, but these certainly belonged to the eastern production circuit.<sup>1</sup>

### Sector 1 (Plans 1–2)

The entire site extends in a north–south direction, about

50 m in length and 36–46 m in depth, and because of its complexity it is divided into four Sectors. Sector 1, part of the site with the highest concentration of trade and other movable artefacts, is located in the central part of the site, at a depth of 40–45 m, and covers the area of 100 m<sup>2</sup>. Presumably it represents the section of the hull with an enclosed space intended for the crew, passengers, galley, cargo and weapon storage and whatever specialised equipment the ship required.

During the six archaeological campaigns in Sector 1, the area of 100 m<sup>2</sup>, divided into 25 squares 2 × 2 m each, was excavated. Research showed that the oriental cargo was mostly concentrated in an area of 50 m<sup>2</sup>. Since the shipwreck was found in the intact state, different parts of the same pots were found during more than one campaign, therefore most of the excavated material could not be restored until the research came to its end. Every item was photographed *in situ* and measured before it was extracted; therefore the exact place of every movable artefact was registered and marked on the site map (Plans 1–2). The stratum which contained the majority of movable artefacts is, in fact, sand of a greasy and dark constitution as a result of the oxidation and disintegration of iron with the traces of soft and fragile wood and other organic items. Ceramic items extracted from this stratum were covered with greasy black soot (organic layers of iron oxide and sulphide) which, in some parts, infiltrated into the structure under the glaze. Therefore, in some cases, it was impossible to remove it entirely (Pešić, 2009: 338). On the other hand, items found in the natural pits at the sea bottom filled with pure sand, were completely clean and more or less covered with incrustation of calcium carbonate common to items found in the sea.

In the spring of 2007, during the expert inspection of the site organised by the Inspection Department and the Dubrovnik Port Authority, part of the *tazza* on the conical foot (39/2007) and a big Iznik polychrome jug (40/2007) were found in the surface stratum. In October that same year, the first campaign of systematic investigation started. During recording and documenting of the current situation of the site at the sea bottom, a complete *tazza* on a conical foot (23/2007), and part of another Iznik polychrome jug (33/2007) were found in the same stratum. Research continued in September 2008, when the underwater excavation started in Sector 1, in the part of the site with the great concentration of movable artefacts (Miholjek and Zmaić, 2013: 107). Beneath the surface sand there was a stratum of sand mixed with dark greasy soot and debris of carbonised wood. In that stratum, in the area of 20 m<sup>2</sup>, an additional 14 specimens were found: shards that belonged to two Iznik polychrome jugs (50/2008, 75/2008), a shard of Iznik dish decorated with bunches of grapes (97/2008) and a small bowl of blue and white oriental faience of undetermined origin (52/2008). In the small area, eight Iznik dishes (55/2008, 58/2008, 59/2008, 60/2008, 61/2008, 62/2008, 65/2008, 98/2008) and three small bowls (53/2008, 63/2008, 64/2008) were found. The dishes and bowls had been stacked in the manner they had been when

being packed for transport, which confirmed the hypothesis that the ship had been carrying oriental commercial cargo intended for the western market (Mihajlović *et al.*, 2012: 50). The underwater excavation at the site continued in May 2009 in the same trench and in the newly explored area. Seven new items were recorded: an Iznik polychrome jug found in many shards (99/2009), three Iznik lids with knobs (128/2009, 129/2009, 134/2009), a whole shallow dish of small dimensions in blue and white technique (113/2009), many fragments of Iznik blue and white lid belonging to a deep bowl with arabesque pattern (119/2009) and blue and white small bowl of undetermined origin.

In 2010, the investigation continued at the same trenches, and spread towards the western part of the site. An Iznik polychrome jug found as a whole (200/2010), three Iznik lids with knobs (206/2010, 211/2010, 235/2010) and a shallow dish in blue and white technique (233/2010) were found in previously opened trenches (Fig. 4.41). At the same time, six shallow dishes with the flanged rim painted in blue and white or in polychrome technique (234/2010, 240/2010, 241/2010, 242/2010, 244/2010, 255/2010) and two *tazze* in blue and white (238/2010, 262/2010) were found in the small area of the new trench. In 2011, investigation of Sector 1 was spreading in a south-westerly direction. Twenty-one new artefacts were found: two *tazza* in blue and white design (04/2011, 06/2011), five shallow dishes with flanged rims painted in blue and white or polychrome technique (02/2011, 03/2011, 12/2011, 24/2011, 34/2011), eight polychrome dishes (09/2011, 13/2011a, 13/2011b, 13/2011c, 13/2011d, 27/2011, 35/2011, 42/2011); two polychrome jugs (15/2011, 32/2011) and four blue and white small bowls of undetermined origin (08/2011, 22/2011a, 22/2011b, 68/2011). In 2012, during the investigation, one small plate in blue and white technique (02/2012) and part of the dish with *tugraques* motives (35/2011) were found.

At the end of this article there is a detailed catalogue, including all the pottery vessels discussed here, and nine plates (Pls 4.5–4.13) of related typological drawings.

### The pottery originating from the workshops of Iznik

Fifty-three artefacts found at the shipwreck most certainly originate from the Ottoman town of Iznik (Fig. 4.42). The dishes were the most common type of vessel made by the potters of Iznik and they were produced in a great variety of shapes and sizes. Likewise, they were represented in the largest number on the Sv. Pavao shallow shipwreck. Common forms are standard dishes (*Tabak*), with flanged rim (8), foliate rim (6), or rimless shallow dish (2), of which 16 were found, followed by flat dishes with narrow rim (*Sahan*) in the same quantity; nine jugs (*Bardak*) with six associated lids; six *tazze* (*Ayakli Tabak/Tas*); and finally a covered bowl (*Kapakli Kâse/Üsküre*), whose lid was the only part found so far (Plates 4.5–4.13).

When trying to analyse and evaluate the Iznik fritware from the shipwreck, we must look back and consider the



Fig. 4.41. *Sv. Pavao shallows: Iznik dishes in situ* (HRZ archive)

history and development of the Iznik workshops and their production. Iznik, the ancient Byzantine Nicea, today is a little town lying on the north shore of Lake Iznik in Turkey's Marmara region, positioned on one of the main trade routes across Anatolia to the West, about 100 km far from Istanbul (Carswell, 2006: 10). Between the 15th and 17th centuries the town was the a major centre of ceramic production, especially in tiles used to decorate monumental buildings and in very luxurious glazed pottery. The natural resources necessary for the production of ceramics, such as the essential raw materials – ranging from very fine clay adequate for pottery because of its quartz abundance, to the minerals needed for glazes and decorations – coupled with an abundance of water and forests offering a ready supply of fuel, provided exceptional conditions for the development of the ceramic industry in this area. Also, its position at the crossroads on the main overland routes provided good conditions for the distribution of Iznik pottery (Queiroz Ribeiro, 2009: 15).

The search for a porcelain-like ceramic in the Islamic world led to the fact that, by the 12th century, Islamic potters in Persia, combining clay with various ingredients like ground up quartz and glassy frit, had produced a very strong white body material that, in many respects, resembled Chinese porcelain (Denny, 2004: 49). Although many different names were applied to this type of ceramic, today the preferred name is *fritware* or *stonepaste*.

The Iznik ceramic wares also had a fritware body, whose high percentage of frit with addition of quartz soda and lead oxide set them apart from earlier pottery produced in the Islamic world. Abū'l Qāsim's classic recipe called for ten parts of silica (quartz pebbles), one part of glass frit and one part of fine white clay (Allan, 1973: 111–120). According to the latest analyses, the composition of the Iznik ceramics body comprises 65–75% quartz, 15–18% frit rich in lead and lime, 3–4% highly plumbiferous frit, and only 8–13% non-calcareous clay with a low proportion of iron oxide that was to impart a slightly pinkish hue to

the body once fired. The addition of frit, obtained from crushed glass, was indispensable here, as when molten it would form a binder between the quartz particles (Maury, 2008: 68). As the fritware paste lacked plasticity and was difficult to work on the wheel, vessels were seldom made in one piece. Instead they were formed in separate sections that were allowed to dry and then stuck together using the fritware paste. Dishes were almost certainly made using a mould attached to a potter's wheel. When the paste was partly dry the foliate rim would have been sculptured by hand. The body was then coated with a white slip used as the base for the painted decoration, also made of quartz-frit, but with finer texture, and mixed 3–8% clay with 7–11% frit (Carswell, 2006: 30). The decoration was applied with a brush using various pigments to this slip coating when dry or perhaps after an initial firing. It was coated with a transparent tin shiny, lead alkali glaze, with a median lead content of 20–40%, and a significant amount of tin oxide, 4–8% (Carswell, 2006: 30), giving the appearance of porcelain. Firing temperatures for Iznik ceramics can only be estimated and such estimations range from 850–900°C to 1200° C (Maury, 2008: 69).

The new shapes and decorations reflect a variety of sources that were developing on the substrate of an older pottery tradition in Iznik region. Some examples show a more or less literal adaptation or only the inspiration of Chinese blue and white porcelain of the Yuan and early Ming dynasties, while the others clearly show the acquisition of Ottoman court style more specifically geometric, inspired by Islamic metalwork as well as illuminated books (Carswell, 2006: 21–29; Atasoy and Raby, 1989: 79). In Ottoman documents, the term *çini* was used to refer to these high-quality ceramic wares, usually intended for the domestic market of the Ottoman Empire. Soon, they started to export them outside the Empire, particularly to Italy, where the local potters began to imitate the Iznik fritware (Atasoy and Raby, 1989: 264–268). So it is not unusual that a cargo of Iznik pottery was found on a sunken Venetian merchant ship near the island of Mljet.

During the 16th century the decoration of the Iznik pottery gradually changed in style and this can be traced on the pottery of the *Sv. Pavao* shallow shipwreck. This development can be examined in several stages.

### First phase (1480–1520)

The first phase of development of Iznik pottery is the period which covers the last part of the reign of the Fatih Sultan Mehmed (1451–1481), the reigns of Bayezid II (1481–1512) and Selim I (1512–1520), up to the beginning of the reign of Sultan Süleyman the Magnificent (1520–1566). This ceramic was painted in blue and white with fine arabesque scrollwork reflecting the style of decoration known as *rumi-hatayi*,<sup>2</sup> contemporary with a new style of decoration in book illumination developed by a palace artist known by cognomen Baba Nakkaş. Motifs such as *rumi* are arabesques on the white ground with alternating panels in white on

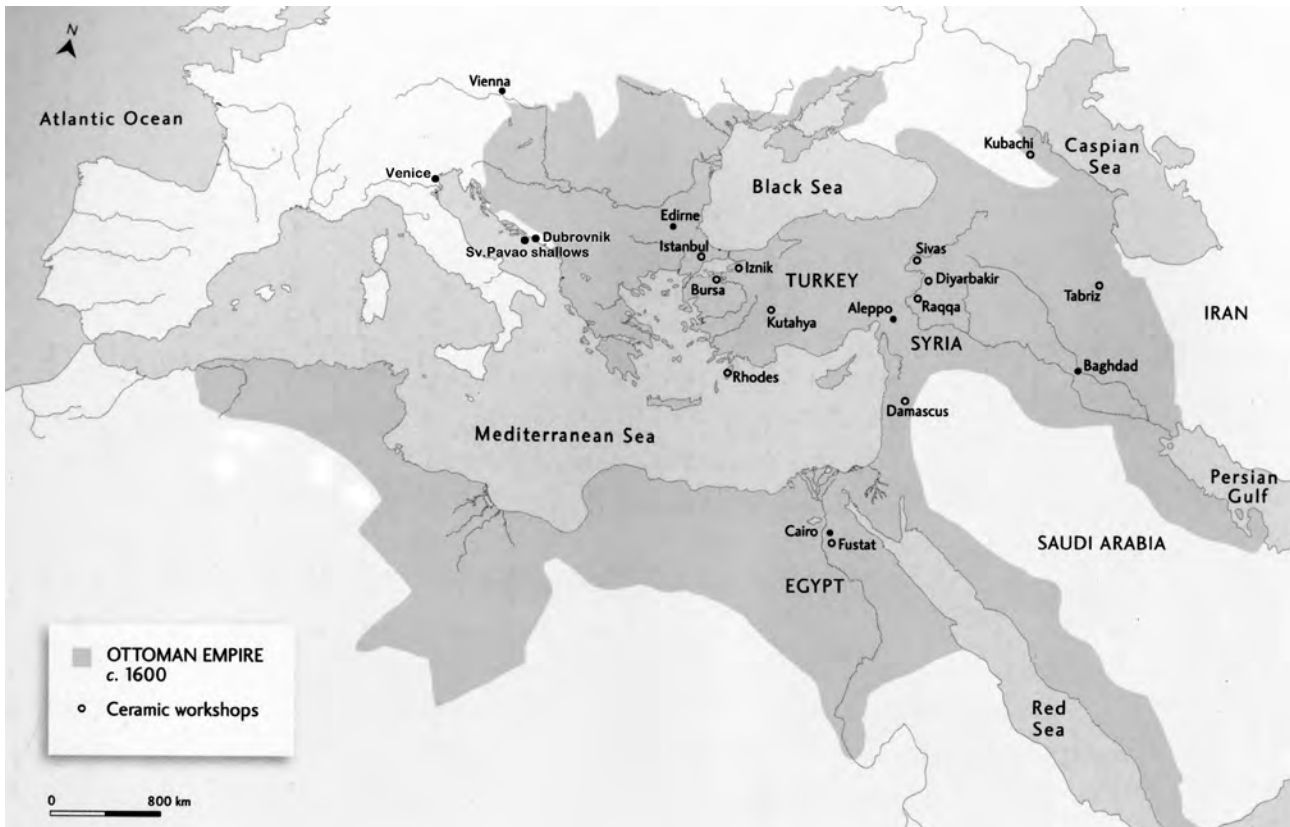


Fig. 4.42. Map with oriental ceramic workshops (after Queiroz Ribeiro, 2009: 16)

blue, based on the half-leaf forms, and *hatayi* are festoons of stylised flowers of Chinese inspiration which, combined with Islamic inscriptions, created the Baba Nakkaş style. The painting is conceived in terms of small, very detailed patterns of fine lines and intricate shading. The pottery designs are strongly highlighted in blue of consistent technical brilliance, skilfully applied in shades of varying strength. Motifs are painted in white on a cobalt blue ground or applied with dark blue lines on a medium or light blue background (Akar, 1988: 8) (Fig. 4.43). The products of this initial phase of the Iznik ceramic are not represented in the commercial cargo of the Sv. Pavao shallow shipwreck.

### Second phase (1520–1540/50)

During the 1520s Iznik fritware was undergoing important changes both at technical and aesthetic levels. Potters moved away from the Baba Nakkaş *rumi-hatayi* style known for its white on the cobalt blue ground to more flowing and free style decoration in a lighter shade of blue and a new turquoise colour obtained from copper oxide, on the white ground (Bilgi, 2009: 26). This is an interim period that appeared between two great court styles, the Baba Nakkaş and the *Saz* style, which came somewhat later (Atasoy and Raby, 1989: 101), when the several concurrent styles co-existed: the ‘*tuğra*kes spiral style’, the ‘potters’ style’ and the ‘Chinese influence’, two of which we can identify in the shipwreck cargo.

First style, developed in a Court context, was directly inspired by the background for *tuğras*, the imperial monogram of Süleyman the Magnificent. It had been popular from the late 1520s to the 1550s, and was a somewhat abstract style, with diminutive quasi-floral motifs, and no representational elements, generally painted in cobalt blue (Atasoy and Raby, 1989: 108). It consisted of fine stems arranged in spirals or forming undulating scrolls bearing tiny rosettes and minute comas or S-shaped stem hooks (Maury, 2008: 116). The earlier name for this group, the ‘Golden Horn ware’, is misleading. That term was used because of the numerous pottery shards decorated in this style found during the excavations at Aksaray and Sirkeci in the Golden Horn area of Istanbul. That suggested a manufacture in Istanbul, without any other supporting evidence. Julian Raby renamed this style the ‘*tuğra*kes spiral’ style, since large quantities of fragments uncovered during the excavations of Iznik demonstrate, without any doubt, that this group of ceramics was produced not in Istanbul but in Iznik (Bilgi, 2009: 27).

Two *tuğra*kes dishes (60/2008, 35/2011; Cat. Nos 1–2; Plate 4.5), of deep rounded form with everted foliate rim and ring foot, are almost equal in dimensions and in concept of decoration (Fig. 4.44). These are made of white paste covered with white slip and painted in cobalt blue under transparent glaze. The branches with small flowers and leaves curve in tight spirals forming seven medallions set at the central circular zone. This zone was separated from the

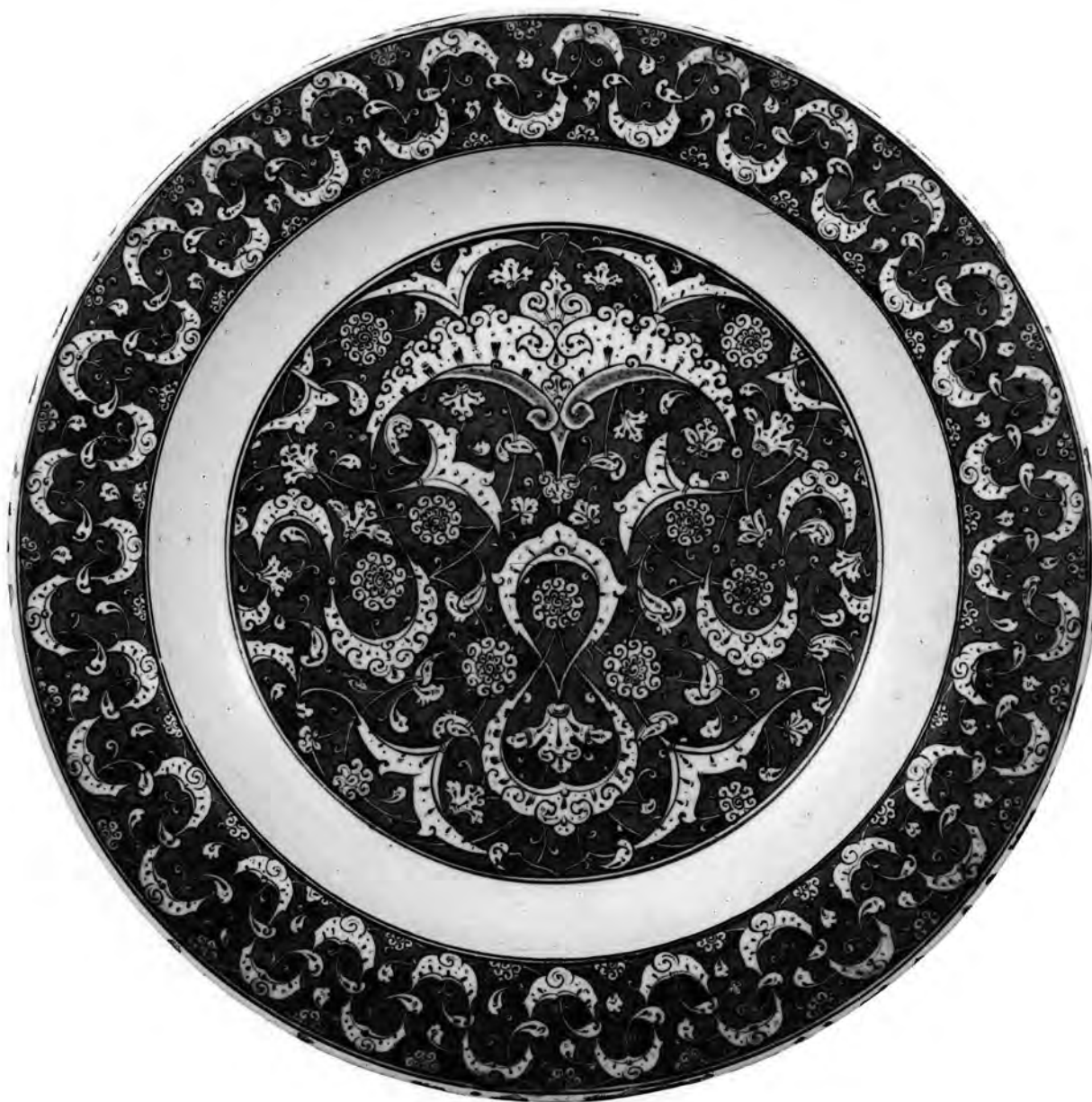


Fig. 4.43. The earliest phase of Iznik production: Baba Nakkaş 'rumi and hatayi' style (after Atasoy and Raby, 1989: 286)

rim with undulating branches of small flowers and leaves in the form of the meander by plain bands. On the underside there is a broad frieze of branches with flowers and leaves.

A number of dishes dating from this period show the influence of Italian pottery. On the other hand objects in this style were designed for the Italian market and certainly exported to Italy, where they were imitated. This was confirmed by two dishes mentioned above, found in the shipwreck cargo transported to Venice.

Another contemporary style resembled a strong Chinese influence, which led, for the first time, to direct copies of Chinese porcelain, very similar in both form and decoration. With the capture of Tabriz (1514) and the conquest of Damascus and Cairo (1517), Chinese porcelain originating from the spoils of war began to reach the court

in large quantities, enriching the collections of the Ottoman sultans (Queiroz Ribeiro, 2009: 15). For the most part, the models were not contemporary 16th century items, but the great Yuan and early Ming porcelains of the 14th and 15th centuries (Atasoy and Raby, 1989: 121). The most frequently imitated motif was, however, the wave and rock border, inspired by the Chinese prototype from the Yuan dynasty (1260–1368) which became an almost constant feature in the decoration of the rims on the Iznik dishes (Atasoy and Raby, 1989: 12; Queiroz Ribeiro, 2009: 23). The most influential models of the Ming period (1368–1644) from the early 15th century that served as inspiration for the potters of Iznik were 'bunches of grapes among the vine leaves', the 'lotus bouquet' and the 'flower scroll'.

The last design, the 'flower scrolls' can be seen on a



Fig. 4.44. Iznik dish of the 'tuğrakeş spiral' style (60/2008) (photo: R. Mosković, HRZ archive)

dish (55/2008; Plate 4.5) from the shipwreck (Fig. 4.45). It was a dish of deep rounded form with everted foliate rim and ring foot, decorated in cobalt blue. The central motif is lotus flower surrounded by seven lotuses linked by scrolling branches and leaves. Around the rim there is another motif influenced by Chinese porcelain, a 'wave and rock' border and the underside is decorated with alternating palmettes and single *çintemani* spots.

Another contemporary model influenced by Chinese porcelain can be seen on Iznik dish with 'bunches of grapes' (97/2008; Cat. No. 4; Plate 4.7). A dish of rounded form with everted rim and ring foot is decorated in cobalt blue and green. Like the Chinese models, there is a composition of three bunches of grapes in the centre surrounded by vine leaves in blue and green with black outlining, the floral sprays in the *cavetto* and a wave and rock border around the rim. The underside is decorated with alternating rosettes and two leaves motifs. Decoration on the dish presents a considerably richer palette: black for the outlines and the bright emerald green for vine leaves, details of the rim, and leaves of bouquets. The colour scheme with emerald green was introduced in the late 1560s (Atasoy and Raby, 1989: 129), which allows the approximate dating of this dish



Fig. 4.45. Iznik dish with 'flower scroll' decoration (55/2008) (photo: R. Mosković, HRZ archive)

and suggests that popular motives like 'bunches of grapes' continued to appear on Iznik pottery in the second half of the 16th century. The other favourite design schemes like 'tuğrakeş' or the 'flower scroll' were combined with new colour schemes and circulated through the entire period of Iznik production. Therefore, four dishes mentioned as representatives of the second phase probably do not belong to that early period but to a production period in



Fig. 4.46. Iznik dish of 'Saz' style (58/2008) (photo: R. Mosković, HRZ archive)

the second part of the 16th century, which overlaps with the shipwreck date in the last third of the 16th century, confirmed by other datable finds like coins.

### Third phase (1535–1560)

The classical Ottoman style started to develop during the second quarter of the 16th century, when Şah Kulu, serving as a court artist under Süleyman the Magnificent (Bilgi, 2009: 26), had introduced the so-called Saz style into Ottoman art. Iznik pottery started to make three-dimensional decorations of masterly performance and originality. This sudden leap forward in artistic achievement was accompanied by an expansion of the palette used. Besides blue, first they started to use turquoise and then olive green, manganese purple and pale grey. Designs represent the illusion of nature (Atasoy and Raby, 1989: 129), based on intersecting arabesques, *saz* leaves and flowers transformed into hybrids almost unknown to nature, or more naturalistic sprays of tulips, hyacinth, pomegranates, artichoke and roses. Compositions on the dishes provided a vertical orientation, presenting the bouquets springing from a leafy tuft or centralised design with a rosette or arabesque surrounded by other similar motifs (Carswell, 2006: 63). Saz style was, at the end of the 19th century, mistakenly referred to as the 'Damascus phase', since this colour scheme was found in Damascus on a significant number of vessels and tiles (Maury, 2008: 120). As in the previous phase, there are several developmental and contemporary styles: initial 'blue and turquoise' (1530s) and 'blue-turquoise and green' (1540s) styles, the 'pomegranate, artichoke and tree' style (1540–1545), the 'Saz leaf and rosette' (1545–1560), the 'Musli group' (1540–1560) and the last, transitional style towards the fourth phase: the 'Master of the hyacinths' (1555–1560) (Atasoy and Raby, 1989: 129–144).

The initial phase of the 'Saz' style with unique decorative surface can be seen on two almost identical dishes from the shipwreck. Contrary to the previous styles, with the obvious presence of *horror vacui*, a new design introduced an economical use of decoration. The major innovation is the treatment of the entire dish as a single, unbroken decorative surface which makes these pieces the forerunners of 'Saz' style of the 1540s.<sup>3</sup> The first dish (58/2008; Cat. No. 5; Plate 4.7) of rimless deep rounded form with ring foot, is made

of white paste covered with white slip painted in cobalt blue and turquoise under transparent glaze. In the centre there is a big leaf of the plane tree (*chinar*) in cobalt blue and turquoise, deeply lobed with a smaller leaf and round burr-like fruit on the same stem. Eight chinar leaves and s-cloud motifs surrounding the central motif (Fig. 4.46). The underside is decorated with alternate compositions of s-cloud motifs and round burr-like fruit.

Another dish comprises two pieces of the same vessel found in different campaigns (59/2008, 250/2010; Cat. No. 6 and Plate 4.7). It is almost identical in dimensions and concept of the composition as the previous one, but with six chinar leaves instead of eight around the central motif and chinar leaves on the underside decoration.

During the second quarter of the 16th century (1540–1560), Iznik ceramic wares marked a renewal of the repertoire with emphasised aesthetics of the Islamic styles from the first and the second phases. This period has been termed by N. Atasoy and J. Raby as the "circle of Musli", according to the mosque lamp of 1549, the best documented Iznik object, which was dated and signed by a painter called Musli (Atasoy and Raby, 1989: 135). The characteristics of the style are the minor design elements such as the cloud bands, which are bound by small flowers, cartouches, medallions or half-medallions of arabesque interlace and the circular knots in the new colour range. A dish of these characteristics was found in the cargo of Sv. Pavao shipwreck (65/2008; Cat. no. 7; Plate 4.5). It has a deep rounded form with everted foliated rim and ring foot with decoration in cobalt blue, turquoise, sage green, greenish black and manganese purple, based on intersecting arabesques. In the centre there is a four-pointed star decorated in rich arabesque pattern surrounded by interchanging bouquets of flowers and medallions filled with the cloud bands. The central motif was mirrored on the edges spreading without restraint to certain zones, the rim, *cavetto* or the bottom (Fig. 4.47). Around the rim there is a border of interchanging tiger strips and trefoil motifs, and the underside is decorated with alternating rosettes and bouquets of tulips.

Towards the end of the 'Saz' style (1555–1560) a new trend with a transitional character appeared, which Atasoy and Raby named the "Master of the hyacinths" (Atasoy and Raby, 1989: 138). It relies on the past in the use of 'Saz' style elements painted in blue, turquoise, purple and sage green with greenish-black outlines, and it insinuates the future design with the hyacinth motif, which became popular in the second half of the 16th century. The rim is framed with a distinct variant of the Chinese wave border. For the first time, this type of border is used in combination with the Ottoman style floral centre, which encompasses both the well and the *cavetto*. This compositional structure and the combination of the rim and floral centre became standard in the second half of the 16th century (Atasoy and Raby, 1989: 138).

All stated features of style can be seen in a dish (62/2008; Cat. No. 8; Plate 4.5) of deep rounded form



Fig. 4.47. Iznik dish of 'Saz' style – 'circle of Musli' (65/2008) (photo: R. Mosković, HRZ archive)

with everted and softly foliated rim and ring foot. It is decorated over white slip under a transparent glaze in pale blue, manganese purple and olive green. In the centre there is a composition with a hyacinth bouquet, springing from a leafy tuft (the base of composition with this detail is not preserved), providing a vertical orientation for the composition. A border of the wave and rock motif was accomplished in the new manner (Fig. 4.48). The underside is decorated with alternating rosettes and bouquets of tulips.

#### Fourth phase (1560–1600)

The second half of the 16th century was a period when the Ottoman Empire, under the reign of Süleyman the Magnificent, reached its political, economic and cultural height. Monumental and public buildings were constructed in large number and, together with these, grew the enormous quantities of Iznik tiles commissioned by the court as a result of the fashion for tile decoration, initiated by chief court architect Sinan (Bilgi, 2009: 30). The influence of the court design studio can be felt strongly in pottery decoration, dominated by a naturalistic style. In the



Fig. 4.48. Iznik dish of the 'Saz' style – 'Master of the hyacinths' (62/2008) (photo: R. Mosković, HRZ archive)

middle of the 16th century the illuminator Kara Memi was appointed head of the court studio when the naturalistic floral repertoire, 'şükûfe', came to predominate. The new floral decoration, the so-called 'four flower' style, after



Fig. 4.49. Iznik dish in polychrome style with 'four flowers' decorations, (61/2008) (photo: R. Mosković, HRZ archive)

the four principal floral types of tulip, carnation, rose and hyacinth (Atasoy and Raby, 1989: 222) began to appear along with the other Chinese-inspired flowers: lotus, chrysanthemum and peony.

Novelty and style characteristic was also represented in the new colour scheme based on the new combination of bright red pigment, the Armenian red, obtained from the iron oxide, and a very fine emerald green (Maury, 2008: 70), although the earlier olive green and purple was still in use. The new red, a colour favoured by Kara Memi, was not used in a thin layer like the other colours; it was applied in thick relief which looked like sealing-wax (Figs 4.49–11) (Atasoy and Raby, 1989: 221). The motifs were used to form an infinite diversity of composition, radiating from central point, symmetrical or free compositions, in which harmony between motifs and colours was one of the fundamental rules to which the decorators adhered (Bilgi, 2009: 32). This group of pottery was mistakenly described as "Rhodes ware", because a collection of about 600 pieces of this type of product was brought from Rhodes to the Musée de Cluny in Paris in the 19th century (Bilgi, 2009: 30–31). The recent excavation in Iznik brought to light finds proving they had been manufactured not in Rhodes but in Iznik.

This peculiar style can be traced on several specimens

of Iznik fritware from the shipwreck. The dish (61/2008; Cat. No. 9; Plate 4.7) in polychrome style of deep rounded form with everted rim and ring foot is decorated in pale blue, olive green and relief red with black outlining. It belongs to the earlier part of the 'four flowers' phase of decoration on Iznik pottery, before the emerald green came into use in the mid-1560s. The composition of roses, tulips, stems of red *Prunus*, hyacinths and branches of pale blue blossoms springing from a leafy tuft, is on the bottom of the decorative field of the dish, providing a vertical orientation for the design (Fig. 4.49). Around the rim there is a wave motif border and the underside is decorated with alternating rosettes and bouquets of tulips.

Another dish (42/2011; Cat. No. 10; Plate 4.6) of deep rounded form with everted rim and ring foot, is decorated in cobalt blue, emerald green and relief red with black outlining. In the centre there is a symmetric composition with branches of *Prunus* blossom and bluebell flowers around the stylised pomegranate and leaves motif, springing from a leafy tuft. Around the rim there is a wave motif border, that became a common motif on the dishes, and the underside is decorated with alternating rosettes and bouquets motifs.

On the fritware from the period of Selim II (1566–1574),



Fig. 4.50. Iznik flat dish with symmetrical 'four flower' decoration (244/2010) (photo: R. Mosković, HRZ archive)

and Murad III (1574–1595) reign, the polychrome floral decoration in the style of Kara Memi continued to be used. The favoured shape of this period was the dish with a narrow flat rim. The choice of this shape and the use of guilloche, cabling or half-rosette borders indicates that the type was introduced in the 1570s or 1580s (Atasoy and Raby, 1989: 254). Some of these characteristics can be seen on the dish (244/2010; Cat. No. 11; Plate 4.10) made in the brilliant polychrome style in the floral symmetry. The flat dish with a narrow rim and the ring foot is painted over the white slip under a transparent glaze in cobalt blue, olive green and relief red, with black outlining. In the centre there is a symmetric composition of tulips and roses springing from a leafy tuft and enclosing three primroses springing from a small dish (Fig. 4.50). The underside is decorated with alternating single *çintemani* spots and double-leaf motifs.

The same floral symmetrical decoration and the use of half-rosette borders can be seen on the polychrome jug found without the curved handle (40/2007; Cat. No. 37; Plate 4.11). The jug has a flaring neck and ovoid body, with conical foot. It is painted in cobalt blue, olive green, and relief red with black outlining. This shape of jug started to appear during the 1560s. The body is decorated in the 'four flower' decoration with six decorative fields separated by branches of serrated, 'Saz' leaves. Decorative fields are arranged alternately with roses springing from a leafy tuft and a bouquet of nine flowers, providing a vertical orientation for the design. The same pattern is repeated on a smaller scale on the neck. Around the shoulder there is a band of leaves (Fig. 4.51) and around the base there is a guilloche border.

The composition of the shallow dish with the narrow rim (34/2011; Cat. No. 12; Plate 4.10) is decorated with the so-called *çintamani* motifs. Its first appearance in Iznik

ceramic dates from the first quarter of the 16th century, but its more intensive use occurred in the period 1580–1585. Three circles represent the spots of the leopard's fur and two stripes the tiger's fur, symbolising the strength and courage (Queiroz Ribeiro, 2009: 80). On the dish, the *çintamani* motif is presented in the criss-cross form, as in the case of the Chinese porcelain dishes from the Yuan dynasty, which confirms one more of many Chinese influences. A composition is painted in cobalt blue, green and relief red, with black outlining. The centre of the plate is divided diagonally into squares by pairs of green and red tiger stripes, each filled with *çintemani* spots. A border of stylised half-rosettes appears around the rim while the underside is decorated with alternating single *çintamani* spots and leaf motifs.

It seems that *çintamani* and tiger stripe motifs were more frequently used in painting closed forms like jugs, considering that five of eight found of the shipwreck were painted in this motif. Unfortunately, most of them were found in many shards, but an Iznik Polychrome *çintamani* jug (200/2010; Cat. No. 38; Plate 4.12) was found almost whole (only a part of the rim is missing). A jug of compressed globular form has a cylindrical neck, ring foot and s-shaped handle; it is painted in underglaze pale blue, green and relief red and outlined in black with a pattern of triple and single *çintamani* spots interposed by tiger stripes. The body is separated by a horizontal guilloche border with a frieze of stylised petals, on the base is single guilloche border, while a scrollwork border runs around the rim (Fig. 4.52).

Two specimens found in fragments that cannot be put together (50/2008; Plate 4.12) and (32/2011) have the same decorative scheme with only a few differences in some details, while the polychrome jug (99/2009; Cat. No. 39; Plate 4.12), found in many pieces without the



Fig. 4.51. Iznik polychrome jug with floral decoration (40/2007) (photo: R. Mosković, HRZ archive)



Fig. 4.52. Iznik polychrome çintamani jug (200/2010) (photo: R. Mosković, HRZ archive)

handle, is decorated only with tiger stripes in the different combination of colours, in pale blue, green and relief red with black outlining. One jug (75/2008; Cat. No. 40; Plate 4.12), found without the rim, base and handle, instead of *çintamani* spots, has rosettes in combination with tiger stripes. Six fritware lids, which presumably belonged to these jugs, were also found on the site (128/2009, 129/2009, 134/2009, 206/2010, 211/2010, 235/2010; Cat. Nos 42–47; Plate 4.11). These had the cone or domed shape with knob, decorated with the frieze of stylised leaves or alternating leaves and *çintamani* spots in cobalt blue and turquoise with black outlining.

At the same time, during the reign of Selim II and Murad III, despite the general tendency of Iznik ceramics to favour a bright polychromy, the taste for cobalt blue and white designs endured, and was renewed with a whole range of distinct motifs from the first half of the century (Maury, 2008: 70). A highly diversified repertoire expressed in the blue and white decoration was based on the Chinese early 15th century 'floral scroll' design, which the Iznik potters first adopted in the 1530s on the dishes with 'triple-scroll' ground, in the 'wheatsheaf' style and in 'kaleidoscope and abstract' design of the 1570s and 1580s (Atasoy and Raby, 1989: 237–245).

The *çintamani* decoration frequently appears as triple scroll ground on the later blue and white dishes, but in the more stylised form. One example of the dish (13/2011d; Cat. No. 13; Plate 4.5) of deep rounded form with everted

foliate rim and ring foot, has a 'three-like' motif at the centre surrounded by leaves on the branches inspired by Chinese Ming productions. The central motif on the triple-scroll ground, which seems reminiscent of the *çintamani* motif, is set in a double ring encircled by a frieze of palmettes. Around the rim there is a border of wave motif and the underside is decorated with alternating single *çintamani* spots and the blossom motifs.

The later blue and white style most frequently appears on so-called *tazza* (*Ayakli Tabak/Tas*), the uniquely Ottoman ceramic form without Chinese, Persian or European influence. *Tazze* takes the form of deep dishes, or shallow bowls, on a high foot (Plate 4.8) (Atasoy and Raby, 1989: 45). In the Sv. Pavao shipwreck cargo six *tazze* decorated in blue and white motifs of different variants have been found so far. On the composition of the *tazza* (23/2007; Cat. No. 14; Plate 4.8), the Chinese scheme of a central open flower with radiating leaf branches opening outward on the triple scroll ground was applied, painted in cobalt blue (Fig. 4.53). Around the rim there is a renewed wave motif border while the underside is decorated with alternating single *çintamani* spots and trefoils.

Another *tazza* (262/2010; Cat. Nos 15; Plate 4.8) is decorated with a central rosette surrounded by scrolling branches with flowers and leaves in cobalt blue. Around the rim there is the same wave motif border and the underside is decorated with alternating rosettes and trefoils motives.

The late 15th and early 16th century Chinese porcelain



Fig. 4.53. Iznik later 'blue and white' tazza (23/2007) (photo: R. Mosković, HRZ archive)



Fig. 4.54. Shallow dish with the 'wheatsheaf' style (52/2008) (photo: R. Mosković, HRZ archive)

inspired another group of later blue and white Iznik ceramic painted with lotus and peony scrolls comprising pointed leaves, and high-arching meander around the central, free-floating rosette. These scroll compositions are distinctive in their decorative motif: a long barbed leaf which looks like an ear of wheat. This motif became the most popular element in the later decoration, from about the 1570s to 1600s, that Julian Raby defines as the "peony and wheatsheaf" style (Atasoy and Raby, 1989: 237–239).

The *tazza* (39/2007; Cat. No. 16; Plate 4.8) on the high foot with everted floriated rim is the earlier example of

wheatsheaf style. It was decorated in a blue and white floral scroll style inspired by Chinese porcelain designs with the central motif (not preserved) surrounded by six peonies linked by scrolling branches, small leaves and wheatsheaf motif. Around the foliated rim there is a border with an alternating wheatsheaf and cloud bands motif that is repeated on the underside of the *cavetto*, and around the foot.

Another *tazza* of the 'wheatsheaf' style (04/2011; Cat. No. 17; Plate 4.8) has a floral scroll in the form of a heart at the centre, encircled by a frieze of palmettes. Around the rim there is a 'wheatsheaf' style border like that on the previous

*tazza*, while the underside is decorated with *çintemani* spots and spirals. The *tazza* (06/2011; Cat. No. 18; Plate 4.8) has a centralised composition with a stylised rosette at the centre rounded with the floral scroll in 'wheatsheaf' style. The rim is decorated with wave motifs and the underside with alternating *çintemani* spots and the trefoil motifs.

Three shallow dishes with narrow rim and ring foot are decorated in the same style. The first example (242/2010; Cat. No. 19; Plate 4.10) has a circular medallion at the centre with a peony flower on the scrolling flowering branch which, together with the 'wheatsheaf' motifs, forms the shape of a heart. Around the rim there is in the new concept of border consisting of small leaves arranged in a zigzag pattern and the underside is decorated with alternating single *çintemani* spots and blossom motives. Another shallow dish (02/2012; Cat. No. 20; Plate 4.9) has a circular medallion at the centre with a central rosette surrounded by the scrolling flowering branch in the 'wheatsheaf' style. As on the previous example the border around the rim is arranged in the zigzag pattern and the underside is decorated with alternating *çintemani* spots and blossom motives. Decoration done in the same manner appeared on the shard of the shallow dish (255/2010; Cat. No. 21; Plate 4.10), with the same zigzag border and floral scroll concept, but without the 'wheatsheaf' motif.

Two very fragmented shallow dishes with almost identical decoration belong to the group of blue and white technique with (52/2008; Cat. No. 22, Plate 4.10) or without the 'wheatsheaf' motif (233/2010; Cat. No. 23, Fig. 4.54). The difference is visible in a shade of cobalt blue turning into anthracite grey on two specimens. Due to the different structure, glaze and pigments, it was believed that these items belonged to other oriental workshops (Pešić, 2009: 347–348), but it seems that they were the product of late Iznik production, under the obvious influence of style decline. Thinner walls of bad quality and cracked glaze are typical for later items that follow the late Iznik production in style and motives. All of the dishes (mentioned previously) have the flanged rim, ring foot and composition decorated with floral motif in the central medallion surrounded by circular high arching, meander scrolls with flowers, 'wheatsheaf' motifs or cloud bands, inspired by the late 15th and early 16th century Chinese forms. Around the rim there is a border consisting of scrolls resembling the clouds, and the underside is decorated with the trefoil motifs.

Another style of decoration used by Iznik potters during the reigns of Selim II and Murad III is based on abstract geometrical elements arranged in various different radial forms and it is well presented in the cargo of the shipwreck. It is an abstract style closer to the tradition of Islamic pottery, characterised by concentric compositions using centralised motifs enclosed in a circular medallion and then encircled by different radial forms. Julian Raby defines it as "kaleidoscope and abstract" design (Atasoy and Raby, 1989: 240). Very often the design radiates from the rosette flower at the centre encircled by the frieze of

palmettes, while the background is filled with tight spiral wave scrolls, as on the blue and white dish (09/2011; Cat. No. 24; Plate 4.6). The transparent glaze is disappearing due to the conditions on the sea bottom, which has caused fading of the cobalt blue and contours of the drawings, but restoration made the composition visible. The central arabesque motif in the kaleidoscope manner is encircled by the frieze of palmettes and a border of wave motif, while the underside is decorated with alternating rosettes and free brush strokes.

The same concept of decoration appears on the lid (119/2009; Cat. No. 25; Plate 4.7) belonging to a deep bowl that still to be recovered. Covered bowls on the pedestal foot (*Kapaklı Kâse/Üsküre*) derive their shapes from Islamic or Ottoman metal prototypes called *tombak*. The fragmented lid has a profiled dome shape missing the top with a knob. It is decorated with blue and white arabesque pattern with stylised lilies that radiate from the centre, on a background of tight spiral wave scrolls, with a border of half-rosettes around the rim.

A different concept of concentric compositions with central medallion encircled by a palmette frieze is found on some pieces, such as the *tazza* in blue and white technique and on the group of shallow dishes painted in blue and relief red. The *tazza* (238/2010; Cat. No. 26; Plate 4.8) is coloured in cobalt blue, with a medallion at the centre encircled by a frieze of eight palmettes and the wave motif border around the rim. The underside is decorated with single *çintemani* spots and trefoils.

This same concept appears on four shallow dishes with narrow rim, in combination with cobalt blue and relief red (241/2010, 24/2011, 02/2011, 03/2011; Cat. Nos 29–32, Plate 4.9). The composition is made of six palmettes that radiate from the central medallion. The use of half-rosette border and the decoration of alternating single *çintemani* spots and petals on the undersides are applied on all specimens.

Another shallow dish (113/2009; Cat. No. 27; Plate 4.10) has a design with a radiated frieze made of the elongated palmettes resembling arcades in blue and white technique. The circular motif that radiates from a rosette set at the centre is divided into 15 arcades filled with four small trefoils. Around the rim there is a frieze of half-rosettes and the underside is decorated with alternating single *çintemani* spots and trefoils.

A similar motif of elongated palmettes appeared on the polychrome jug (15/2011; Cat. No. 41; Plate 4.12) which can be dated to 1590s according to analogue examples (Gezira Museum, Cairo, inv. no. 324) and it represents the latest Iznik item in the shipwreck cargo. The jug found without the handle has a flaring neck and ovoid body with conical foot. The body is divided into 20 vertical arcades arranged alternately in blue and green, containing branches of blossom. Around the rim there is a cabling border in blue, black and red and around the shoulder and at the base of the body there is a guilloche border.

Towards the end of the 16th century a wider repertoire



Fig. 4.55. Iznik flat dish with decline in quality of the decoration (240/2010) (photo: R. Mosković, HRZ archive)

of motifs was depicted on the Iznik vessels, like human figures and animals amongst floral motives, sailing ships on the open sea, architectural motifs and mythical fantastic creatures. Griffins, dragons, sirens, harpies, two-headed eagles, the phoenix and the simurgh are some of the fantastic creatures that form part of the animal decoration of Iznik pottery. This symbolism dates back not only to classical antiquity, but also to the Chinese, Indian, Persian and Christian traditions, acquiring its own particular iconography in each culture (Queiroz Ribeiro 2009, 73). In the group of dishes with the mythical fantastic creatures on the green-ground, two polychrome dishes (13/2011a, 13/2011b; Cat. Nos 33 and 34; Plate 4.6) are included, depicting the scene with confronted harpies. The dishes have a deep rounded form with everted rim and ring foot. They are decorated in cobalt blue, turquoise, green and relief red with black outlining. In the central circle there is a symmetric composition of two confronted harpies flanked by a column with flower bowls surrounded by branches of white flowers on the green-ground. Around the central circle there is a border of half-rosette motives and a wave motif around the rim, while the underside is decorated with alternating rosettes and bouquets motives.

### Fifth phase: decline

At the same time, the last quarter of the 16th century represents the beginning of decline in the quality of Iznik pottery. The decline will be reflected much clearer during the following 17th century, which can be linked to the slow decay of the Ottoman Empire and the loss of patronage by the Ottoman court (Carswell, 2006: 106). Another important factor was that from the middle of the 16th century increasing quantities of Chinese porcelain were

imported into Ottoman Empire and the Iznik craftsmen failed to compete with the high quality imports. The mass production of cheaper vessels for the market place and a wide distribution outside the Empire led to a gradual decline in quality (Bilgi, 2009: 32). There are no more new techniques, colours or designs that could incite a future development. Although the decoration did not greatly change in terms of composition, there was a regression in technique, which is clearly evident on some specimens from the shipwreck.

The shallow dish with the narrow rim (240/2010; Cat. No. 28; Plate 4.9) is decorated in blue with a large stylised flower at the centre encircled by a band of half-rosettes and wave motif in the decline technique (Fig. 4.55).

Another shallow dish (12/2011; Cat. No. 36; Plate 4.9) is painted pale blue with the circular medallion at the centre, rounded by two simple cloud bands connected with radiating motif. The border around the rim is arranged in the zigzag pattern.

Same example of the style decline is visible on the shallow dish (234/2010; Cat. No. 35; Plate 4.10) decorated in pale blue. At the centre there is a rosette encircled by five motifs consisting of stylised flowers surrounded by small leaves and a half-rosettes motif border around the rim. The decline in quality on all specimens previously mentioned is noticeable in the paste and glaze as well as in the colours, while the decoration became less detailed and was performed clumsily.

### Blue and white bowls of undetermined origin

Besides fritware originating from Iznik workshops, six small blue and white bowls were found on the site, still



Fig. 4.56. Blue and white Oriental bowl of undetermined origin (63/2008) (photo: R. Mosković, HRZ archive)

of undetermined origin. The bowls were intended for the western market like the Iznik fritware. They were found stacked for transport next to the group of Iznik dishes. All the bowls are of approximately the same dimensions and shape, of small size from 12–13 cm in diameter and 5.3–6 cm in height. Their form derives from a typical Chinese small size bowl with a narrow foot and flaring rounded rim. The bowls belong to the Islamic pottery of fritware body covered with white slip and decorated in cobalt blue under a transparent glaze. Unlike the glaze on the Iznik fritware, the glaze on the bowls is of inferior quality, which can be clearly seen in its cracked surface. Although the form and decorative patterns of the bowls derive from the Chinese 15th century Ming *minyao* blue and white export ware,<sup>4</sup> the general concept of their decoration is more geometric than genuine Chinese design and thus closer to the principles of the Islamic art.

Three bowls (53/2008, 108/2009, 68/2011; Cat. Nos 48, 51, 53; Plate 4.13) from this group are decorated only on the inside. The border around the inside rim consists of small leaves arranged in a zigzag pattern and in the centre there is a medallion with an abstract motif. On two specimens this central motif looks like some kind of very distant reminiscence of a popular Chinese ‘rock and flower’ motif, while the third bowl has a round medallion divided into 12 fields and it makes a completely stylised rosette. However while the rim still retains some details of its Chinese origin, the motif on the centre, although of vegetable origin, does not correspond to the Chinese originals.<sup>5</sup> Two further bowls (64/2008 and 08/2011; Cat.

Nos 50 and 52; Plate 4.13) have the same decoration in the centre as the previous specimens, but on the outside the highly stylised undulating scroll design is applied, more abstract than vegetable composite blossoms, linked by scrollwork from the Chinese prototypes.

Another bowl (63/2008; Cat. No. 9; Plate 4.13) follows the form and pattern of early 15th century Chinese *lianzi* bowls, but in much simpler performance (Fig. 4.56). The radiating spear-like leaves on the outside are the painted equivalent of the carved lotus-panels on celadon of the Song dynasty (AD 960–1279), performed in a new, more Islamic manner (Carswell, 2006: 62). Around the rim there is a simple border of double horizontal thin line and in the centre there is a round medallion with rosette.

The origin of these ceramic bowls has not been determined so far, but they certainly belong to the Oriental production. In view of the decorative patterns, their shape and characteristically cracked glaze, they were previously attributed to the Persian workshops of the 16th and 17th century, during the reign of Safavid dynasty (1501–1722) (Pešić, 2009: 348). Pottery produced in the 16th century Sefavid workshops rarely survive and preserved pieces mostly belong to the later 17th century period (Crowe, 2008: 75–79). Therefore, no analogical items were found to confirm that origin.

Finally, if we take into consideration the similarities in quality of the fritware body and glaze between bowls mentioned previously and two very fragmented blue and white shallow dishes (Fig. 4.54), belonging to the Iznik workshops because they have the design of the ‘wheatsheaf’



Fig. 4.57. Iznik polychrome dish with coat of arms (after Atasoy and Raby 1989: fig. 736, Ashmolean Museum, Oxford, inv.no. x 3260)

motif, the possibility that the bowls are the product of late Iznik production should not be rejected. Generally speaking, the use of genuine Chinese motifs and shapes performed in various, often more Islamic, variants, appears again in the end of the 16th century, under the obvious influence of decline in style and quality.

## Conclusions

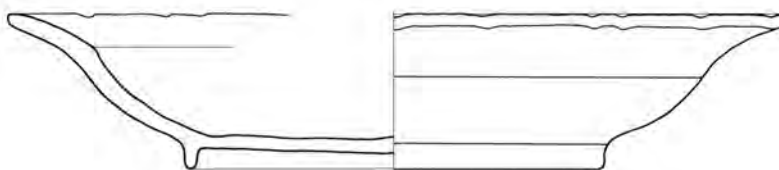
The cargo of the Sv. Pavao shipwreck confirms that the Iznik fritware was exported to Europe, mainly to the Italian clients that dominated maritime commerce in the Mediterranean Basin. The interest and taste for such pottery in general grew among Europeans, and exports increased, not only to areas in Italy but also in France, Germany, Austria and England (Passos Leite and Queiroz Ribeiro, 2000: 64). European imports seem to have increased as a result of improved commercial and diplomatic contacts following the battle of Lepanto in 1571 (Mack, 2002: 109). Although the Iznik fritware held a special attraction for the Europeans, documented evidence of their interest in the 16th century is surprisingly scanty (Allan, 1991: 72). The only literary evidence seems to be between 1573 and 1577 when the Habsburg Ambassador in Istanbul sent Iznik tiles worth 100 ducats to Venice and, in 1577, he recommended them to the Bishop of Salzburg, Wolf Dietrich von Raitenau. Also, a Venetian inventory of 1587 lists 30 pieces of majolica from Constantinople (Mack, 2002: 109). All the more interesting is the set of dishes

emblazoned with a European coat of arms dispersed among various museums, commissioned by the workshops at Iznik. Besides a fragmentary dish found recently in excavations in Iznik, there are nine known examples of plates carrying this coat of arms whose identifications have caused some controversy (Fig. 4.57) (Passos Leite and Queiroz Ribeiro, 2000: 65). The most likely candidate seems to be a member of the Spingarolli de Dessa family of Dalmatia. Whether the service was commissioned from Iznik by that family or it was a gift from the Ottoman Turks to a family member with commercial ties is unknown (Passos Leite and Queiroz Ribeiro, 2000: 65). It is certain that the Dalmatian city of Ragusa, today Dubrovnik, had a flourishing trade with the Bosphorus and Levant in the 15th and 16th centuries. On the contrary, in the whole of Croatia the products of Iznik workshops were documented only in Dubrovnik (Kovačić, 2006: 167) and in a few sherds in the medieval old town of Ružica in Slavonija (Radić and Bojčić, 2004: 215–216). Therefore, the shipwreck of the Sv. Pavao shallows represents the most important site of Iznik fritware in the Croatian region and, in general terms is still the only shipwreck with such cargo found in the Mediterranean. It holds a great importance in the adjustment of current phasing, chronology and the affiliation of specific styles of Iznik production.

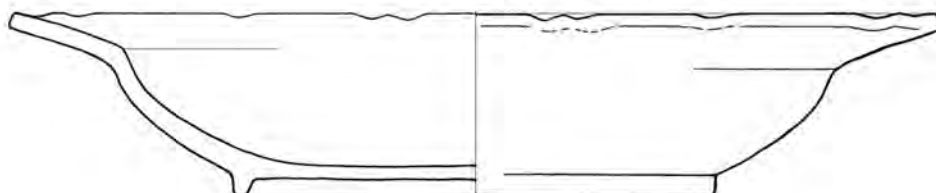
## Notes

- 1 In addition to the literature quoted in the text, the reader is also referred to Carswell (2000); Carswell and Henderson (2003); Cotter (2001); Crowe (2001); Hayes (1992); Horvat and Biondić (2007); Kovacs (1984); Lane (1957); Necipoğlu (1990); and Perkić (2009)
- 2 *rumi* – a highly stylised vegetal form specific to the Islamic repertoire in reference to the Seljukids of Rum; *hatayi* or *hitayi* are highly stylised floral motifs inspired by Chinese art (China being *Hitay* in Ottoman); in the western world labelled as ‘arabesques’ motifs.
- 3 Distribution of the composition on the vessel of all early Iznik wares had been limited by the structure of the vessels to zonal decorative schemes. The new approach however spreads the design, without restraint, to certain zones, the *cavetto*, rim or the bottom.
- 4 I would like to thank Milica Japundžić, the *counsellor of Mimara Museum in Zagreb (Croatia)* for her immense help with the analysis of the Islamic blue and white bowls.
- 5 Pers. comm. M. Japundžić.
- 6 drawings in 4.5–4.13: V. Zmaić Kralj and S. Čule.
- 7 photo in catalogue: R. Mosković, HRZ archive.

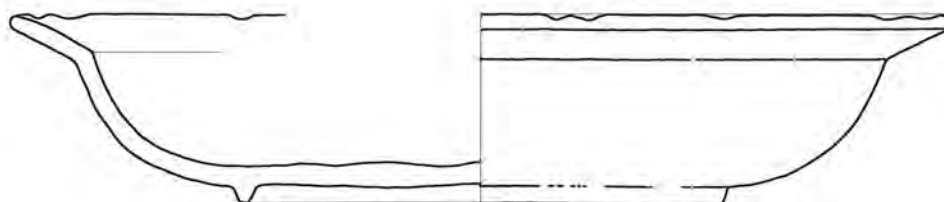
55/2008



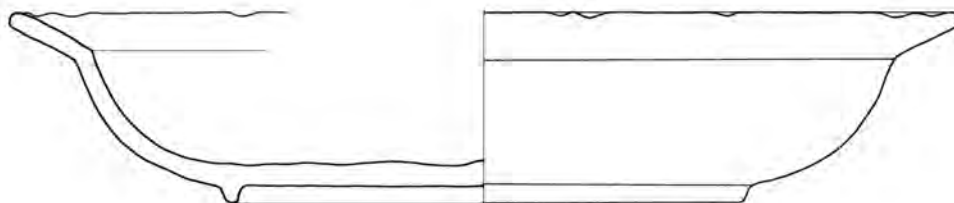
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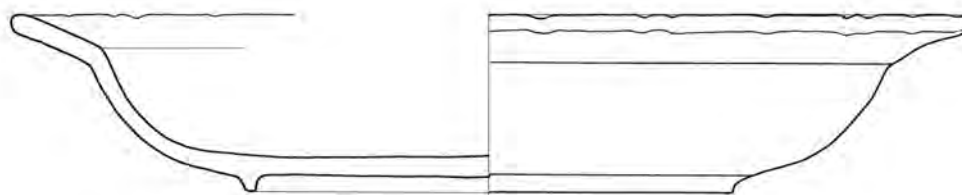
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60/2008



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65/2008

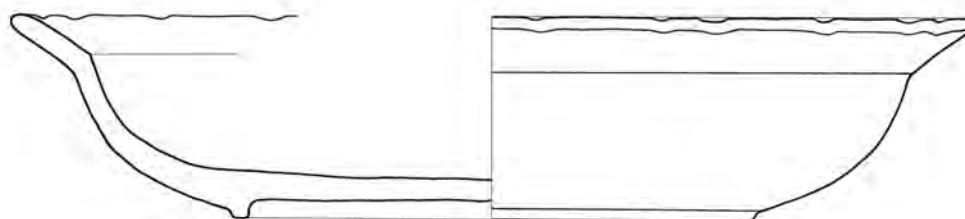
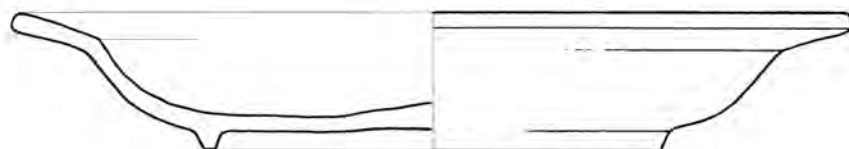


Plate 4.6

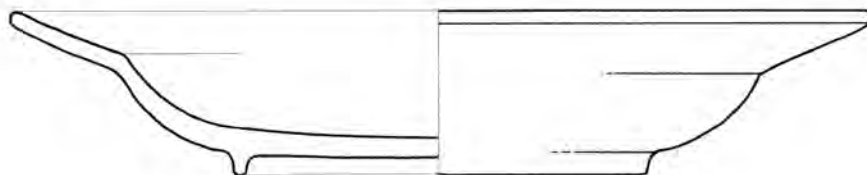
27/2011



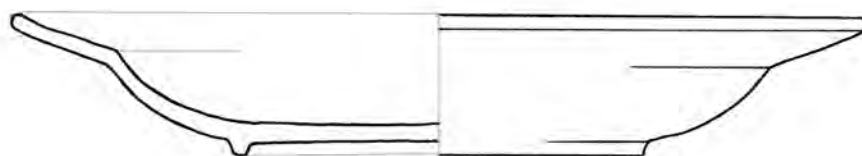
42/2011



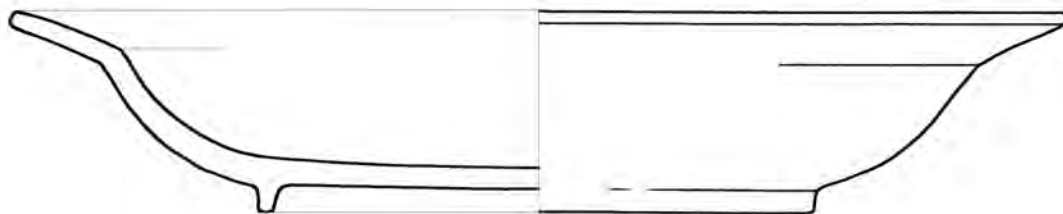
13/2011a



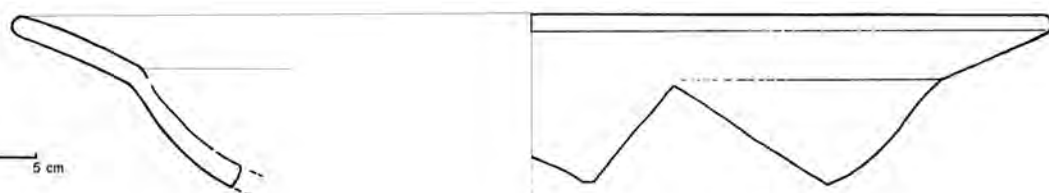
13/2011b



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13/2011c



0 5 cm

## Plate 4.7

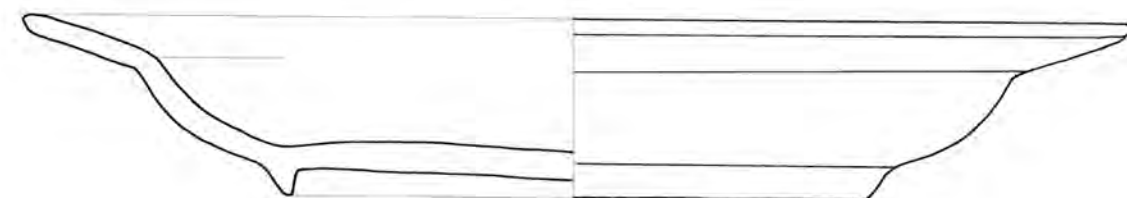
58/2008



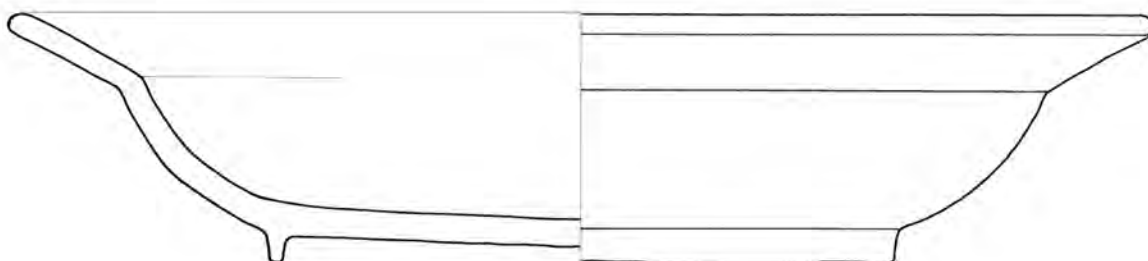
59/2008



97/2008



61/2008



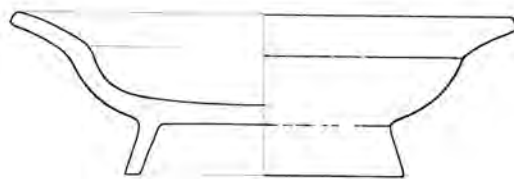
119/2009



0 5 cm

**Plate 4.8**

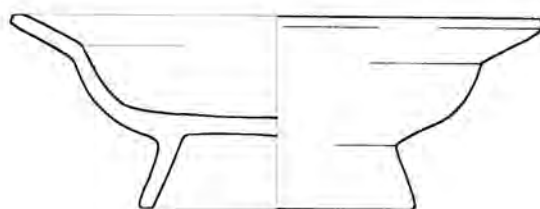
06/2011



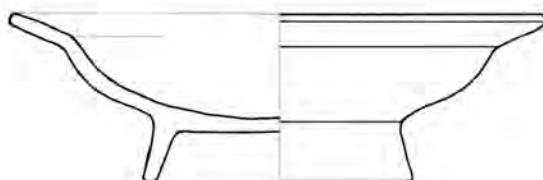
04/2011



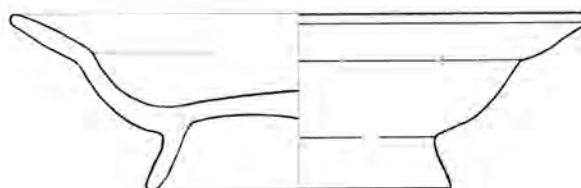
23/2007



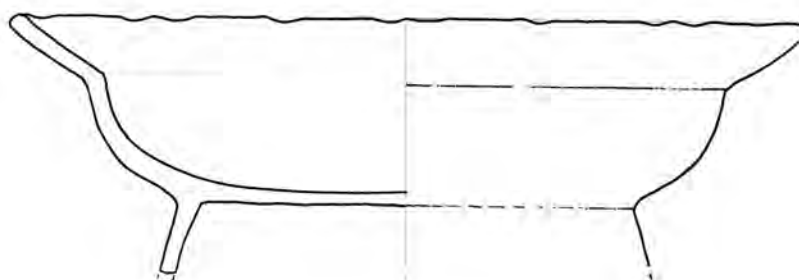
262/2010



238/2010

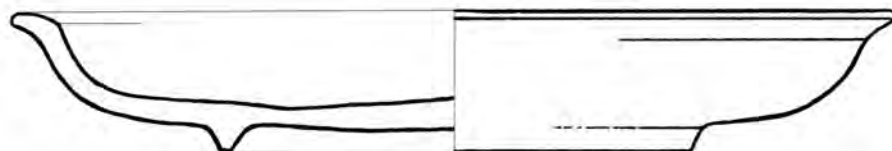


39/2007

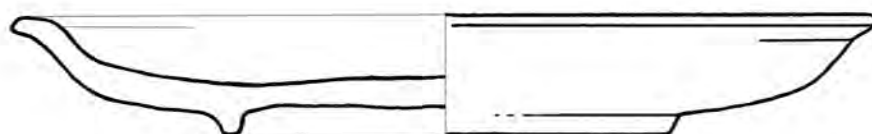


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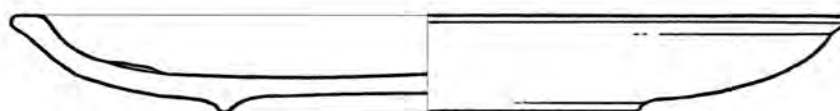
12/2011



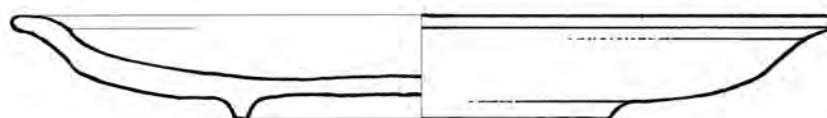
02/2012



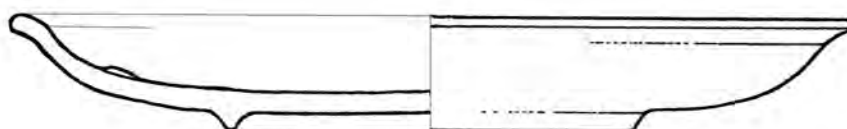
241/2010



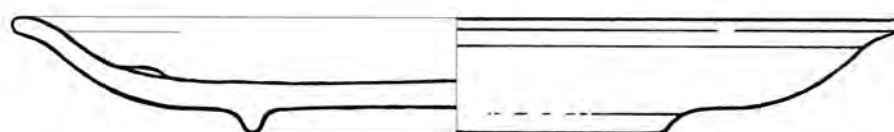
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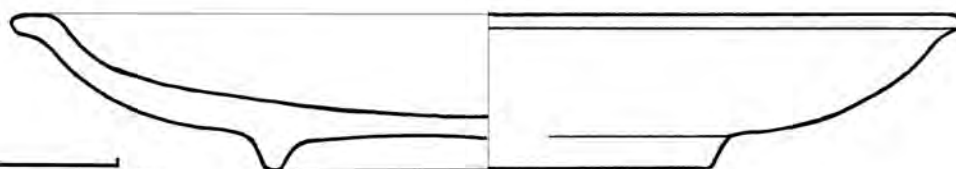
03/2011



24/2011



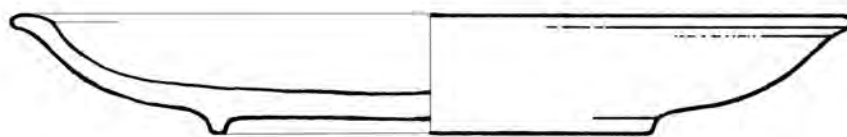
240/2010



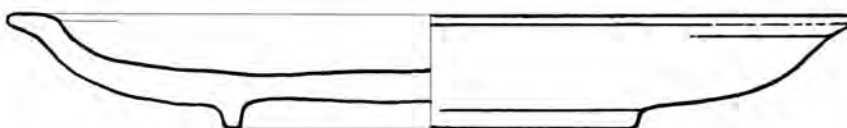
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**Plate 4.10**

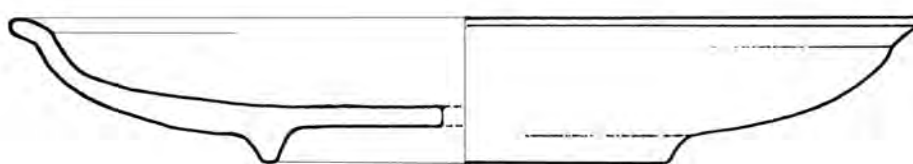
234/2010



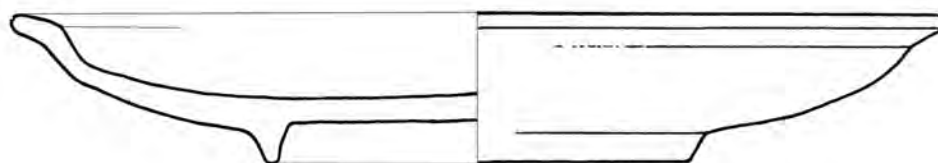
242/2010



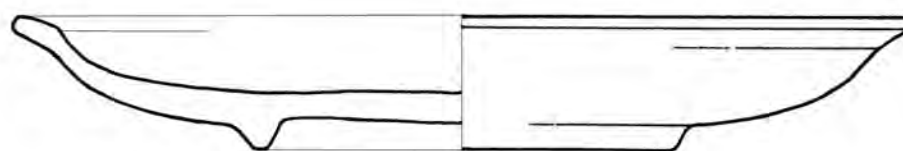
255/2010



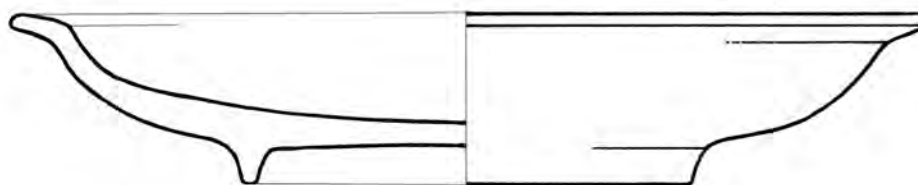
244/2010



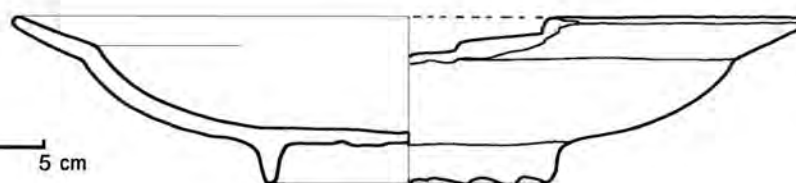
34/2011



133/2009

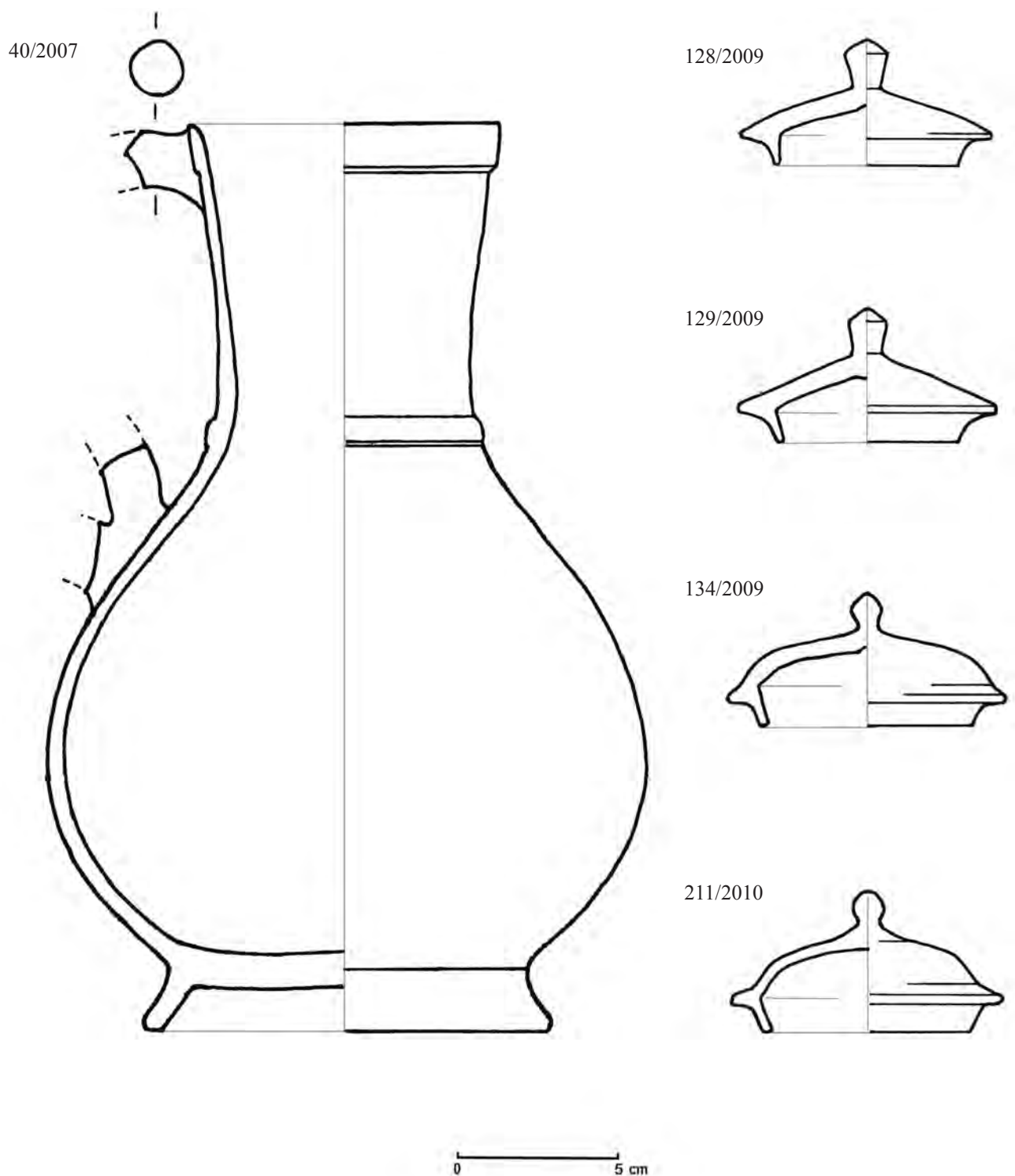


233/2010



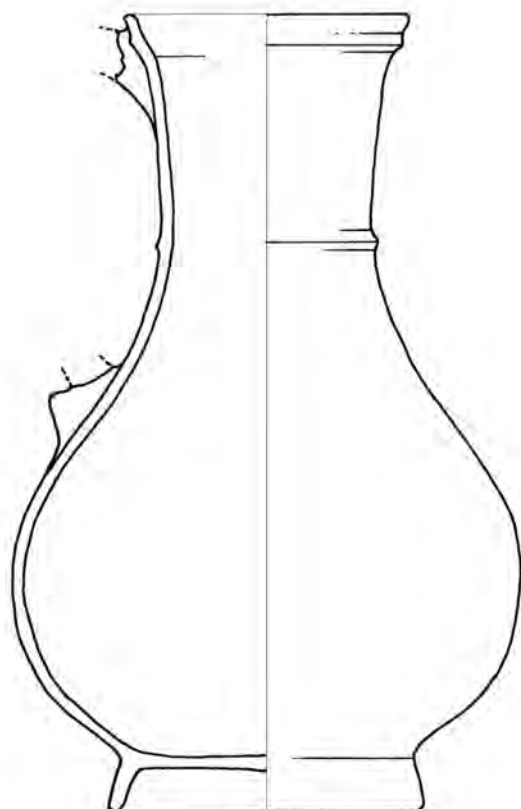
0 5 cm

## Plate 4.11

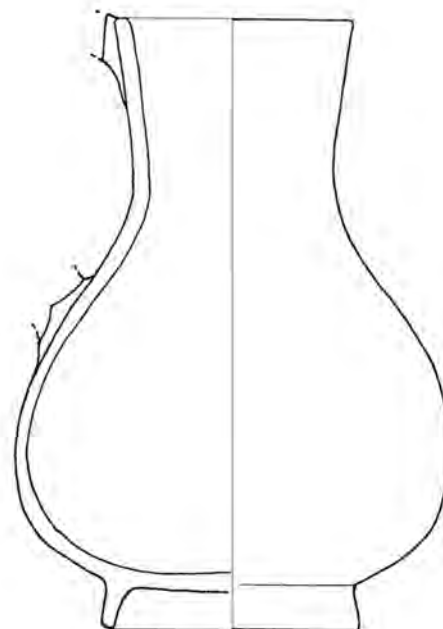


**Plate 4.12**

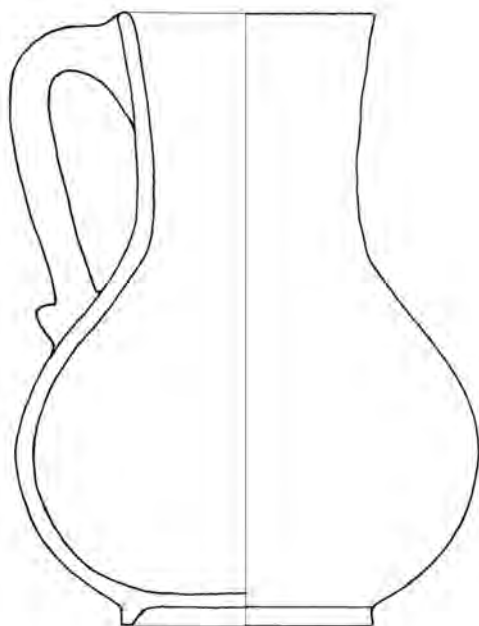
15/2011



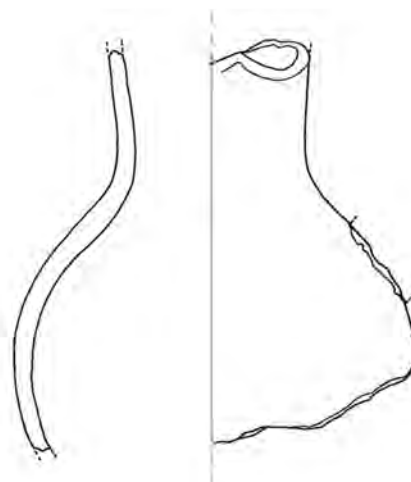
99/2009



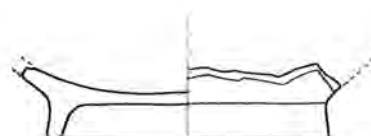
200/2010



75/2008



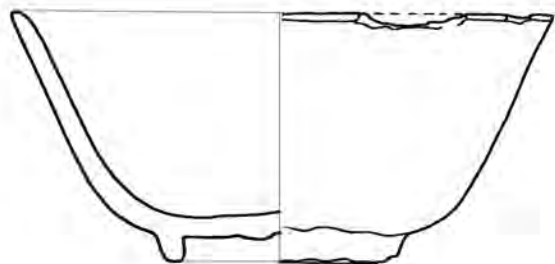
50/2008



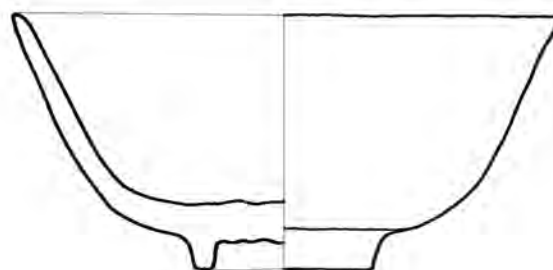
0 5 cm

## Plate 4.13

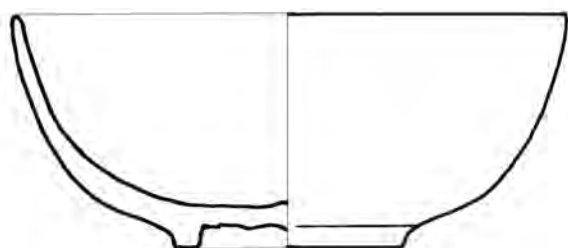
53/2008



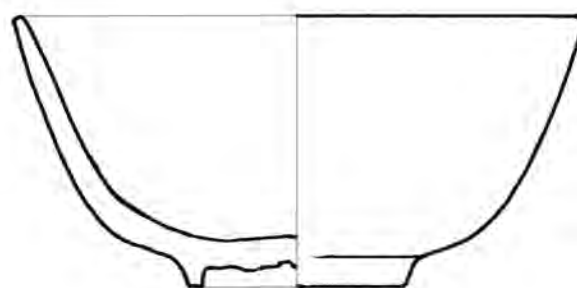
68/2008



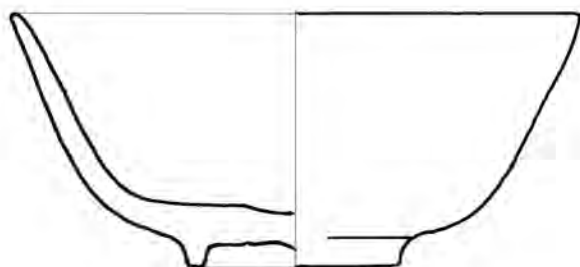
108/2009



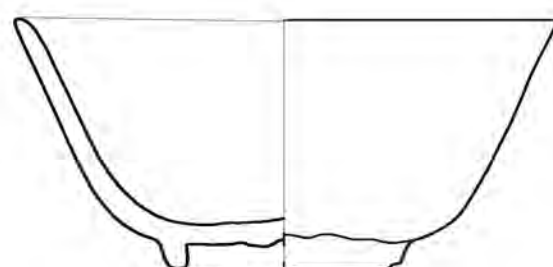
08/2011



68/2011



64/2008



0 5 cm

## Catalogue

Abbreviations: H. = height; Diam = diameter



### 1. 60/2008

Dish with *tuğra* spiral style decoration; Iznik, 1530/40–1600  
Fritware, underglaze painting in cobalt blue over a siliceous slip coating  
H. 7.1 cm; Diam: 35.2 cm



### 3. 55/2008

Dish with “flower scroll” inspired by Chinese porcelain designs; Iznik, c. 1570–1580  
Fritware, underglaze painting in cobalt blue over a siliceous slip coating  
H. 5.5 cm; Diam: 29 cm



### 2. 35/2011

Dish with *tuğra* spiral style decoration; Iznik, 1530/40–1600  
Fritware, underglaze painting in cobalt blue over a siliceous slip coating  
H. 7 cm; Diam: 35.2 cm



### 4. 97/2008

Dish with “bunches of grapes” inspired by Chinese porcelain designs; Iznik, 1560–1600  
Fritware, underglaze painting in cobalt blue and emerald green with black outlining over a siliceous slip coating  
H. 5.5 cm; Diam: 33.8 cm

**5. 58/2008**

Dish of 'Saz' style with leaves of plane; Iznik, 1530–1540  
Fritware, underglaze painting in cobalt blue and  
turquoise over a siliceous slip coating  
H. 5.6 cm; Diam: 33.7 cm



**6. 59/2008**

Dish of 'Saz' style with leaves of plane; Iznik, 1530–1540  
Fritware, underglaze painting in cobalt blue and turquoise  
over a siliceous slip coating  
H. 5.9 cm; Diam: 33.9 cm



**8. 62/2008**

Dish of 'Saz' style/'Master of the Hyacinths' with a  
hyacinth bouquet; Iznik, 1555–1560  
Fritware, underglaze painting in cobalt blue, manganese  
purple and olive green over a siliceous slip coating  
H. 6.5 cm; Diam: 35.2 cm



**7. 65/2008**

Dish of 'Saz' style/'circle of Musli' with arabesque  
motifs; Iznik, c. 1540–1560  
Fritware, underglaze painting in cobalt blue, turquoise,  
manganese purple and olive green over a siliceous slip  
coating  
H. 7.5 cm; Diam: 35.4 cm

**9. 61/2008**

Dish in polychrome “four flowers” style; Iznik, *c.* 1560–1565

Fritware, underglaze painting in pale blue, olive green and relief red with black outlining

H. 7.6 cm; Diam: 35 cm

**11. 244/2010**

Flat dish with a narrow rim in polychrome style with a symmetric floral composition; Iznik, *c.* 1560–1575

Fritware, underglaze painting in cobalt blue, olive green and relief red, with black outlining

H. 3.2 cm; Diam: 20.4 cm

**10. 42/2011**

Dish in polychrome style with a symmetric floral composition;

Iznik, *c.* 1570–1575

Fritware, underglaze painting in cobalt blue, emerald green and relief red with black outlining

H. 4.6 cm; Diam: 28 cm

**12. 34/2011**

Flat dish with a narrow rim in polychrome style decorated with the *çintamani* motifs; Iznik, *c.* 1580–1585

Fritware, underglaze painting in cobalt blue, green and relief red, with black outlining

H. 2.9 cm; Diam: 19.5 cm



**13. 13/2011d**

Dish with everted foliate rim in blue and white technique inspired by Chinese productions; Iznik, c. 1570–1580  
Fritware, underglaze painting in cobalt blue over a siliceous slip coating  
H. 6.9 cm; Diam: 35 cm



**15. 262/2010**

Tazza decorated with the scrolling branches in blue and white technique; Iznik, c. 1570–1580  
Fritware, underglaze painting in cobalt blue over a siliceous slip coating  
H. 5.7 cm; Diam: 18.6 cm



**14. 23/2007**

Tazza decorated in blue and white technique; Iznik, c. 1570–1580  
Fritware, underglaze painting in cobalt blue over a siliceous slip coating  
H. 6.7 cm; Diam: 18.5 cm



**16. 39/2007**

Tazza with foliate rim decorated in the “peony and wheatsheaf” style; Iznik, c. 1575–1580  
Fritware, underglaze painting in cobalt blue over a siliceous slip coating  
H. 9 cm; Diam: 28 cm



**17. 04/2011**

*Tazza* decorated in the blue and white “wheatsheaf” style; Iznik, c. 1580–1585  
Fritware, underglaze painting in cobalt blue over a siliceous slip coating  
H. 5.6 cm; Diam: 17.8 cm



**19. 242/2010**

Flat dish decorated in the blue and white “peony and wheatsheaf” style; Iznik, c. 1580–1585  
Fritware, underglaze painting in cobalt blue over a siliceous slip coating  
H. 2.4 cm; Diam: 18.5 cm



**18. 06/2011**

*Tazza* decorated in the blue and white “wheatsheaf” style; Iznik, c. 1580–1585  
Fritware, underglaze painting in cobalt blue over a siliceous slip coating  
H. 5.6 cm; Diam: 17.8 cm



**20. 02/2012**

Flat dish decorated in the blue and white “wheatsheaf” style; Iznik, c. 1580–1585  
Fritware, underglaze painting in cobalt blue over a siliceous slip coating  
H. 2.5 cm; Diam: 18.6 cm



**21. 255/2010**

Flat dish decorated with the scrolling branches in blue and white technique; Iznik, c. 1580–1585

Fritware, underglaze painting in cobalt blue over a siliceous slip coating

H. 3.2 cm; Diam: 20 cm



**23. 233/2010**

Dish decorated in the "wheatsheaf" style in blue and white technique; Iznik, c. 1580–1585

Fritware, underglaze painting in cobalt blue over a siliceous slip coating

H. 3.7 cm; Diam: 17.7 cm



**22. 52/2008**

Dish decorated in the "wheatsheaf" style in blue and white technique; Iznik, c. 1580–1585

Fritware, underglaze painting in cobalt blue over a siliceous slip coating

H. 3.7 cm; Diam: 17.7 cm



**24. 09/2011**

Dish decorated with "kaleidoscope and abstract" design in blue and white technique; Iznik, c. 1575–1580

Fritware, underglaze painting in cobalt blue over a siliceous slip coating

H. 6.8 cm; Diam: 35.2 cm

**25. 119/2009**

Lid of a deep bowl on the pedestal foot decorated with the "abstract" design in blue and white technique; Iznik, c. 1575–1580

Fritware, underglaze painting in cobalt blue over a siliceous slip coating

H. – cm; Diam: 28.6 cm

**27. 113/2009**

Flat dish with the narrow rim decorated with circular motif that radiates from a central rosette; Iznik, c. 1580–1585

Fritware, underglaze painting in cobalt blue over a siliceous slip coating

H. 3.6cm; Diam: 19 cm

**26. 238/2010**

*Tazza* decorated in the blue and white technique with palmettes that radiate from the central medallion; Iznik, c. 1580–1585

Fritware, underglaze painting in cobalt blue over a siliceous slip coating

H. 5.8 cm; Diam: 20 cm

**28. 240/2010**

Flat dish with the narrow rim decorated with a central rosette, decline of technique; Iznik, c. 1580–1585

Fritware, underglaze painting in cobalt blue over a siliceous slip coating

H. 3.6cm; Diam: 19 cm



**29. 241/2010**

Flat dish with the narrow rim decorated with palmettes that radiate from the central medallion;

Iznik, c. 1580–1585

Fritware, underglaze painting in cobalt blue and relief red over a siliceous slip coating

H. 2.1 cm; Diam: 18cm



**31. 02/2011**

Flat dish with the narrow rim decorated with palmettes that radiate from the central medallion;

Iznik, c. 1580–1585

Fritware, underglaze painting in cobalt blue and relief red over a siliceous slip coating

H. 2.4 cm; Diam: 19.2 cm



**30. 24/2011**

Flat dish with the narrow rim decorated with palmettes that radiate from the central medallion;

Iznik, c. 1580–1585

Fritware, underglaze painting in cobalt blue and relief red over a siliceous slip coating

H. 2.5 cm; Diam: 18.2 cm



**32. 03/2011**

Flat dish with the narrow rim decorated with palmettes that radiate from the central medallion;

Iznik, c. 1580–1585

Fritware, underglaze painting in cobalt blue and relief red over a siliceous slip coating

H. 2.2 cm; Diam: 17.7 cm



**33. 13/2011a**

Dish in polychrome style with confronted harpies; Iznik, c. 1580– 1585

Fritware, underglaze painting in cobalt blue, turquoise, emerald green and relief red with black outlining  
H. 5.5 cm; Diam: 28.6 cm



**35. 234/2010**

Later blue and white “flowerpot” flat dish, decline of technique; Iznik, c. 1570–1590

Fritware, underglaze painting in cobalt blue  
H. 2.5cm; Diam: 18.3 cm



**34. 13/2011b**

Dish in polychrome style with confronted harpies; Iznik, c. 1580– 1585

Fritware, underglaze painting in cobalt blue, turquoise, emerald green and relief red with black outlining  
H. 4.6 cm; Diam: 28.6 cm



**36. 12/2011**

Later blue and white flat dish decorated with a circular medallion rounded by the cloud bands, decline of technique; Iznik, c. 1570–1590

Fritware, underglaze painting in cobalt blue over a siliceous slip coating  
H. 3 cm; Diam: 19,2 cm

**37. 40/2007**

Polychrome jug decorated in the “four flower”; Iznik, c. 1575–1580

Fritware, underglaze painting in cobalt blue, olive green, relief red with black outlining

H. 29 cm; Diam of body: 19 cm

**39. 99/2009**

Polychrome jug with tiger stripes decoration; Iznik, c. 1580–1585

Fritware, underglaze painting in pale blue, green and relief red with black outlining

H. 20 cm; Diam of body: 14.2 cm

**38. 200/2010**

Polychrome *çintamani* jug; Iznik, c. 1580–1585

Fritware, underglaze painting in pale blue, green, relief red and outlined in black

H. 20 cm; Diam of body: 15 cm

**40. 75/2008**

Polychrome jug with tiger stripes a rosettes decoration; Iznik, c. 1580–1585

Fritware, underglaze painting in pale blue, green and relief red with black outlining

H. – cm; Diam of body: 13 cm



**41. 15/2011**

Polychrome jug; Iznik, c. 1580–1590  
Fritware, underglaze painting in cobalt blue, green and relief red  
H. 25.5 cm; Diam of body: 16.3 cm



**43. 129/2009**

Polychrome lid of the cone shape with knob; Iznik, c. 1560–1585  
Fritware, underglaze painting in olive green with black outlining  
H. 4 cm; Diam: 7.9 cm  
(206/2010, 211/2010, 235/2010)



**42. 128/2009**

Polychrome lid of the cone shape with knob; Iznik, c. 1560–1585  
Fritware, underglaze painting in pale blue with black outlining  
H. 3.8 cm; Diam: 7.8 cm 3.8 cm



**44. 134/2009**

Polychrome lid of the domed shape with knob; Iznik, c. 1560–1585  
Fritware, underglaze painting in cobalt blue and turquoise with black outlining  
H. 4.1 cm; Diam: 8.6 cm

**45. 206/2010**

Polychrome lid of the cone shape with knob; Iznik,  
c. 1560–1585  
Fritware, underglaze painting in cobalt blue and green  
with black outlining  
H. 3.5 cm; Diam: 8.6 cm

**47. 235/2010**

Polychrome lid of the cone shape with knob; Iznik,  
c. 1560–1585  
Fritware, underglaze painting in cobalt blue and  
turquoise with black outlining  
H. 3.2 cm; Diam: 7.7 cm

**46. 211/2010**

Polychrome lid of the domed shape with knob; Iznik,  
c. 1560–1585  
Fritware, underglaze painting in cobalt blue and  
turquoise with black outlining  
H. 4 cm; Diam: 8.4 cm

**48. 53/2008**

Small bowl of undetermined origin, with design imitating Chinese blue and white *lianzi* bowls; Second half of the 16th century  
Fritware, underglaze painting in cobalt blue over a siliceous slip coating  
H. 5.7 cm; Diam: 12.6 cm

**50. 64/2008**

Small bowl of undetermined origin, with design imitating Chinese blue and white *lianzi* bowls; Second half of the 16th century  
Fritware, underglaze painting in cobalt blue over a siliceous slip coating  
H. 6.1 cm; Diam: 12.2 cm

**49. 63/2008**

Small bowl of undetermined origin, with design imitating Chinese blue and white *lianzi* bowls; Second half of the 16th century  
Fritware, underglaze painting in cobalt blue over a siliceous slip coating  
H. 5.7 cm; Diam: 12.2 cm

**51. 108/2009**

Small bowl of undetermined origin, with design imitating Chinese blue and white *lianzi* bowls; Second half of the 16th century  
Fritware, underglaze painting in cobalt blue over a siliceous slip coating  
H. 5.3 cm; Diam: 12 cm

**52. 08/2011**

Small bowl of undetermined origin, with design imitating Chinese blue and white *lianzi* bowls; Second half of the 16th century  
Fritware, underglaze painting in cobalt blue over a siliceous slip coating H. 6 cm; Diam.: 12.5 cm

**53. 68/2011**

Small bowl of undetermined origin, with design imitating Chinese blue and white *lianzi* bowls; Second half of the 16th century  
Fritware, underglaze painting in cobalt blue over a siliceous slip coating  
H. 6.1 cm; Diam: 13 cm

## 4.4. Other pottery finds

### *Sauro Gelichi*

#### **Abstract**

*Oltre alla ceramica di Iznik, appartenente sicuramente al carico, dal relitto provengono altre forme ceramiche che si possono suddividere in quattro categorie: a) quattro contenitori a fondo piatto con due anse, di produzione ottomana; b) una singola brocca a fondo piatto, sempre di produzione ottomana; c) scodelle emisferiche e piatti invetriati (alcuni monocromi e altri dipinti) e, ceramiche ingobbiate, tra cui esemplari di graffita (una scodella con stemma centrale ed un grande piatto con un motivo che rappresenta un suonatore di liuto); d) frammenti di almeno un piatto in maiolica di produzione italiana (sud?). Dato il ridotto numero di esemplari (e in due casi la presenza di graffiti incisi a cotto sul piede dei recipienti: segni di proprietà?) è possibile attribuire questo vasellame all'uso di bordo. Si tratta di materiale cronologicamente abbastanza omogeneo, databile al terzo quarto del XVI secolo e dunque coerente con la cronologia dell'imbarcazione. Rappresenta un'eccezione il grande piatto di Graffita Rinascimentale che è sicuramente più antico. Tutte le ceramiche del gruppo c) sono attribuibili a produzione veneta.*

*Osim iznik keramike koja pripada brodskom teretu, na brodolomu je pronađena i ostala keramika koju možemo razvrstati u četiri kategorije: a) četiri posude otomanskog porijekla s dvije ručke i ravnim dnom, b) vrč otomanskog porijekla s ravnim dnom, c) olovno glazirane polukuglaste zdjele i tanjuri (dio je jednobojan, dio oslikan) i keramika s premazom od kojih nekoliko primjera pripadaju graviranoj keramici (zdjela s grbom u sredini i veliki višebojni gravirani tanjur ukrašen motivom svirača na lutnji), d) ulomci najmanje jednog tanjura majolike (južne?) talijanske proizvodnje. Zbog malog broja ulomaka (i prisutnosti urezivanja na dnu posuda nakon pečenja u dva slučaja; znakovi vlasništva?), moguće je okarakterizirati ove posude kao posude svakodnevne upotrebe. Kronološki je ovaj materijal gotovo homogen, a datiran je u treću četvrtinu 16. stoljeća i uz to odgovara dataciji broda. Jedini je izuzetak veliki "Graffita Rinascimentale" tanjur koji predstavlja najstariji nalaz na brodu. Sva je keramika iz grupe c) talijanske, venecijanske proizvodnje.*

In addition to the large amount of Iznik pottery, numerous other examples of ceramics were found in the shipwreck. These other items, often very fragmented, can be divided into four categories: a) small unglazed containers (for transport?); b) spouted unglazed jugs; c) glazed pottery, sometimes with slip, of various types; d) tin-glazed pottery.

*Category a)* is currently composed of four specimens: small fairly tall, thin, ovoid containers with two-handles (16/2007) (Fig. 4.58). There are parallels with specimens

from the excavations of Saraçane in Istanbul (Hayes, 1992: 292, no. J3, fig. 126), dated from between the end of the 15th and the mid-16th century.

*Category b)* is represented at this time by a single spouted jug (Ibriq Type) (15/2007) (Figs 4.59a–b), with a flat base and a tapering spout on the shoulder obliquely opposite the handle. A probable parallel is with the K2 group from Saraçane (dated from the mid-16th to the mid-17th century) (Hayes, 1992: 292, fig. 106).



Fig. 4.58. Small fairly tall, thin, ovoid container with two handles (16/2007, Category 'a') (photo: R. Mosconi, HRZ archive)

Category c) is the most numerous, but also more diversified (and not easy to distinguish because the surfaces are often sulphated). There are some small fragments of lead-glazed cooking pots, and various other typologies and shapes. The more usual shapes are small hemispherical bowls (sometimes slightly bell-shaped) or plates, covered with slip and lead glaze. Some of these are monochrome, and others are decorated with simple motifs in green and yellow (100/2009, 169/2009, 163/2009) (Figs 4.60a–b, 4.61a–b, 4.62a–b). Four plates are decorated in blue ("Maculato" type) (114/2009, 215/2010) (Figs 4.63, 4.64a–b), and only one in green on yellow (*Corpus delle Ceramiche del fiume Adige nel territorio di Albaredo d'Adige*, 2009: 110–111, nos 147–150). Alongside these products there is also a basin of larger dimensions, with very simple polychrome decoration in green, yellow and brown (219/2010) (Figs 4.65a–b). Generally, these ceramics are very simple products, with the outside lacking surface treatment. Also within this group, however, are four objects with *sgraffito* decoration. The first one is a small flared hemispherical bowl, decorated in green and yellow with a simplified coat of arms (19/2007) (Figs 4.66). Two other fragmentary pieces are monochrome *sgraffito* under brown glaze (212/2010) (Fig. 4.67). The last one is an unusual large polychrome *sgraffito* plate decorated with a more complex central motif (17/2007) (Figs 4.68a–b): a man walking while playing a lute in a landscape with leafy trees, on

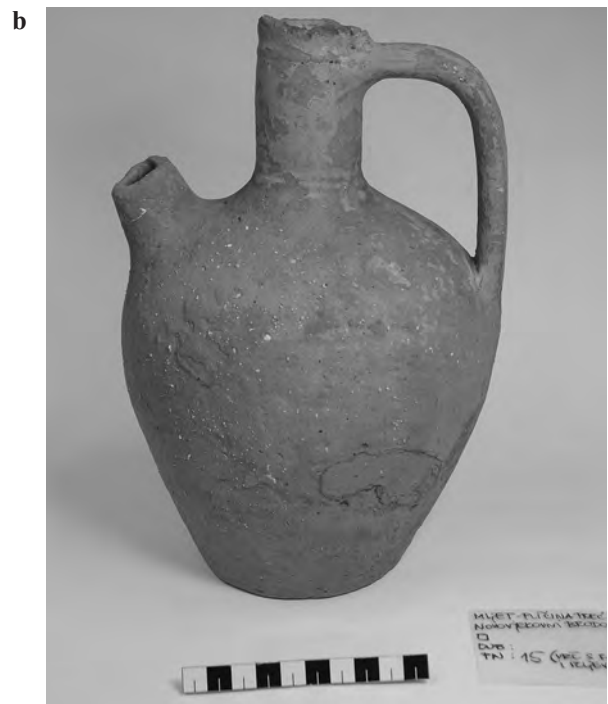


Fig. 4.59. Spouted jug with a flat base and a tapering spout on the shoulder obliquely opposite the handle (15/2007, Category b) (a. before restoration; b. after restoration) (photo: R. Mosconi, HRZ archive)

a background with roulette decoration. The colours are green, yellow and black (manganese). The surface is very worn, probably due to chemical action in the water. It belongs to the so-called 'Renaissance Sgraffito' type. Two

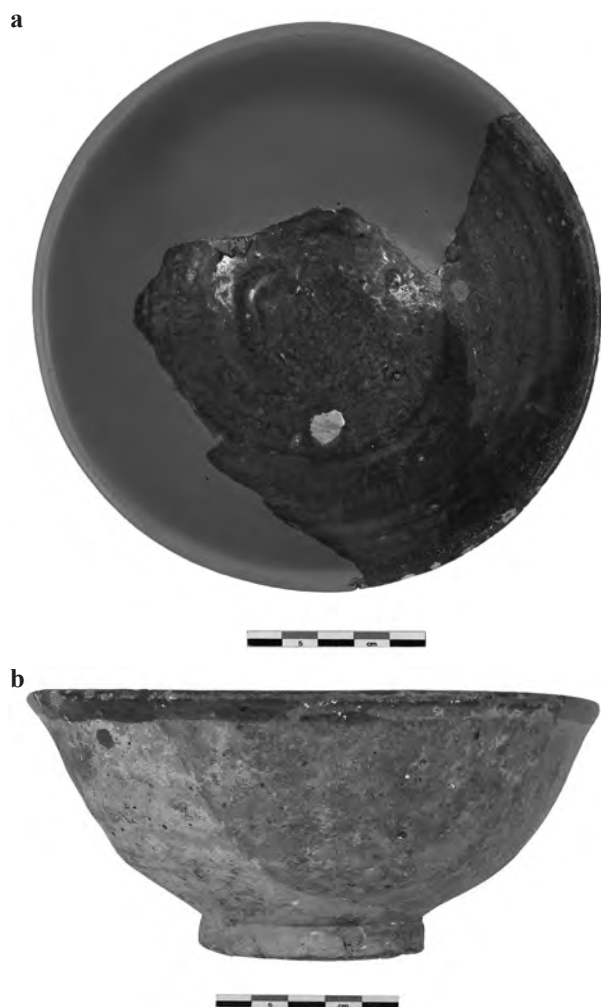


Fig. 4.60. Small monochrome hemispherical bowl covered with slip and lead glaze (100/2009, Category c) (a. inner surface, front; b. outer surface, profile) (photo: R. Mosković, HRZ archive)

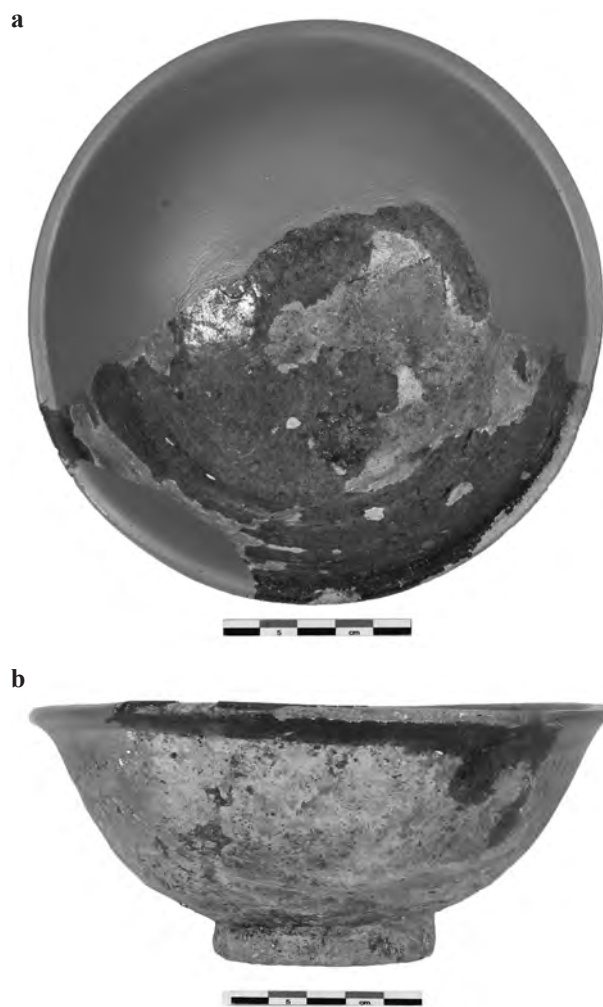


Fig. 4.61. Small monochrome hemispherical bowl covered with slip and lead glaze (169/2009, Category c) (a. inner surface, front; b. outer surface, profile) (photo: R. Mosković, HRZ archive)

of these items present *sgraffiti* in the bottom of the foot: one a clearly recognizable ‘M’; another a large asterisk.

*Category d)* tin-glazed pottery is represented by the fragments of perhaps a single dish, covered with a very dense white tin glazed, partly lost (186/2010) (Fig. 4.69). It is possible that this object is from southern Italy.

The pottery of the first two categories was produced in Turkey. In the first case it is likely they were purchased and transported on the ship for their contents. The rest of the very heterogeneous ceramics would have been part of the galley equipment on board the ship. The glazed cooking pots were a very common type in Veneto during the 16th century. Perhaps the unglazed Turkish jug was also used by the crew. Although produced in Turkey, it was at the time a rare object, but not valuable enough to justify purchase for trading. The rest of the ceramics also had to belong to the crew: confirmed by their typological

heterogeneity, their similar shapes (almost all containers of small dimensions), and their rather modest quality, with the outside almost never treated, and with extremely simplified decoration. A couple of these objects, a bowl and a basin, bearing obvious signs of use, both have graffiti under the base. In the case of the bowl it is a letter (“M”) and could also be interpreted as a sign of the owner. Apart from the Turkish products, the technological and typological characteristics show that the rest of the ceramics can be safely assigned to shops operating in Veneto, if not in Venice itself. Macroscopic diversity in the clay and, in some cases, technical characteristics, suggests, however, that they do not come from the same workshop.

The group of ceramics is therefore substantially homogeneous, being types rather current in 16th century Venetian production. The large plate with the “Renaissance type” decoration, which reproduces a motif quite common in this type of pottery, is an exception in its quality and size. Even the background, with roulette incisions and

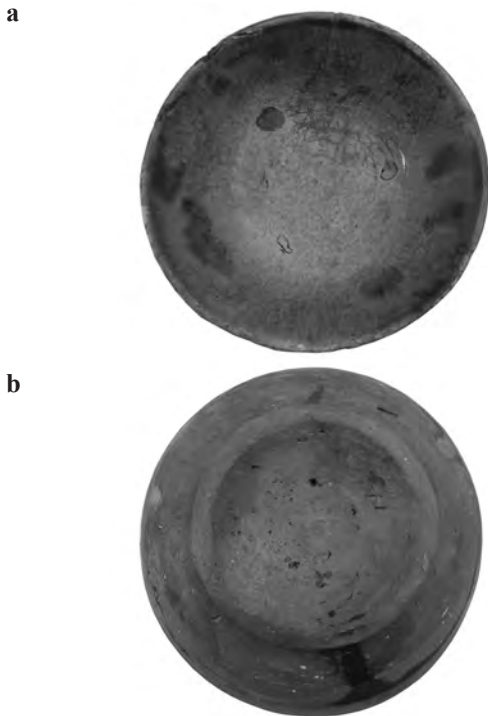


Fig. 4.62. Plate covered with slip and lead glaze decorated with simple motifs in green and yellow (163/2009, Category c) (a. inner surface, front; b. outer surface, front) (photo: R. Mosković, HRZ archive)

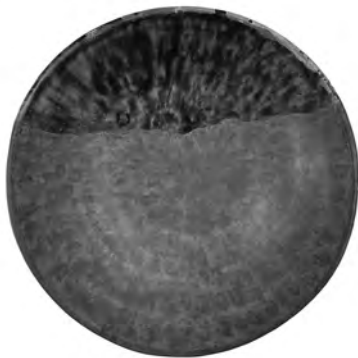


Fig. 4.63. Plate decorated in blue ("Maculato" type, 114/2009, Category c) (photo: R. Mosković, HRZ archive)

leafy trees, falls into the category of typical decoration of this style. The traditional chronology of this pottery (first half of the 16th century) would be slightly earlier than the chronology of the ship, based on the coins and the inscription engraved on the bell board. However, the rest of the pottery is consistent with a date around the third quarter of the 16th century. Confirming this chronology is the presence of a Turkish jug, the four small Turkish containers, and the bowl with the *sgraffito* arms decoration. This bowl has close connections with Group B of San Giovanni in Persiceto (Bologna) (Gelichi (a cura di), 1986: 45–46), dated to about the third quarter of the 16th century. The large plate in Renaissance *sgraffito*, then, would be the oldest, and would have been in use for a long time.

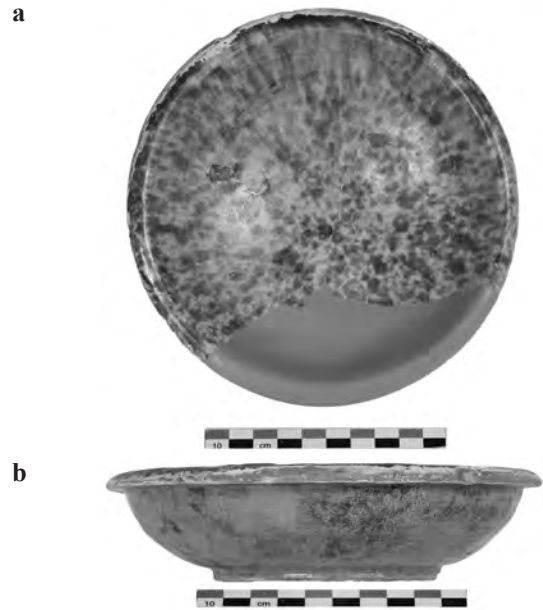


Fig. 4.64. Plate decorated in blue ('Maculato' type, 215/2010, Category c) (a. inner surface, front; b. outer surface, profile) (photo: R. Mosković, HRZ archive)

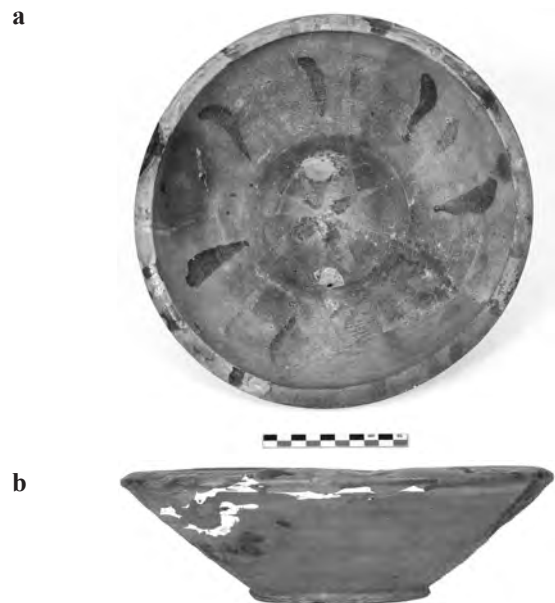


Fig. 4.65. Basin with very simple polychrome decoration in green, yellow and brown (219/2010, Category c) (a. inner surface, front; b. outer surface, profile) (photo: R. Mosković, HRZ archive)



Fig. 4.66. Two fragmentary pieces of monochrome *sgraffito* under brown glaze, decorated in green and yellow with a simplified coat of arms (212/2010, Category c) (photo: R. Mosković, HRZ archive).

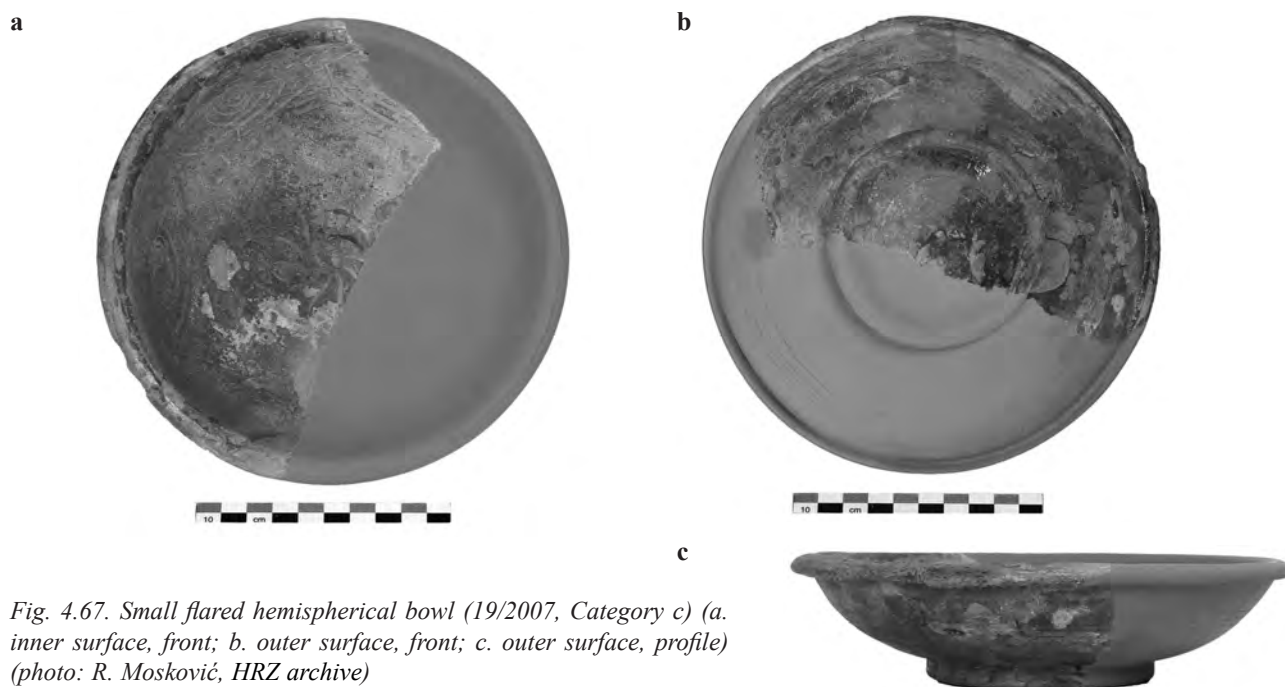


Fig. 4.67. Small flared hemispherical bowl (19/2007, Category c) (a. inner surface, front; b. outer surface, front; c. outer surface, profile) (photo: R. Mosковиć, HRZ archive)



Fig. 4.68. Large polychrome sgraffito plate decorated with a complex central motif (17/2007, Category c) (a. inner surface, front; b. outer surface, profile) (photo: R. Mosковиć, HRZ archive)



Fig. 4.69. Fragments of dish covered with a very dense tin glazed (186/2010, Category 'd') (photo: R. Mosковиć, HRZ archive)

## 4.5. Glass finds

*Margherita Ferri*

### Abstract

*Tra i rinvenimenti si conta un discreto quantitativo di frammenti in vetro. Essi possono essere attribuiti a tre sole tipologie di recipienti molto simili l'una all'altra e tutte realizzate congiungendo due paraisons all'altezza del collo. Oltre ad un solo esemplare di grande bottiglia con rigonfiamento sul collo e corpo schiacciato, sono state rinvenute almeno 14 bottiglie di dimensioni minori prive del rigonfiamento sul collo e almeno tre recipienti con versatoio e corpo decorato con spirali ottenute a stampo. I recipienti sono molto uniformi per il colore, il tipo di vetro, la forma del corpo su base ovale e per la tecnica di produzione a due paraisons. Si tratta di prodotti ottomani che facevano parte del carico, probabilmente differenziati in base al contenuto. Poco si conosce sull'industria ottomana del vetro della fine del XVI secolo, ma la testimonianza del carico di Mljet conferma l'esistenza di una produzione in rapida espansione almeno inizialmente finalizzata alla produzione di recipienti funzionali a contenere prodotti locali destinati all'esportazione.*

*Brodolom je sadržavao veću količinu staklenih predmeta. Pronađene staklene posude mogu biti podijeljene u tri homogene skupine: boce koje su sužene na stranama i s izbočinom u donjem dijelu vrata; barem 14 boca suženih na obje strane i bez izbočine na vratu; 3 vrča na kojem je vidljiva narebrena spiralna dekoracija. Svim staklenim posudama nedostaje veći dio tijela. S obzirom na broj nalaza i visoku standardizaciju njihovih oblika i dekoracija, očito je da su stakleni nalazi s brodoloma bili dio brodskog tereta. Također je moguće da su staklene posude kupljene i prevožene i radi svojeg sadržaja. Varijante koje možemo razlikovati prema veličini, dekoraciji i postojanju grlića možda odgovaraju različitim vrstama tekućina koje su se prevozile. Iako nema jednoznačnih arheoloških indikatora koji bi točno definirali različite proizvode kraj je 16. i početak 17. stoljeća vrlo važan period za otomansku industriju stakla, osobito za proizvodnju odgovarajućih spremnika za proizvode lokalne proizvodnje.*

The shipwreck contained a substantial amount of glassware. However, no single specimen could be completely restored due to the thinness of the glass of the body. The containers recovered can be easily divided into three very homogeneous groups.<sup>1</sup>

The first group consists of only one item. It is a fragment of a bottle (Fig. 4.70: 171/2009), with the body in almost colourless transparent glass, but with a green shade near the rim, where the glass is thicker. The rim is thickened and rounded, and the neck almost cylindrical with a bulge in it. It is assumed that the item was manufactured from two *paraisons*, but this cannot be proved, as it was broken at the shoulder. The diameter of the rim is 4 cm. This item

is a “standard vessel type” as defined by Hayes (1992: 410): a flask with a truncated body, flattened on the sides and with a bulge in the lower part of the neck.

The second group consists of at least 14 bottles, of an intense green colour (Fig. 4.71: 42/2008; 196/2010; 127/2009; 111/2009; 210/2010; Fig. 4.72). They have the rim more or less markedly rolled inwards (diam. at rim 5–6 cm), the neck constricted in the middle (without a bulge). They were manufactured by joining two *paraisons*, with an irregular seam combined with thickening of the wall at the shoulder, the result of adding a second gather of glass to the free-blown neck. The plain body is flattened at the sides, the base is not acutely kicked, and the bottom

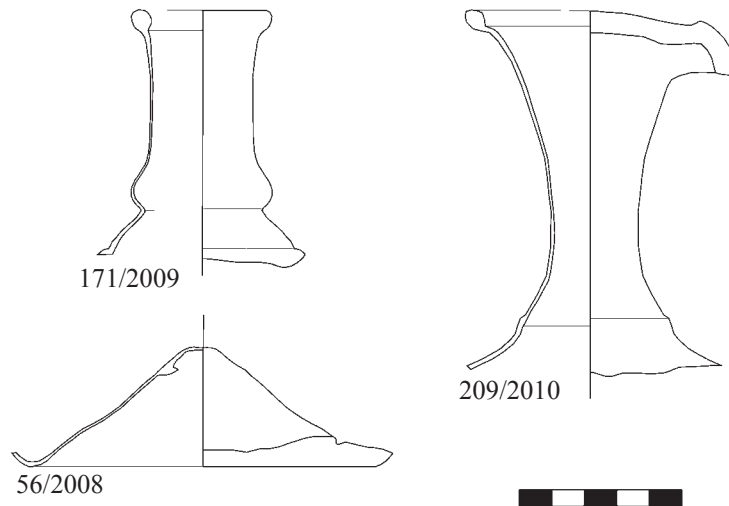


Fig. 4.70. 171/2009: bottle, first group; 209/2010 and 56/2008: jugs, third group (drawing: M. Ferri)

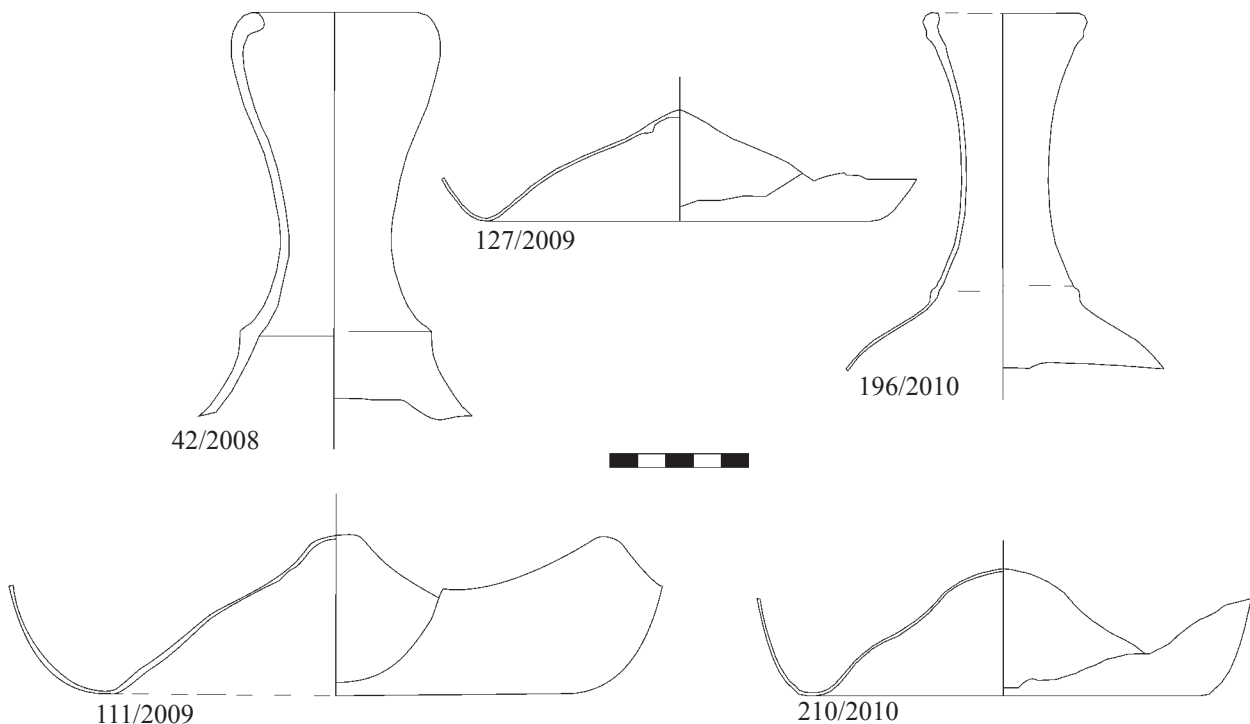


Fig. 4.71. Bottles, second group, drawings (drawing: M. Ferri)

has a pontil scar (diam. at base 13–17 cm). Hayes defines these bottles as a rare variant of a standard vessel type (Hayes, 1992: 410).

The third group has closed forms in an intense green colour, and may in fact be considered a variant of the second group. It comprises at least three jugs or pitchers (Fig. 4.70: 209/2010; 56/2008). The lip is rolled inwards, with a heart-shaped opening and a spout that turns slightly down. The neck is constricted in the middle, without a bulge, and the vessel has an irregular seam at the shoulder to connect the mould-blown body to the free-blown neck.

The body has spirally twisted ribbing. The bottom is smaller than the second group of bottles (diam. at base 8–11 cm), and the base is kicked. In the Saraçhane (Hayes, 1992) and Marmaray Sirkeci excavations (Ozgumus, 2010; Canav Ozgumus, 2012) jugs/pitchers with spouts are not mentioned, but the quality and colour of the glass, as well as the fabrication technique with two *paraisons* is similar to the second group. These smaller vessels were perhaps used for serving drinks. The glassware described above, considering the larger size, could instead have had a primary use as transport containers and for storage in the cellar.



Fig. 4.72. Bottles, second group, pictures (photo: R. Mosковиć, HRZ archive)

The traditional dating attributed to this type of bottle, produced from two *paraisons*, is fully compatible with the dating of the ship that was carrying them, on the basis of the date engraved on the bell found on board and the analysis of other materials recovered (such as the coins).

As already mentioned, the distinctive manufacturing technique and the characteristic colour of the glass lead to the firm conclusion that the bottles in the ship are Ottoman, and it is likely that they were produced in Constantinople. Their presence in a merchant ship presumably *en route* for the northern Adriatic is unique, but it may not have been unusual, if we look at their contents.

Literature on the history of glass agrees that the glassmaking industry in the Islamic world continued its decline in the 16th century, and extant material indicates that European imports were the stimulus for glass produced locally under the Ottomans (Rogers, 1983; Diba Soudavar, 1983: 187; Jenkins, 1986: 47; Carboni, 2001: 374–375; Carboni and Whitehouse, 2001: 278). For information about glass production before the 18th century we are forced to rely on contemporary accounts and illustrated manuscripts. From documents of the time and from excavations we know that imports, particularly Venetian products, sometimes adapted to the stylistic requirements of foreign markets (Carboni, 2007: 269), were popular.

However, glass was also produced in Ottoman Empire at this time, and there seems to have been an improvement in the quality of local glass, judging by Palace accounts of 1573–1575, and from an order of the Sultan Ahmed Mosque of 1609–1617 (Rogers, 1983: 245). Detailed building records imply that window panes and glass vessels were being manufactured in Constantinople in the middle of the 16th century; in 1582 the *Surname-i-Humayun* provides pictorial evidence of local glassblowers (Rogers, 1983: 250–251; Jenkins, 1986: 49; Carboni 2001: 280). In the next century, Ewliya Celebi mentioned the presence in the city of four glass factories (Jenkins, 1986: 51). For earlier periods, it is necessary to go back to about the 10th century, when a written source describes the installation of a furnace near the coppersmiths' quarter and the church of Saint Mary Chalkoprataia (Henderson and Mundell Mango, 1995: 346).

However, there are no unequivocal archaeological indicators that exactly define the different products of the 16th century. Production wastes have not been found in Saraçhane, although the increase of the presence of green glass in deposits of the late 16th to the first half of the 17th century suggests the development of local production, of which only few signs are left (Hayes, 1992). From the Marmaray excavation only few objects with thermal cracks

and production waste were recovered, which indicate local production in the Ottoman period (Ozgumus, 2010: 130, fig. 13; Canav Ozgumus, 2012: 330).

Nevertheless, it seems certain that a glass industry producing suitable containers for locally manufactured products existed. We know from European travellers who wrote accounts of glass factories in Shiraz, Persia, that in the middle of the 17th century there were at least three glass factories that manufactured bottles for different purposes: containers for rose water, for pickled fruits, and for wine in long-necked bottles protected by wicker covering (Jenkins, 1986: 52). For the area of Persia, it is thought that expatriate Italian craftsmen brought about this revival (Carboni, 2001: 374–375), but it is remarkable that there was a well recognised production with a specific target.

The end of the 16th and the beginning of the 17th centuries is a very important period for the Ottoman glass industry: production increased, glass manufacturing improved, and by 1640, there is detailed evidence for the sale and consumption of imported and locally produced glass on the open market in Istanbul (Rogers, 1983: 260–266).

Given the number of items recovered and the highly formal and decorative standardisation, glassware recovered from the Sv. Pavao shipwreck is clearly part of the cargo, and the glassware is to be considered as containers for other items, or as objects in themselves. They may have been commercialised for their artistic value, but this possibility frankly appears unlikely. It is probable that glassware was purchased and transported aboard the ship for its contents. The cargo of the Sv. Pavao shipwreck indeed allows us to assert that, about 1570–1580, the production of glass bottles in Turkey included variants, differentiated by size, decoration and the possible presence of a spout, perhaps corresponding to the different products they contained.<sup>1</sup>

### *Note*

- 1 I would like to thank Nergis Günsenin, Seniz Atik and the Rakow Library of the Corning Museum of Glass (NY) for their help.

## 4.6. Metal finds

*Jurica Bezak*

### Abstract

*Dal 2007 al 2012, durante le sei campagne di scavo sul relitto post-medievale di Sveti Pavao, sono stati ritrovati oltre un centinaio di reperti metallici. Gli oggetti in metallo relativi all'artiglieria, all'attrezzatura navale e alle monete sono stati analizzati in contributi separati, mentre in questo articolo sono trattate tutte le altre categorie di manufatti metallici, quali gli oggetti d'uso quotidiano e quelli di funzione più varia come, ad esempio, la campana di bordo, le stoviglie, i candelabri e altre componenti. Il recupero della campana di bordo costituisce inoltre un importante contributo per la precisa datazione del relitto. I restanti reperti metallici ci offrono l'opportunità di ricostruire alcuni aspetti della vita di bordo sulle navi mercantili veneziane.*

*Tijekom šest etapa istraživanja, od 2007. do 2012. godine, na lokalitetu novovjekovnog brodoloma pronađeno je preko stotinu nalaza izrađenih od metala. Budući da su metalni predmeti koji se odnose na naoružanje, brodsku opremu i kovani novac obrađeni kao zasebne cjeline, u ovom radu prezentirani su samo nalazi koji spadaju u grupu upotrebnih predmeta i predmeti nedefinirane funkcije. Ponajprije je riječ o brodskom zvonu, kuhinjskim posudama, dijelovima svijećnjaka i vage te drugim predmetima koji su se upotrebljavali na brodu. Pronalazak je broskog zvona bio jedan od najvažnijih elemenata za precizniju dataciju brodoloma. Drugi nalazi pružaju nam mogućnost rekonstrukcije i introspekcije u dio svakodnevnog života na venecijanskom trgovačkom brodu koji je krajem 16. stoljeća potonuo u vodama otoka Mljeta.*

### Introduction

Metal finds from this post-Medieval shipwreck can be categorised, according to their function, into these groups: ship's ordnance, ship's equipment, coins, items of everyday use and items of undefined function. In regard to the metal composition, these items or their remains are made of copper and copper alloy, lead, pewter, silver and iron. Statistical analysis of metal items (Fig. 4.73) is based upon items retrieved in the period from the first stage of research to 2012. Since the site is neither completely excavated nor investigated, it is expected that subsequent research will produce a larger number of finds of various types. Current statistical analysis is, due to that fact, a temporary overview which cannot give definitive conclusions. Of a total number of around 100 finds, this paper interprets the ship's bell, kitchen vessels, candlestick and scale parts and finds made out of lead and iron. These

are the finds which were a part of the ship's inventory, and none can be attributed to the cargo. They represent material traces of everyday life and activities on board the 16th century Venetian merchant ship. The catalogue does not contain all metal finds. Considerations on the smaller fragment which could not be identified were left out because they were unrecognizable and corroded parts of iron items.<sup>1</sup>

### The ship's bell

Bells were used on ships to mark the passing of time during the day, marking half hours, change in guard shifts and time for prayer and food. Sound from the bell could serve as a warning sign in case of danger, fire, fog or an enemy ship (Wede, 1972: 4). Apart from this practical use, bells were often ascribed some apotropaic function.

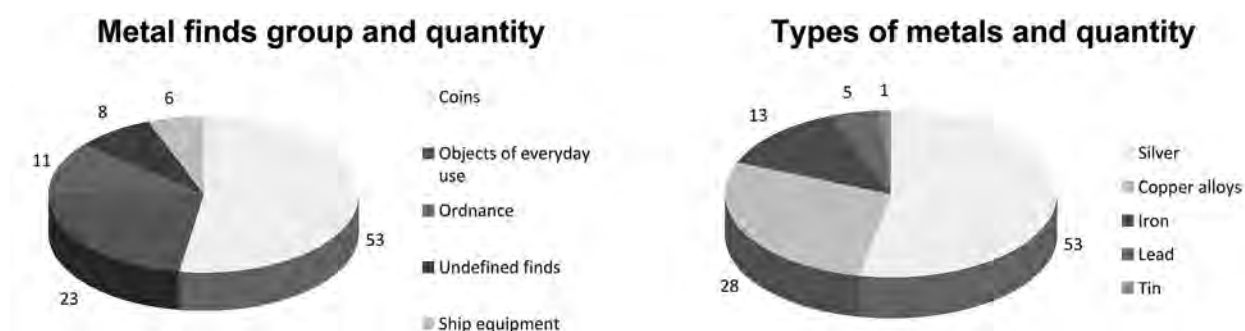


Fig. 4.73. Statistic analysis of metal finds

It was believed that the bell held a supernatural power which protected from storm and sea monsters (Wroblewska, 2008: 155). It is painfully obvious that these “supernatural powers” did not save the Venetian merchantman from capsizing near the dangerous shallow of Sv. Pavao.

The bronze ship’s bell (224/2010; Cat. No. 1) was found after three years of research, during the 2010 campaign. It was found during the excavation in trench AB at the depth of 43 m in a layer of dense sand (Fig. 4.74). First examination showed the bell undamaged but with the clapper missing. It was sporadically covered by a thin layer of incrustation, but the moulding wires and a sequence of Latin letters were clearly visible. The inscription with Latin letters “MDLXVII” signifies the numbers 1567, thus indicating the year in which the bell was cast and, possibly, the year in which the ship was launched to sea.

The discovery caused great thrill among the members of the research team. The shipwreck was dated by analysing the ship’s ordnance and the typology of Iznik pottery to the 16th century. The bell and its inscription established the *terminus post quem*, the earliest date in which the shipwreck could have happened. The ship’s bell is 19.6 cm high including the canon ring (Fig. 4.75). Its sound bow rim measures 14.8 cm and weighs 1.446 kg. The crown on top has a single suspension canon ring 6 cm high and 5.1 cm wide. The canon ring is rhomboidal and divided into three openings. The diameter of the circular opening on top is 1.3 cm, and two parallel ellipsoid openings are situated to the left and right of the first opening. Two moulding wires, which go around the bell, are located where the head crosses to the shoulder of the bell. An inscription field is located a little lower and it is bordered by two streams of triple moulding wires that emphasise the inscription. Latin letters (Pl. 4.14) in relief, which signify the numbers of the year 1567, are situated alongside the half of the bell’s girth and the inscription field with a large gap between the letters. The letters are identical and vary slightly in height from 1 to 1.2 cm. The bell’s waist is below the inscription field and does not have any other decorative symbols or workshop markings apart from two streams of thinner and thicker moulding wires. The transition from the end of the waist to the sounding bow and the rim are also indicated by the moulding wires. Judging by the outer



Fig. 4.74. The ship’s bell in situ (photo: R.Mosković, HRZ archive)



Fig. 4.75. The ship’s bell (photo: R.Mosković, HRZ archive)



Fig. 4.76. Bell cast by Zuanbattista del Ton in 1597, now at the Museo Storico Navale of Venice (photo: C. Beltrame with permission of the Museo Storico Navale in Venice)



Fig. 4.77. The ship's bell found on shipwreck near bay of Saladinac on the island of Biševo (photo: J. Macura, HRZ archive)

and inner surface of the wall the casting of the bell was of high-quality. Laboratory examination<sup>2</sup> established that the bronze alloy consists of copper (Cu, 67.9%), tin (Sn, 28.5%), lead (Pb, 1.8%), nickel (Ni, 0.3%), iron (Fe, 1.4%) and sulphur (S, 0.05%). Although historical sources from the 16th century note few recipes concerning the relation between copper and tin which gives the bell a sonorous tone, the recipes are considered to be more indicative than prescriptive (Avery, 2011: 79). In regard to the mentioned recipes, the bell from the Sv. Pavao shipwreck contains a somewhat higher percentage of tin, which means it must have been more expensive because tin was at that time 40–45 % more expensive than copper. It also means the bell was well designed because the alloy which holds a larger

percentage of tin is harder and cannot be honed when the cooling process finishes (Avery, 2011: 79).

From the aesthetic viewpoint the bell is very graceful, especially taking into consideration the relation between height and rim diameter. From the perspective of technology and style, some characteristics indicate a Venetian origin. The bell from the Arsenal in Venice cast by Zuanbattista del Ton in 1597 (Avery, 2011: 241, fig. 732) resembles the bell from Sv. Pavao in its shape, inscription style and the position of moulding wires. Still, the biggest analogy is related to the inscription style (Fig. 4.76). During the process of lost wax casting the inscription and relief were cast from wax in a separate mould. While they were still soft they were taken out of their mould and set on the false bell model (Avery, 2011: 77). The letters on both bells, which signify the numbers, have the same font type and similar gaps between letters. In search for more analogies with other bells from the Venetian ships, we can isolate only one more shipwreck in the Croatian part of the Adriatic where a ship's bell was found. It is a shipwreck from the bay of Saladinac, on the island of Biševo, where a ship's bell was also found. The basic resemblance lies in the shape of the canon ring with three openings (Fig. 4.77).

Comparing the 16th century bells found on Spanish shipwrecks: The Western Ledge Reef wreck (Wats, 1993: 118, fig. 19) and Tortugas shipwreck (Stemm *et al.*, 2013: 35, fig. 56), we can see the difference in the shape of the canon ring. Those from the bells found on Spanish ships are in the shape of a reversed triangle and the central opening is triangular, not rounded as seen on Venetian bells from the Croatian part of the Adriatic. The bell from Sv. Pavao is, therefore, undoubtedly equally important for dating the ship's launch as well as for providing knowledge about Venetian ship's bells.



Fig. 4.78. The copper cauldron in situ (photo: I. Miholjek, HRZ archive)



Fig. 4.79. 16th century drawing of pan for frying eggs (after B. Scappi, 1570)

### Ship's kitchenware: vessels for cooking and serving food

Items of kitchenware or their remains are often found on Medieval and post-Medieval shipwrecks, primarily because of the fact that most of ship's kitchenware was, in that period, made out of copper and various of its alloys. The reason copper was used is simple: it was resistant to corrosion even if it was exposed to long term harmful effects of salt water. Another important fact is that the kitchen and diet of the crew became *conditio sine qua non* to permit a long term sailing. Therefore, every merchant boat or warship had a certain number of kitchen vessels made from various copper alloys, depending on its size and on the crew number.

The most important position in the ship's galley was the copper cauldron for preparing food. The cauldron of the Sv. Pavao shipwreck (14/2007; Cat. No. 2) was found during the first research stage in 2007. Despite the fact it was found on the surface layer of the bottom (Fig. 4.78) it is completely preserved (Miholjek, 2009: 278). The parts missing are the attachments for handles and a smaller segment of the bottom where the cauldron was in contact with the seabed and sand. The tapered cauldron has a slightly spherical bottom. It is 27 cm high and the diameter of the mouth measures 41–45 cm. It is made out of two plates of copper sheet 2–3 mm thick, which are joined by rivets (Pl. 4.15). The upper part with the mouth is formed by joining the sides of one plate with five rivets, and the bottom part by hammering the other plate into a bowl shape. Both parts are riveted together by a horizontal line of 38 rivets of 2 cm diameter. On the opposite sides, 3.2 cm below the mouth, four rivets can be seen, which were used to secure the attachments for the handles. The volume of the cauldron to the height of the bearing is 20 litres.

The cauldron was made by hammering, and traces of rough hammering are seen on all surfaces of the vessel. Samples of metal and dark residue were taken from



Fig. 4.80. Insert for frying eggs found on the shipwreck (photo: R. Mosković, HRZ archive)

the bottom and analysed. Analysis of the metal sample showed that the cauldron is made of copper (99%) with traces of other elements (Ca, Cr, Fe, Sn, Pb, As, Sb), and the analysis of the residue showed remains of organic compounds. Traces of tin (Sn) in the alloy composition of the cauldron indicate that it was used for preparing food. The inner wall of the metal vessels was frequently coated with tin in the 16th century, since copper gives the cooked food an unpleasant taste (Moore, 1998: 100). Similar finds from the post-Medieval shipwrecks in the Croatian sea are found on the 16th century Venetian wreck *Gagliana Grossa* from Gnalić (Filep and Jurdana, 2013: 103) and near the island of Šipan (Kisić, 1979: 94) and on the 18th century shipwreck near Grebeni on the island of Vis.

The cauldron from Mljet belongs to the hanging cauldrons which were hung above the fireplace. Although no traces of a fireplace were found on the site, many logs and pine cones used for making fire indicate its existence.



Fig. 4.81. Part of the food warmer vessel (photo: R. Mosковиć, HRZ archive)

Three pine cones (69/2008, 192/2010, 254/2010; Cat. No. 26) and ten logs (30–40 cm long) were found together. Such finds are quite rare on post-Medieval shipwrecks. The only examples to date were found on the *Mary Rose* shipwreck (Dobbs, 2009: 129).

Four finds can also be attributed to galley ware, and they were found in a well preserved condition so their function could be determined. A copper alloy frying pan (227/2010; Cat. No. 3) was found just 2 m from the cauldron. The round and shallow pan has a diameter of 25 cm, a height of 5 cm and a horizontally bent-over flattened edge 5 mm wide. Four rivet holes are visible on one side of the pan, two next to the edge 18 cm apart and two more among them spaced of 4.5 cm apart (Pl. 4.16). The arrangement of the holes indicates that the pan had one wooden handle which was inserted into a bearing (attached by rivets) which is not preserved. Single-handled pans are often found on shipwrecks dated to the 16th century. An almost identical example was found on a Venetian merchant shipwreck *Gagliana Grossa* (Filep and Jurdana, 2013: 102, fig. 8).

The most important find among the copper alloy kitchenware recovered on the Sv. Pavao shipwreck, which unequivocally indicates a Venetian origin, is a part of a pan for frying eggs (13/2007; Cat. No. 4) and a part of a food warmer (46/2008; Cat. No. 5). A large selection of contemporary kitchenware is presented by Bartolomeo Scappi in his book *Opera di Bartolomeo Scappi, cuoco*



Fig. 4.82. 16th century drawing of the food warmer vessel (after B. Scappi, 1570)

*secreto di Papa Pio V divisa in sei libri* published in Venice in 1570. Thanks to the illustrations in the book, the function of these two vessels was determined with certainty. In Scappi's book the vessel (Scappi, 1570: tab. 8) is described as "*padella p fare oui frittolate*" – a pan used for frying eggs (Fig. 4.79). It consisted of, according to Scappi's illustration, two parts: the base with three legs which is put on the fire and a specially designed insert in which the eggs were fried. Only a partially preserved insert was found on the wreck (Fig. 4.80): the base of the pan was not recovered.

The insert is a round plate 23.5 cm in diameter equipped with seven hemispherical sockets 6.5 cm in diameter and 2.7 cm in depth. The edge of the insert was bent by 1.1 cm so it could be inserted in the pan. Two holes are visible on one side of the rim probably for attachment of some kind of handle. The opposite side of the rim was, unfortunately, not preserved (Pl. 4.17). The construction design of the pan enabled simultaneous cooking of seven eggs in a way that all eggs were separated from each other.

Unfortunately, the food warmer was also partially preserved. The complete base of the vessel is missing, and the upper section is greatly damaged by corrosion (Fig. 4.81). According to the illustration by Scappi (1570: tab. 17) the vessel called *Schalda vivande con le sue piastrelle* consisted of three parts: biconical vessel and two "shims" or lids (Fig. 4.82). The upper part of a conical vessel is 10 cm high, the diameter of the bottom is 8.8 cm and the diameter of the mouth 20 cm. The profile of the rim's edge is round, and decoration with the hammered motif of a rope is found 3–3.5 cm below the edge of the vessel (Pl. 4.18). The better preserved part of the vessel shows it was made of two layers of copper alloy so the vessel would better preserve the heat. Four rivets found on the bottom of the vessel were used to attach the second vessel, which served as a base. That vessel was not preserved; the only evidence of its existence is a circular shape on the place of conjunction. The volume of the vessel measures 0.65 litres, and it was most likely used to warm the food for a highly ranked or 'privileged' member of the crew. Finding these vessels is of extreme importance for the knowledge about the typology of 16th century kitchenware. These finds are unique in their type among those recovered so far

on post-Medieval shipwrecks. The only analogy with the food warmers can be found on the *Vasa* shipwreck (Matz and Hammarakiöld, 2001: 209).

The fourth find (17A/2011; Cat. No. 6) most likely served as a lid, but it is not yet restored. Although it is damaged the preserved part is sufficient to all an estimate its full original shape. The diameter of the lid is 28 cm, its height 6 cm, and it has a hole in the middle for a handle, which is pressed into the material. The almost vertically raised side of the lid, 2.5 cm in height, ends with a rounded bent edge which sat on the edge of the pot or pan.

It is also difficult to determine the function of the last, fifth copper alloy vessel (5/2011; Cat. No. 7). In fact, taking its shape into consideration, it may have been used as a bowl but also as a wash-basin, so it could be used as a kitchen vessel or as a vessel for personal hygiene. The diameter of the vessel is 35 cm, it is 11 cm high and has a horizontally buckled edge 2 cm wide (Pl. 4.16). It is made by hammering a metal sheet 1–1.5 mm in thickness. The dilemma about its use derives from the fact that it was found outside the area which had a high concentration of kitchenware. Furthermore, no handles were found on the vessel, so it could not have been used for serving food.

Other finds belonging to the kitchen vessels are small remains of copper alloy vessels (Pl. 4.17). Among them are fragments of rim (18/2007, 87/2008; Cat. Nos 8 and 9), handles (83–08, 257/2010; Cat. Nos 10 and 11) and base (239–10; Cat. No. 12).

There is only a single vessel, found within the wreck, which was used for drinking liquids. It is a pewter flagon with a handle and a lid (25/2007; Cat. No. 13), very badly damaged, that could not be restored after the conservation process. The pewter flagon on a low foot with a paunchy body is 22.5 cm high, the diameter of the base is 15.5 cm and the diameter of the rounded mouth below the lid 10 cm. The elegantly shaped massive flagon was cast of a lead and tin alloy in 56.7% (Pb) to 43% (Sn) ratio. The flagon has a lid with a thumb piece for easier opening, decorated with four spherical sprouts. The lid is connected to the banded handle on the rim of the mouth by a hinge. Similar finds of identical pewter flagons are documented on wrecks from the 16th century: *Mary Rose* (Weinstein, 2005: 435–436, figs 11.14 and 11.16) and *El Gran Grifon* (Martin, 1972: 68). The pewter flagon from the Sv. Pavao wreck is stylistically very similar to the pewter flagon from the wreck near Šipan (also dated to the 16th century) (Kisić, 1979: 73–98, fig. 29). Such flagons types are called the “Hanseatic jugs” because they were manufactured in the northern cities of Germany (Kisić, 1979: 94). The pewter flagon from the Sv. Pavao wreck is probably an object of personal use rather than part of the cargo since only one specimen was found.

### Fragments of candlestick and scale

Various types of lamps were used on ships from the very beginning of maritime travel. Oil lamps – *lucernae* – were frequently used in Antiquity and candles in the Medieval

times, as witnessed by numerous finds from various shipwrecks. Only three candlestick fragments were found on Sv. Pavao wreck (Pl. 4.20), thus indicating that they were simply used on board and were not part of the ship’s cargo. They include two candlestick bases and one middle part of the candlestick. The first base (35/2007; Cat. No. 14) was cast in brass. Its upper part is missing so its original shape cannot be reconstructed. The diameter of the base is 17 cm, and another rim rises above a narrow rim at an angle of 80°. This rim was used to prevent the molten wax from spilling from the candlestick. The upper part gradually narrows and ends with a damaged mouth 5.5 cm in diameter. The other candlestick base (32/2007; Cat. No. 15) is somewhat smaller and manufactured by hammering from two parts joined together by soldering. The bottom is missing on the funnel-shaped base. It widens in the upper part in the shape of shallow platter, 9.4 cm in diameter, with a bulb on top containing a hole 1 cm in diameter. Traces of production are visible around the hole because it marks the place where the candlestick was fixed. According to the third find, the middle part of candlestick (168/2009; Cat. No. 16), parts were joined by screwing them together. A part of the connecting bolt clearly visible on the upper section of the middle part of the candlestick supports this hypothesis. The middle part is 19.4 cm high. It is in the shape of a spindle that slowly narrows towards the top. Decoration comprises profiled rings between which are thin parallel incised lines. These items do not bear the manufacturer’s mark which would clearly define their origin. Main manufacturing centres of that period were the German cities of Lubeck, Hamburg and the Belgian city Dinant (Stadler, 2006: 107). On the basis of analogies from the Gnalić shipwreck (Petricoli, 1970: 33), their origin points to German production centres.

The last item within this group of objects is one scale platter (68/2008; Cat. no. 17) (Pl. 4.20). The hemispherical shape of the platter (diam. 6.2 cm), three holes for hanging and its small volume indicate that it was probably a part of a scale used to measure the weight of precious metals, probably various gold and silver coins used in trade exchange. This type of precise scales was frequently part of a merchant ship’s inventory, as witnessed by finds from the *Gagliana Grossa* wreck (Filep and Jurdana, 2013: 161, figs 137–140) and early 17th century wreck at the Mijoka site (Zmaić, 2009: 439). Another type of scale is known to have been used in maritime trade on late Medieval ships. A simpler and larger beam scale was used weigh larger objects. A similar find, with a plate of diameter 30 cm was found on a wreck of a merchant ship from the 16th century in the bay of Sudurad on the Šipan island (Kisić, 2006: 141, 142).

### Lead items

Five lead items were found on the site, among which the most interesting and rarest is a lead seal (28/2011; Cat. No. 18). The diameter of the seal is 1.6–1.8 cm, the thickness 2 mm, and weight 4 g. Surfaces and edges are

damaged and the coupling between the two halves is just barely visible (Fig. 4.83). In spite of that, both halves bear traces of impressed stamps. A motif of cross with identical hands in relief is stamped in a circular stamp on one side, and a simple loop sign is visible on the other side (Pl. 4.21). Lead seals were used to mark quality, volume, origin and manufacturer during the Medieval period. Lead seals found in archaeological excavations can in most cases be connected to the manufacturing and trade of textile merchandise (Terzer, 2006: 112). This specimen was found incrustated and connected to an Ottoman coin and cannot be connected to a specific trade merchandise. The only parallels for this find are the lead seals from the *Gagliana Grossa* shipwreck, where five specimens were found (Terzer, 2006: 112–114, figs 1–4).

The function of other lead finds from the site is not known. Find 246/2010 (Cat. No. 19) is a hollow tube and may be part of a lead pipe or a weight for a fishing net. Find 14/2011 (Cat. No. 20) is a disc 2 mm thick and 1.6–1.8 cm in diameter. It weighs 30 g and the edges show that the circular form was made by a series of cuts. Additional lead finds include two small plates. One (45/2008; Cat. No. 21) is circular with a diameter of 6 cm, thickness of 1 mm and weight of 32 g (Pl. 4.21); the other (32/2011; Cat. No. 22) is a bent small plate with a rectangular hole in the middle, weighing 36 g.

### Ferrous finds

Thirteen iron objects have been recorded. The functions of only three have been identified. All were found in deeper layers of sand, in anaerobic conditions which saved them from corrosion to a certain extent. Other finds are unrecognisable and covered by incrustation, hence are not included here, but are included in the statistical analysis considering their number in relation to items made of other metals. Two items belong to a locking mechanism. A key (1/2011; Cat. No. 23) and a lock cartridge (252/2010; Cat. No. 24) were found. The key is covered by a thick layer

of oxides, thus its actual dimensions cannot be properly ascertained. According to the actual shape it had a round end for holding, and the part which entered the lock had three sprouts of various length. The lock cartridge is partially preserved, and a rectangular section (14 × 6 cm) has a rectangular space for the knob, while part of the breach is only barely visible. The cartridge is broken at this point and only a segment of the opening is visible. Because the place for the handle survives we can be quite sure that the cartridge was part of a door rather than a chest which did not have a mechanism of this kind. The third find (236/2010; Cat. No. 25), part of a bolt or nail of rectangular cross-section, was found in Trench V. Since a few thick wooden planks with holes were found in the vicinity, it was probably used to connect various elements of the ship's structure.

### Conclusion

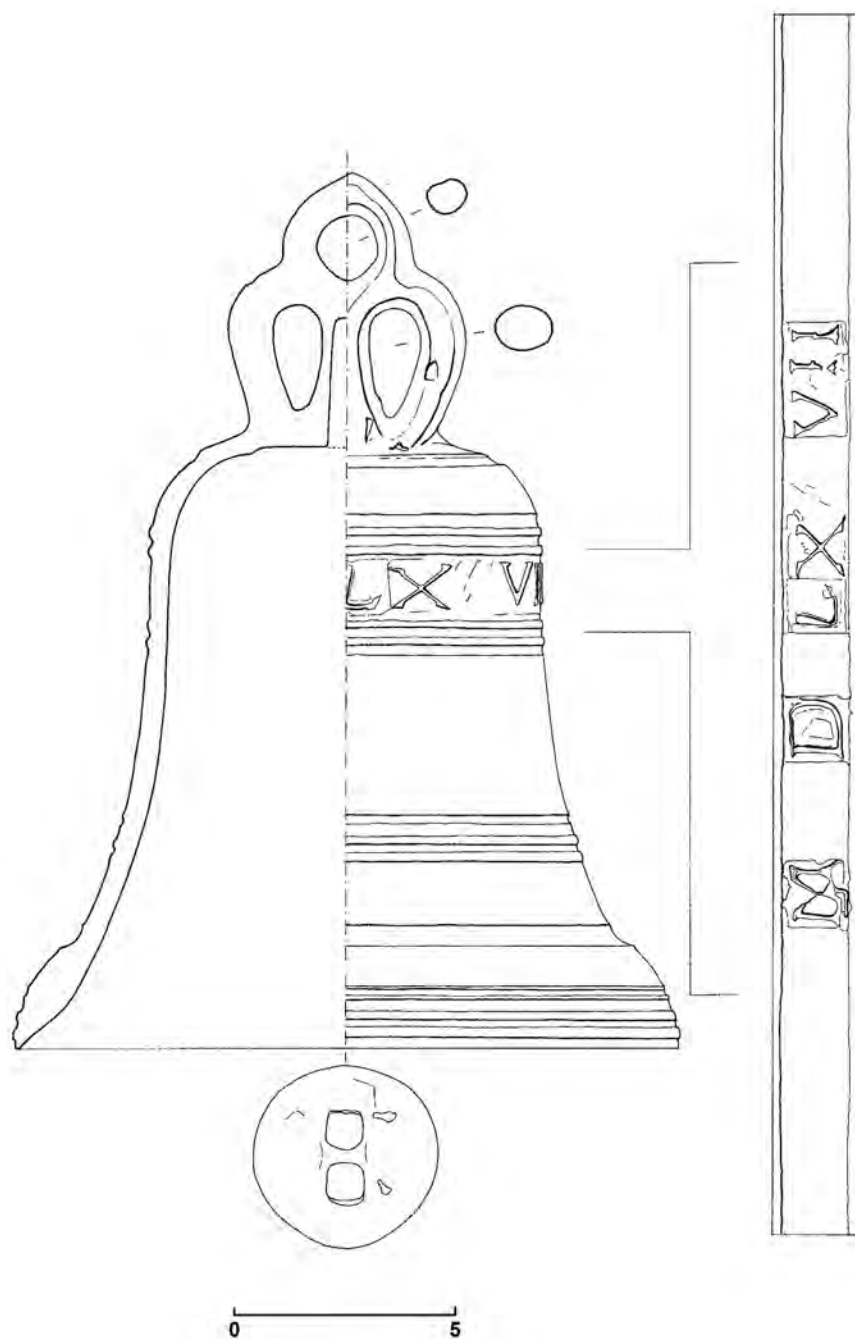
Various metal items found on the site expand the knowledge we have about the Venetian merchantmen around the end of the 16th century. The discovery of the ship's bell with the year 1567 set the *terminus post quem*, the earliest date at which the shipwreck could have happened. Based on stylistic characteristics and analogies it is established that the origin of the bell is Venetian. Its importance also massively contributes to the research of style and history of ship's bells. Seven vessels and few examples of rim and handle fragments belonging to the ship's kitchenware were found on the site. A large proportion of them – i.e. copper alloy cauldron, pan, lid, bowl and pewter flagon – represent frequent finds of ship's kitchenware as seen on many shipwrecks. Nevertheless, two vessels present themselves as rare types of finds and therefore differ from the usual kitchenware repertoire: part of a pan for frying eggs and a food warmer. These are unique finds of kitchenware recovered on Venetian post-Medieval shipwrecks. These artefacts give us the opportunity to reconstruct and interpret part of daily life on board the ship. Evidence for trade activities which conducted on the ship are the coins, a fragment of a platter (belonging to a weighing scale) and one lead seal. Considering the site was found in its intact state and that it has not been completely investigated, future excavation will surely produce more metal finds.

### Notes

- 1 Detailed catalogue of the finds can be found at the end of the text.
- 2 The metal objects mentioned in the text were analysed in the Natural Science Laboratory of the Croatian Conservation Institute (Laboratory report 194/2013 by D. Mudronja). Metal samples from prepared cross-cuts were analysed by X-ray fluorescent spectroscopy using the Atrax device (Bruker AXS). Quantity analysis was made by Spectra 5.3 software, through a comparison with the bronze standard SUS 36/16 and NIST 1107.



Fig. 4.83. Lead seal (photo: D. Jakopović, HRZ archive)

**Plate 4.14**

224/2010

*Plate 4.14. The ship's bell (drawing: A. Ivanković)*

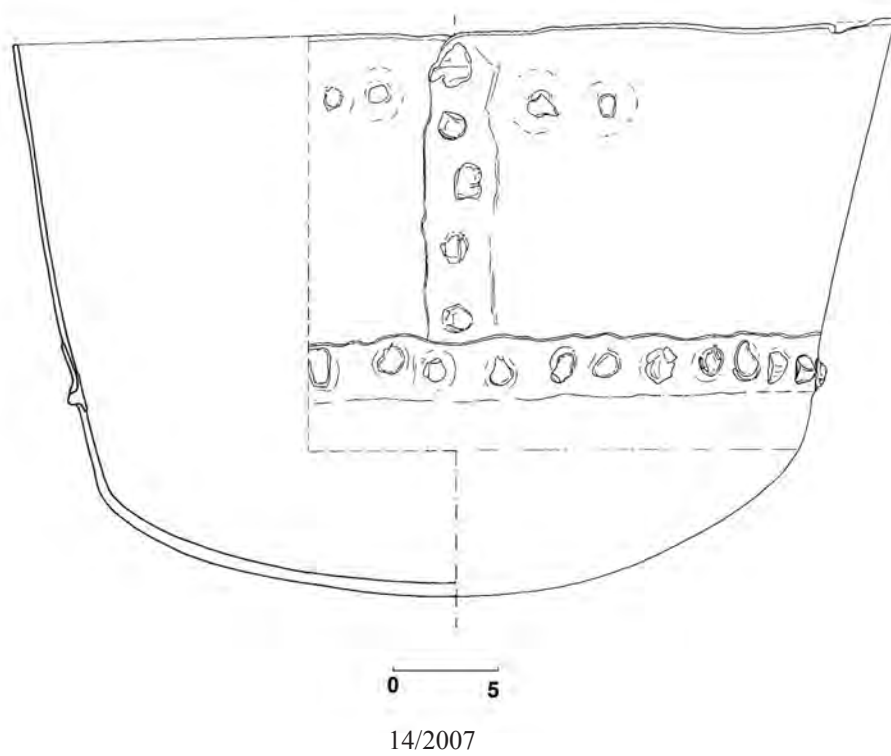
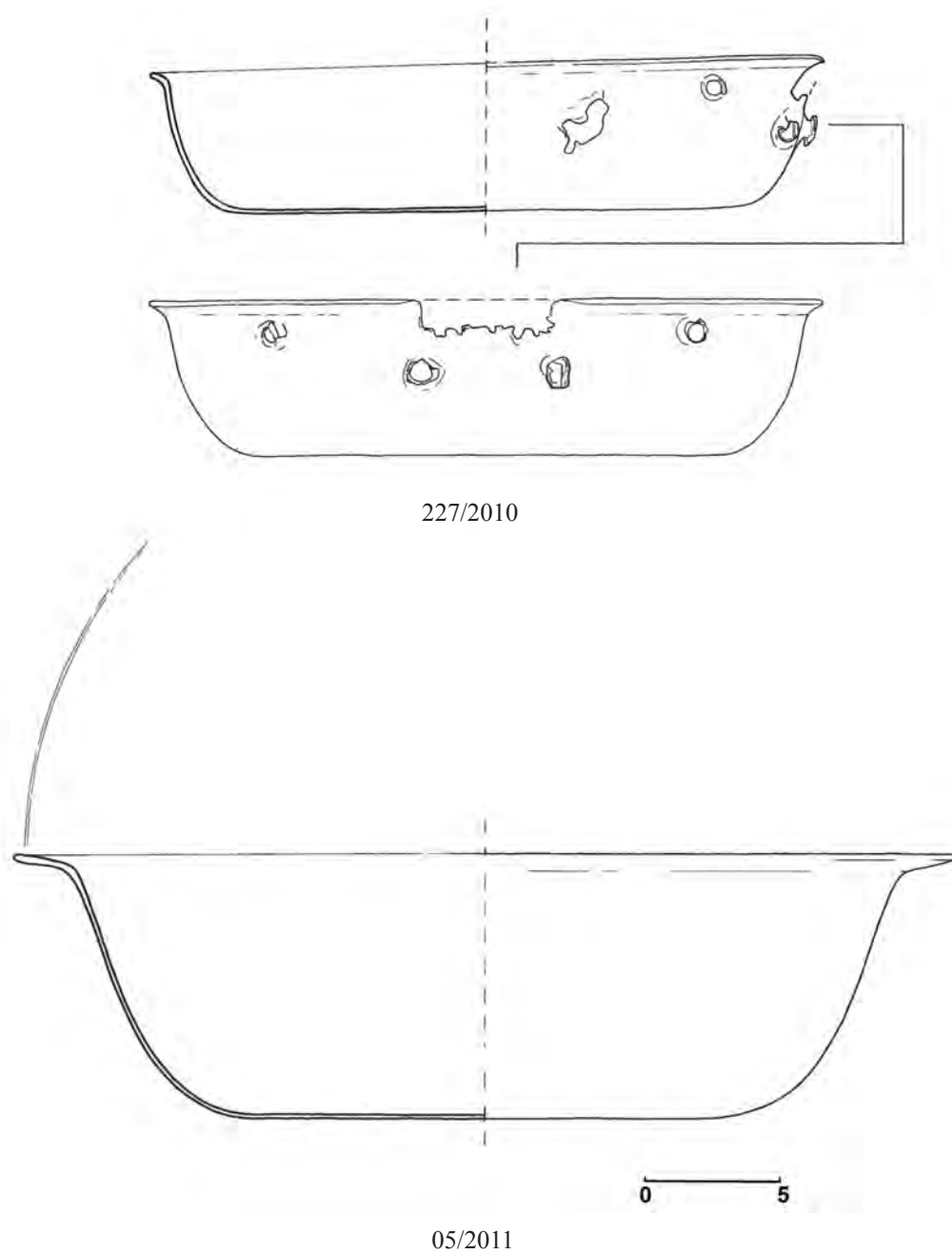
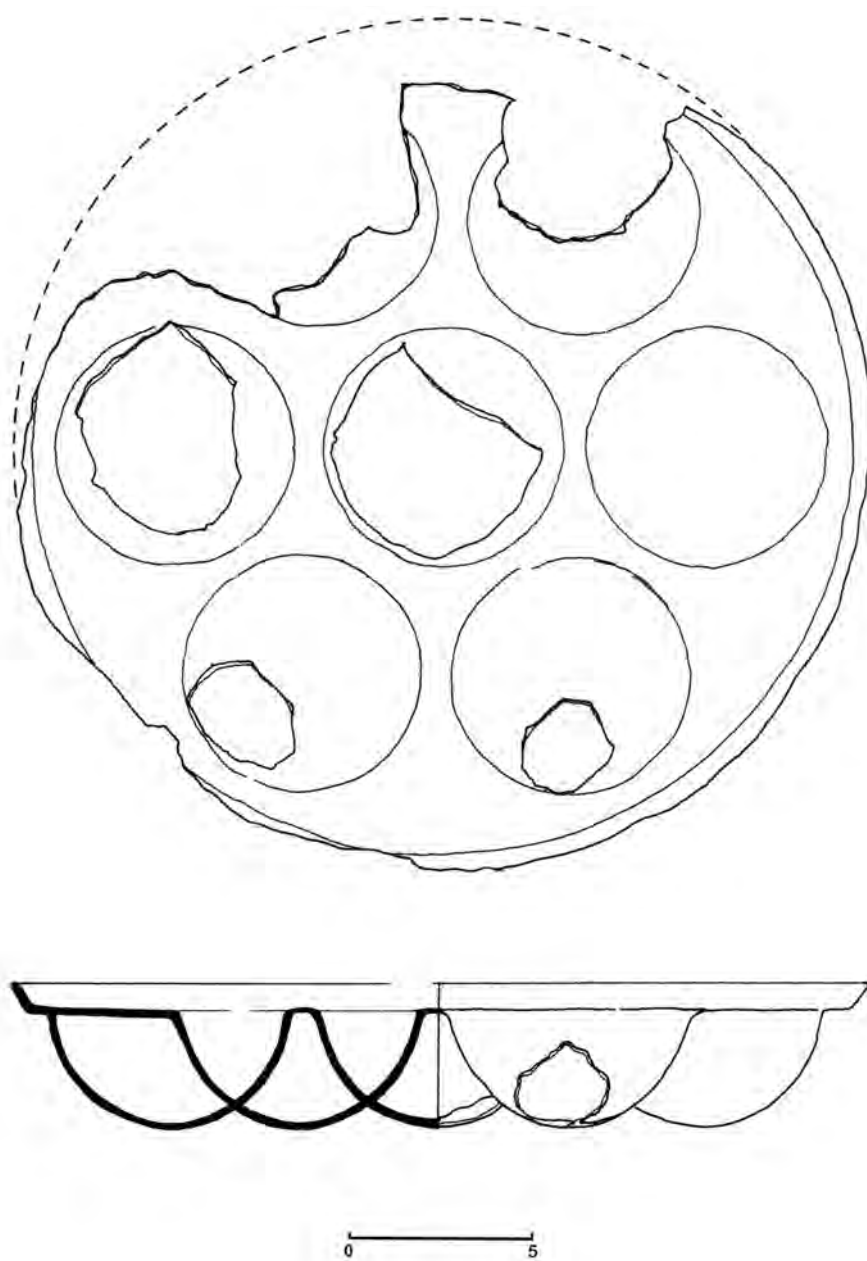


Plate 4.15. Copper cauldron (drawing: A. Ivanković)

**Plate 4.16**



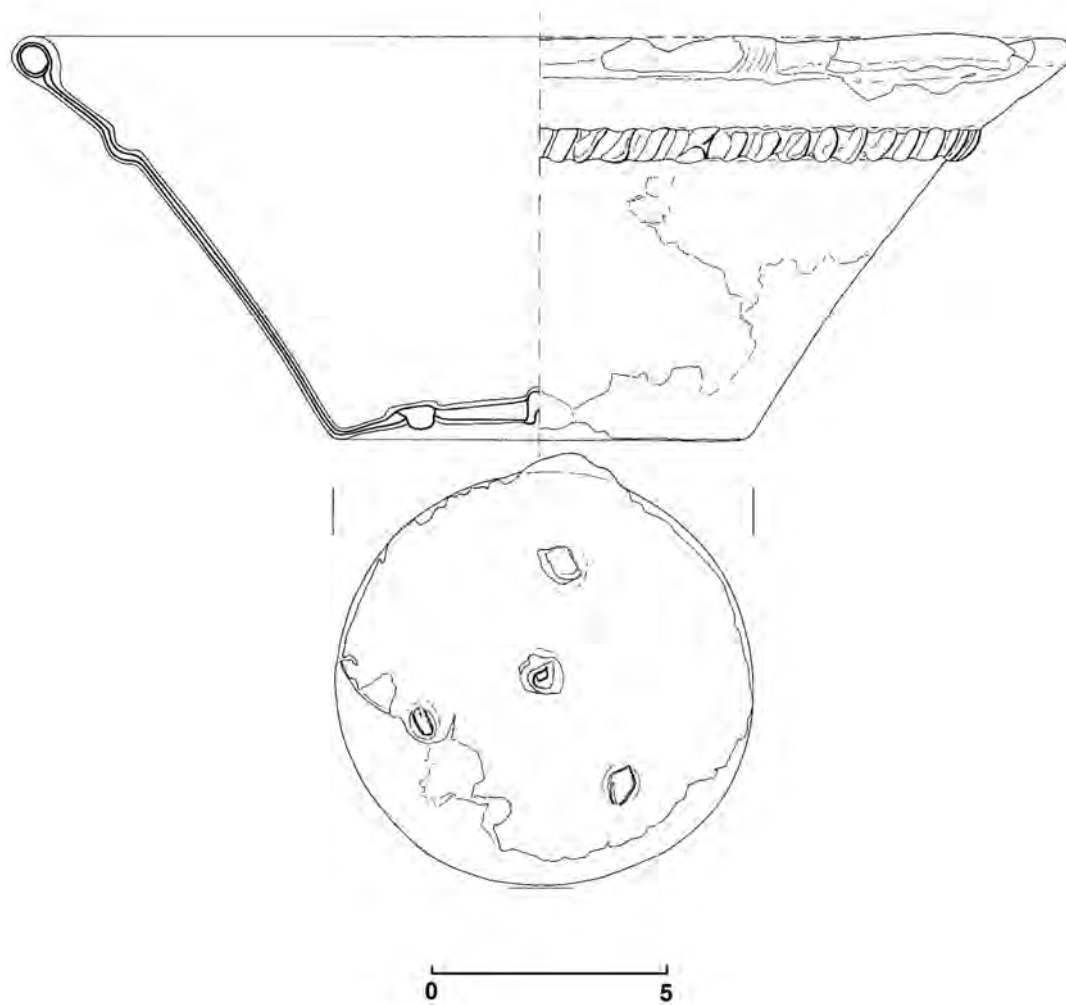
*Plate 4.16. Copper alloy frying pan and bowl or wash-basin (drawing: A. Ivanković)*



13/2007

Plate 4.17. Insert for frying pan for eggs (drawing: V. Zmaić)

**Plate 4.18**



46/2008

*Plate 4.18. Part of the food warmer vessel (drawing: A. Ivanković)*

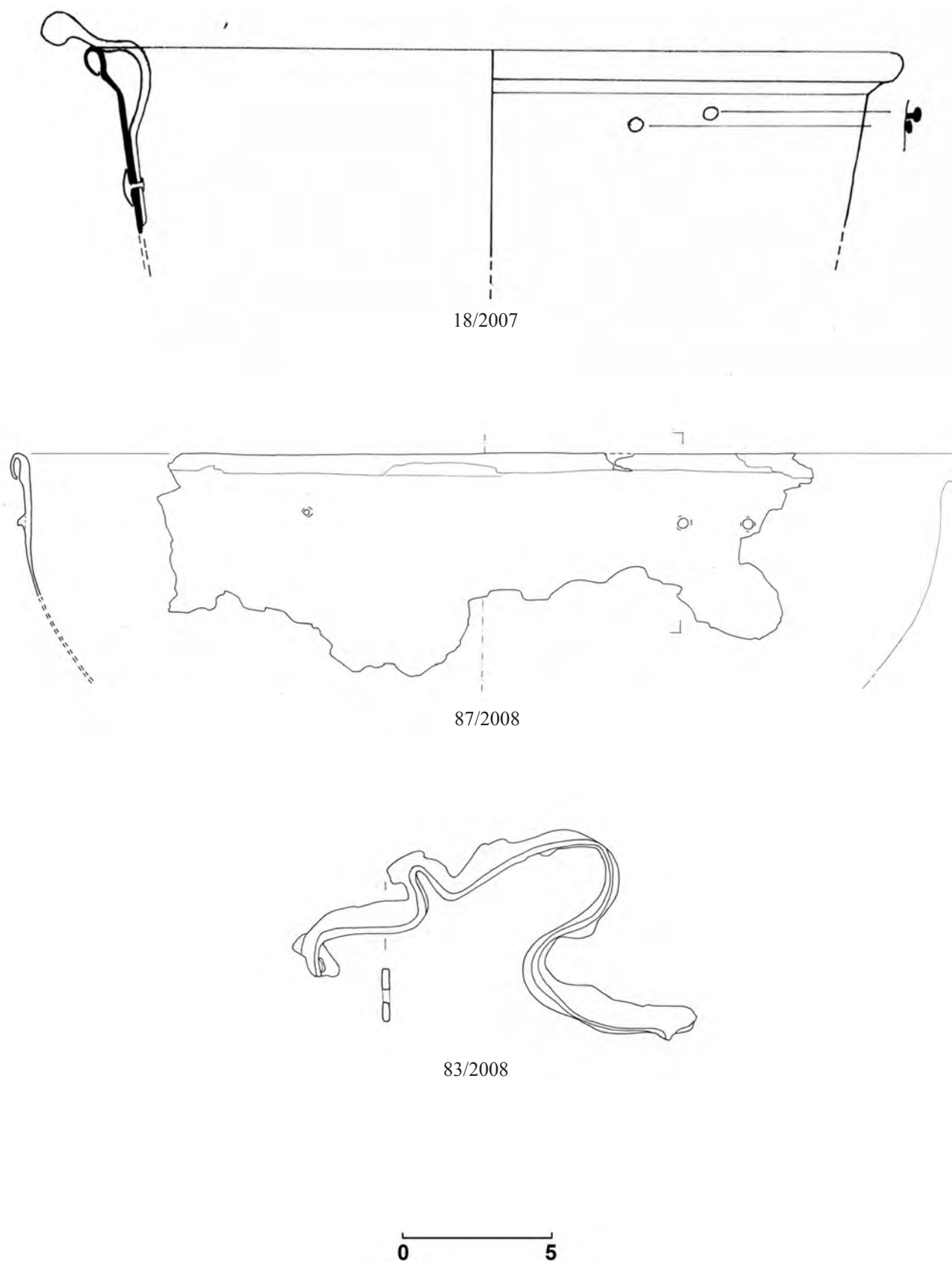
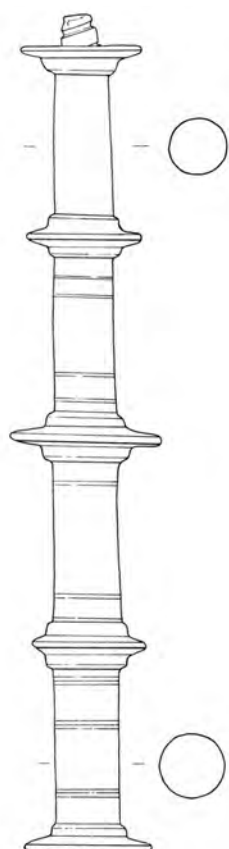
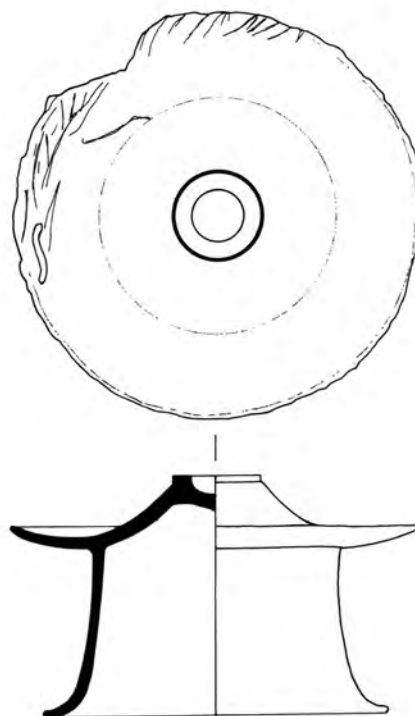


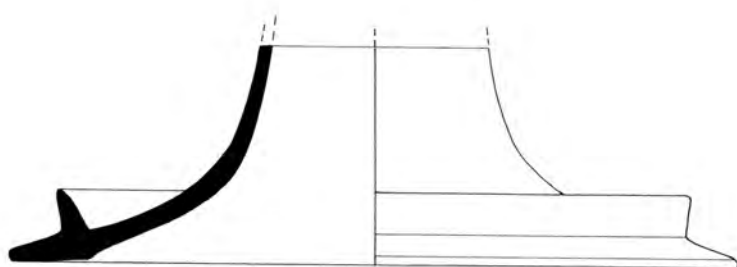
Plate 4.19. Fragments of copper alloy vessels (drawing: V. Zmaić)

**Plate 4.20**

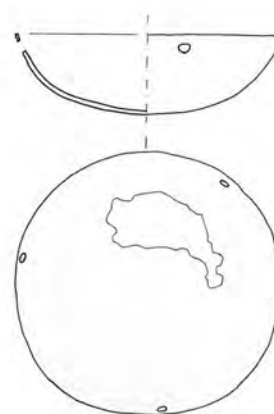
168/2009



32/2007



35/2007

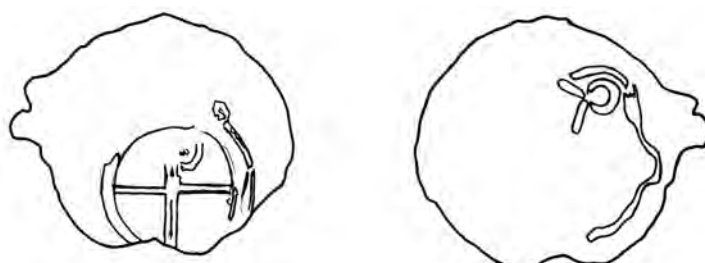


68/2008

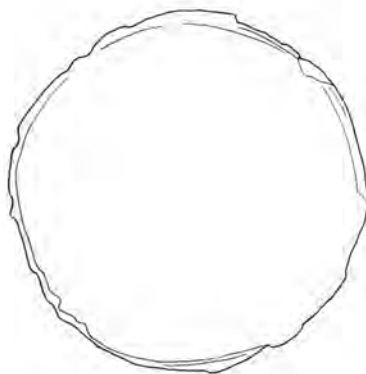
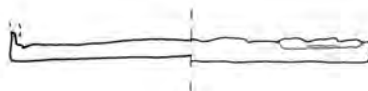


Plate 4.20. Fragments of candlestick and scale (drawings by A. Ivanković (168/09) & V. Zmaić (32, 35, 68/08))

## Plate 4.21



28/2011



45/2008



Plate 4.21. Lead objects (drawings by P. Dugonjić (28/11) and V. Zmaić (45/08))

## Catalogue

*Abbreviations:* Diam = diameter; H. = height; L = length;  
Th. = thickness; Vol. = volume; W. = weight; Wid. = width  
photo: R. Mosković, HRZ archive



### 1. 224/2010

*Ship's bell with inscription MDLXVII (1567)*

Metal: Bronze, Technique: casting

Dimensions: H.: (including canon ring): 19.6 cm, Diam (sound bow): 14.8 cm, (inscription field) 8.7 cm, W.: 1.446 kg

Provenance: Venetian



### 2. 14/2007

*Ship's cauldron*

Metal: Copper, Technique: hammering, riveting

Dimensions: H.: 27 cm, Diam (rim): 41–45 cm, Vol. (approx. working vol.): 20 lit.



### 3. 227/2010

*Frying pan*

Metal: Copper alloy, Technique: hammering

Dimensions: H.: 5 cm, Diam (rim): 25 cm

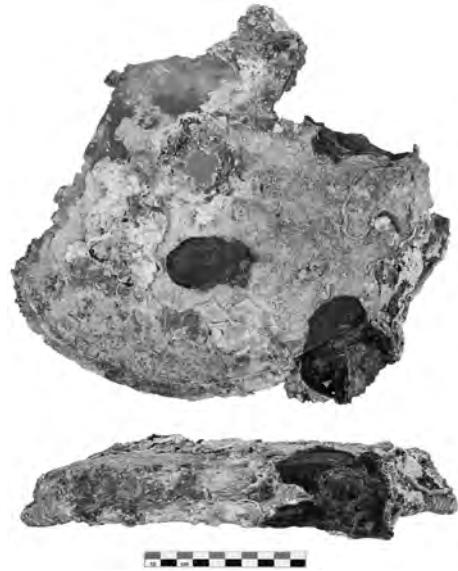
Four rivet holes visible on one side indicate that the pan had one wooden handle.

**4. 13/2007***Insert for frying eggs*

Metal: Copper, Technique: hammering

Dimensions: H.: 5 cm, Diam: 23.5 cm, seven hemispherical sockets diam.: 6.5 cm, depth: 2.7 cm.

Provenance: Venetian

**6. 17A/2011***Lid*

Metal: Copper alloy, Technique: hammering

Dimensions: H.: 6 cm, Diam (rim): 28 cm

**5. 46/2008***Food warmer fragment*

Metal: Copper, Technique: hammering from two layers of copper sheet

Dimensions: H.: 10 cm, Diam (rim): 20 cm, (bottom) 8.8 cm, Vol. 0.65 lit.

Decoration: hammered motif of rope is found 3–3.5 cm below edge of vessel.

Provenance: Venetian

**7. 5/2011***Copper alloy vessel*

Metal: Copper alloy, Technique: hammering

Dimensions: H.: 11 cm, Diam (rim): 35 cm, (base) approx. 18 cm

Function: unknown (may have been used as bowl and/or wash-basin).



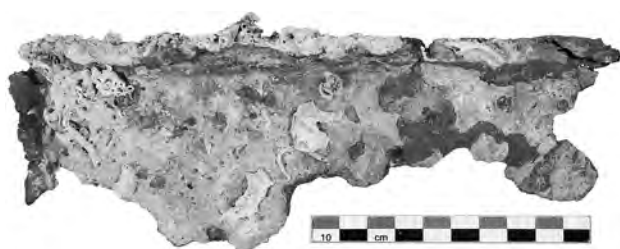
**8. 18/2007**

*Vessel fragment*

Metal: Copper, Technique: hammering

Dimensions: Diam (rim): 27.5 cm

Type of vessel: unknown



**9. 87/2008**

*Rim fragment*

Metal: Copper, Technique: hammering

Dimensions: Diam (rim): approx. 36 cm

Type of vessel: unknown

Function: unknown



**11. 257/2010**

*Handle fragment*

Metal: Copper alloy



**10. 83/2008**

*Handle fragment*

Metal: Copper

Dimensions: Th.: 2 mm



**12. 239/2010**

*Base fragment*

Metal: Copper, lead (space between two layers of copper sheets filled with lead)

Dimensions: Diam: c. 36 cm



**13. 25/2007**

*Pewter flagon (type: Hanseatic jug)*

Metal: Pewter

Technique: casting

Dimensions: H.: 22.5 cm, Diam (base): 15.5 cm, (mouth) 10 cm

Provenance: northern Germany



**14. 35/2007**

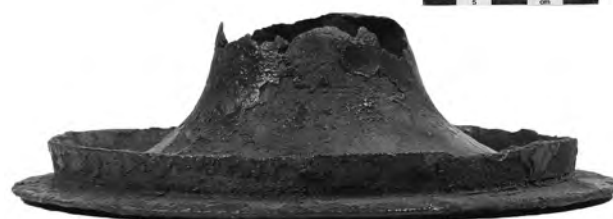
*Candlestick base fragment*

Metal: Brass

Technique: casting

Dimensions: Diam (bottom): 17 cm

Provenance: German production centres



**15. 32/2007***Candlestick base fragment*

Metal: Copper alloy

Technique: hammering, soldering

Dimensions: Diam: (platter): 9.4 cm

Provenance: German production centres

**16. 168/2009 (right)***Middle part of candlestick*

Metal: Brass

Technique: casting

Dimensions: H.: 19.4 cm

Decoration: five profiled rings, thin parallel incised lines

Provenance: German production centres





**17. 68/2008**

*Scale plate*

Metal: Copper alloy

Technique: hammering

Dimensions: H.: 1.7 cm, Diam: 6.2 cm



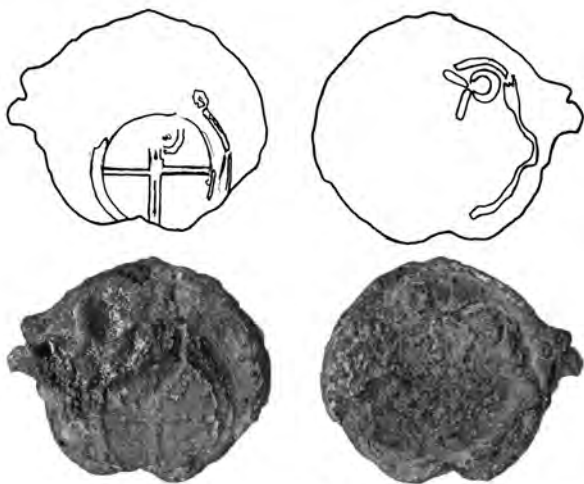
**19. 246/2010**

*Lead fragment*

Metal: Lead

Dimensions: Diam: 30-36 mm, Th.: 3-5 mm, L.: 60 mm

Function: unknown (part of pipe or fishing net weight)



**18. 28/2011**

*Lead seal*

Metal: Lead

Technique: casting

Dimensions: Diam: 16-18 mm, Th.: 2 mm, W.: 4 g.

Marks: impressed stamps; one side with motif of cross with identical arms inside of the circular stamp, second side with simple loop sign.



**20. 14/2011**

*Round lead object*

Metal: Lead

Dimensions: Diam 16-18 mm, Th.: 2 mm, W.: 30 g.

Function: unknown



**21. 45/2008**

*Lead plate*

Metal: Lead

Dimensions: Diam: 6 cm, Th.: 1 mm, W.: 32 g.

Function: unknown



**23. 1/2011**

*Key*

Metal: Iron

Dimensions: W.: 5.3 cm, L.: 11.5 cm (actual dimensions unknown)



**22. 32/2011**

*Bent lead plate with rectangular hole*

Metal: Lead

Dimensions: W.: 36 g.

Function: unknown



**24. 252/2010**

*Lock cartridge*

Metal: Iron

Dimensions: H.: 14 cm, Wid.: 6 cm

**25. 236/2010**

*Bolt or nail fragment*

Metal: Iron

Dimensions: H.: 5.5 cm, rectangular head  $2.5 \times 2.5$  cm, rectangular cross-section

**26. 69/2008, 192/2010, 254/2010**

Pine cones

Material: Wood

Pine cones were found with fuel logs, they indicate galley fireplace

## 4.7. The Ottoman *Akches*

### *Garò Kùrkman*

#### Abstract

*Le indagini archeologiche sottomarine sul relitto di San Paolo hanno messo in luce 50 monete Ottomane (Akçe). Malgrado tutte le monete abbiano subito notevoli danni, dovuti alla corrosione per effetto dell'acqua salata, 41 di esse sono state comunque identificate con successo sia per il nome del sultano che per il conio. Le restanti 9 monete notevolmente corrose sono state classificate grazie alle tracce di scritte solo parzialmente conservate, quindi decifrando sia il nome del sultano che il conio.*

*Podvodno arheološko istraživanje brodoloma kod Plićine Sv. Pavla rezultiralo je pronalaskom 50 otomanskih novčića (Akçe). Iako je novac pretrpio oštećenja izazvana dugotrajnim izlaganjem slanoj vodi 41 je primjeraka novca uspješno dešifrirano i pripisano kovnicama i sultanima za vrijeme kojih su iskovani. Preostalih 9 korodiranih novčića je djelomično dešifrirano zahvaljujući tragovima natpisa koji ukazuju na sultana ili kovnicu.*

When a sultan of the Ottoman Empire died, the next sultan (son, uncle or brother) was promptly enthroned; a *khutbah* was delivered after Friday prayers at the mosque, calling his name, thus proclaiming him as the next sultan; and lastly coins belonging to the previous sultan were collected to be melted down and re-minted in his own name. The Ottoman tradition thus prohibited the use of old dated coins. To find a group of coins so diversely dated, and therefore quite illegal, would point to a money chest of a ship's captain, collected in various ports, rather than belonging to one random merchant.

The analysis of the 50 coins from the shipwreck shows that they belonged to four different sultans, namely: Sultan Selim I (Yavuz), 9th Ottoman sultan, who succeeded to the throne in H 918/AD 1512; Sultan Süleyman I (Kanûnî/Magnificent), 10th Ottoman sultan, who succeeded to the throne in H 926/AD 1520; Sultan Selim II (Sarı), 11th Ottoman sultan, who succeeded to the throne in H 974/AD 1566; and finally Sultan Murad III, 12th Ottoman sultan, who reigned H 982/AD 1574–H 1003/AD 1595. This means that the ship sank during or after the reign of Sultan Murad III.

A short glimpse at the monetary system of the Ottoman

Empire reminds us that the unit of weight, as in all Islamic countries, was the “*dirham*”. One *dirham* weighed 3.207 g. During the Beglik period, i.e. until the conquest of Byzantium, the Ottomans did not mint gold coins, but used Venetian *ducats* and other gold coins. They minted only silver and copper coins. Following the conquest of Constantinople/Istanbul, they minted their first gold coins, in H 882/AD 1477–1478 and H 883/AD 1478–1479. At the beginning it was called “*Gold Sikke*” (coin), then during Sultan Süleyman's reign “*Sultaniye*”, then later again “*Hasene-i Sultaniye*”. But a silver coin was always an *akche*. A gold *sikke* was equal to 20 silver *akches* (the equation changed according to the inflation of the period); and a silver *akche* was equal to eight copper *mangirs* (this equation also changed according to the inflation of the period). In fact, such change could occur a number of times during the reign of the same sultan.

A copper coin was called by merchants “*Pul*” during Sultan Mehmet II's reign, “*Fels*” or “*Fulus*” during the 16th–17th centuries and “*Mankur*” (or “*Mangir*”) during the 18th century. The interesting fact about copper coins is that they were not minted by the state mint but by “*Mültezim*”, people who undertook to do a job instead

of the state; in this case to mint coins. Then, the treasury could randomly stop any person on the street and, by force, exchange any *akches* in their possession with *mangirs* in fair trade! This was considered a way of collecting taxes.

In Rajab 881/October 1476, the Ottoman financiers decided that a copper *pul* should weigh one *dirham*, and eight of these should equal one *akche*. If a denomination smaller than *pul* was to be used, then one *dirham* of copper was cut into three *pul*, called a “*cırık*”. Hence, 24 of these equalled an *akche*. There are actually two methods of minting a coin. In the first, called the “Almarco” system, the number of coins to be struck is important. For example, if 1000 coins were to be struck from 1 kg of silver bullion, their individual weights would (and could) never be equal. Instead, there would be an average weight. In the second system, called the “Alpezzo”, the weight of each coin was standard. Therefore, 1 kg of silver will yield so many numbers of coins of that particular standard weight. Generally the “Almarco” system was used for the minting of smaller denominations and the “Alpezzo” system for larger.<sup>1</sup>

### Catalogue (Pls 4.22–23)

The following catalogue includes descriptions of 50 Ottoman *akches* recovered during the excavations of the Sv. Pavao shipwreck. Each coin has been described both in its obverse (Obv.) and its reverse (Rev.) reporting the translation of what it is written and still readable on it. Diameter (ø) and weight (g = in grams) of the coins are also indicated.

#### 9th Sultan Selim Shah I bin Bayezid II

28 known mints.

Reigning period: A.H. 07 Safar 918–09 Şawwāl 926/A.D. 24 April 1512–22 September 1520.

The Ottoman coins found in the shipwreck, minted by Sultan Selim Shah I, are, in total, five *akches*, three “Qustantiniyya”, one “Amasya” and an illegible one.

#### Kostantaniyye (Qustānīniyya) 918 قسطنطينيه

1–152 /1a–1b, Akche, ø 11.5 mm, 0.66 g.

Obv. Sulta(n) Selim Sha(h) bin Bayezid (Han)

Rev. Azze (n)asrühü duribe (Kos)tantiniyye 918



152 1a-1b

2-217/24a–b, Akche, ø 12 mm, 0.68 g.

Obv. Sultan Selim bi(n) Bayezid (Han)

Rev.(Azze nasrühü duri)be Kostantiniyye sene 918

3-152/2a–b, Akche, ø 11.5 mm, 0.52 g different die

Obv. Sult(an) S(elim) Sha(h) b(in) (Bayezid)

Rev. Azze (nasrühü duri) be Kostanta(niye) (9)18

#### Amasya (Āmāsyā) 918 اماسيه

4- 217/14a–b, Akche, ø 12.5 mm, 0.65 g different die

Obv. Sultan Selim Shah bin Bayezid (Han)

Rev. Azza nasrühü duribe Amasiye sene (9)18

Very worn, almost undecipherable but very probably Sultan Selim coin

5-217/6a–b, Akche, ø 11.1 mm, 0.65 g different die

Obv. Sul(tan) Sel(im) sah bin Bayez(id)

Rev. (double-strike, hence illegible)

#### 10th Sultan Süleyman bin Selim Shah I

63 known mints.

Reigning period: A.H. 17 Şawwāl 926–21 Şafar 974/AD 30 September 1520–07 September 1566

The Ottoman coins found in the shipwreck, minted by Sultan Süleyman, are, in total, 17 *akches*; three “Edirna”, two “Nowaberda”, one “Nowar”, two “Qaratowa”, three “Sidre Qapisi”, and six very worn, therefore illegible coins.



217/27a-b

#### Edirne (Edirna) ادرنه

6-217/27a–b, Akche, ø 12 mm, 0.63 g

Obv. Sultan Süleyman (bin) Selim (Shah Han)

Rev. Azze Nas(rühü) duribe Edirne sene (926)

7-217/34a–b, Akche ø 12.1 mm, 0.55 g

Obv. Sultan ..... (written clockwise, in all probability a Sultan Süleyman)

Rev. Azza nasarü(hü) duribe (Ed)irne (926)

8-217/217-12a–b, Akche, ø 11.8 mm, 0.54 g

Obv. Sultan Süleyman bin Selim Han

Rev.Azza nasrühü duribe Edirne sene (926)

#### Novaberde (Nowāberda) نوابرده

9-217/13a–b, Akche, ø 12 mm, 0.53 g

Obv. Sultan Suleyman Shah bin Selim Shah Han  
Rev. Azza nasrühü duribe Novabrd(e) sene (926)

10-217/40a-b, Akche, ø 11.9 mm, 0.50 g  
Obv. Süleyman Han Selim .....  
Rev. .... Novaber(de)

*Novar (Nowār) نوار*

11-217/23a-b, Akche, ø 12.5 mm, 0.68 g  
Obv. (Su)ltan Süleyman bin (Selim) Shah ....  
Rev. (Azza nasrühü) duribe Novar sene (9)26



*Kratova (Qarātowa) قرطوه*

12-217/8a-b, Akche, ø 11 mm, 0.42 g  
Obv. (Sul)tan Suleyman Shah bin Selim Shah  
Rev. Azze nasrühü Duribe Kratova

13- 217/31a-b, Akche, ø 14 mm, 0.70 g  
Obv. (Sultan) Süleyman bin Se(lim) ..... (worn)  
Rev. (Azza nasrühü duribe Kra) tova .....  
(worn)

*Sidrekapsi (Sidre Qapisi) سدره قپسي*

14-217/16a-b, ø 13 mm, 0.50 g  
Obv. Sultan Süleyman bin Selim Han  
Rev. (Azza nasrühü) duribe Sidrekapsi (926)

15-217/21a-b, Akche, ø 13.4 mm, 0.62 g  
Obv. (Sultan) Süleyman bin Selim Han  
Rev. (Azza nasrühü) duribe Sidrekapsi sene 926

16-217/22a-b, Akche, ø 12.5 mm, 0.63 g  
Obv. Sultan Süleyman Shah bin Selim Han  
Rev. Azza nasrühü duribe Sidrekapsi 926

*Very worn, almost undecipherable but very probably  
Sultan Suleyman coins*

17-153/1 a-b, Akche, ø 11.9 mm, 0.43 g  
Obv. süleyman? worn  
Rev. ?

18-155a-b, Akçe, ø 10.9 mm, 0.59 g  
Obv. Sultan Süle(yman?) ...  
Rev. ? illegible

19-217/29 a-b, Akçe, ø 12 mm, 0.67 g  
Obv. Sultan Süleyma(n bin) Selim Shah (han)  
Rev. (Azza) nasrū (hū) duribe .....(worn) .....? sene  
9(26)

20-217/36a-b, Akche, ø 12 mm, 0.62 g  
Obv. worn illegible  
Rev. worn ..... sene 92(6)

21-217/19a-b, Akche, ø 11.5 mm, 0.70 g  
Obv. Sultan Süleyman bin Selim Han  
Rev. Azza nasrühü Duribe illegible worn

22-217/42a-b, Akche, ø 14.6 x 11 mm, 0.64 g  
Obv. Süleyman ..... (worn) ..... written  
clockwise  
Rev. Hallede Mülke duribe Kost ..... written  
clockwise

### 11th Sultan Selim II bin Süleyman I

Reigning period: A.H. 09 Rabī' al-awwal 974-01  
Ramaḍān 982/AD September 1566–15 December 1574.  
The Ottoman coins found in the shipwreck, minted by  
Sultan Selim II, are, in total, five *akches*, one “Edirna”,  
one “Nowaberda”, two “Sidre Qapisi” and one very  
worn, therefore illegible coin.

*Edirne (Edirna) ادرنه*

23-217/15a-b, Akche, ø 12mm, 0.55 g  
Obv. (Sultan ) Se(lim bin) Süleyman Han  
Rev. Azza nasrühü duribe (E)dirne sene 97(4)

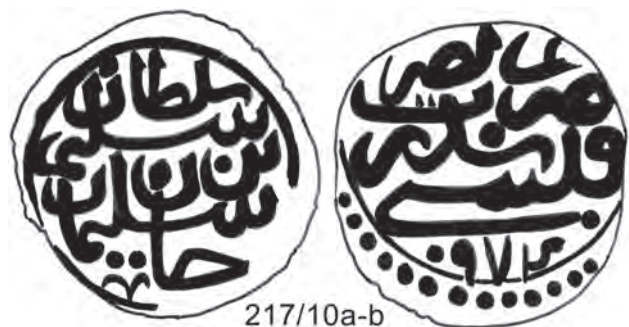
*Novaberde (Nowāberda) نوابرده*

24-217/25a-b, Akche, ø 13 mm, 0.66 g  
Obv. Sultan Selim (Shah) bin Sü(leyman) (worn)  
Rev. Azza nas(rühü duribe) (N)ovaberde sene 974

*Sidrekapsi (Sidre Qapisi) سدره قپسي*

25-217/9a-b, Akche, ø 12 mm, 0.49 g  
Obv. Sultan Selim bin Süleyman Han  
Rev. Azze nasrühü duribe Sidrekapsi 974

26-217/10a-b, Akche, ø 12 mm, 0.68 g  
Obv. Sultan Selim bin Süleyman Han  
Rev. Azze nasrühü duribe Sidrekapsi 974



*Very worn, almost undecipherable but very probably Sultan Selim II coin*

27-157 a-b, Akche, ø 11.8 mm, 0.35 g

Obv. (Sul)tan Sel(im) ...?

Rev. ? illegible

### 12th Sultan Murad III. bin Selim II

Reigning period: A.H. 08 Ramaḍān 982–05 Jumādā al-  
ulā 1003/AD 22 December 1574–16 January 1595.

The Ottoman coins found in the shipwreck, minted by Sultan Murad III, are in total 14 akches, one “Qustantiniyya”, five “Nowaberda”, one “Saqiz”, one “Sidre Qapisi”, three “Uskub”, and three very worn coins, therefore illegible.

**قسطنطينيه**  
*Kostantaniyye (Qusṭanṭiniyya)*

28- 217-11a-b, Akche, ø 13 mm, 0.68 g

Obv. Sultan (Mu)rad bin Selim (Han)

Rev. Azze nasrühü duribe Kostantiniyye sene 9(82)

**نوابرده**  
*Novaberde (Nowāberda)*

29-154a-b, Akche, ø 12.4 mm, 0.34 g

Obv. (Sultan) Murad bin Selim Han

Rev. Azza (nasrühü) Duribe Novaber(de) 982

30-151a-b, Akche, ø 11 mm, 0.24 g

Obv. (Sul)tan (Murad)bin (Selim Han)

Rev. (A)zza (na)srühü) duribe (Nov)aberd(e)

31-217/3a-b, Akche, ø 15mm, 0.66 g

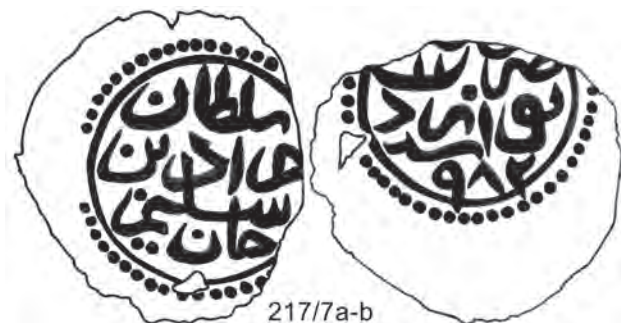
Obv. Sultan Murad bin Selim (Han)/ (double-strike)

Rev. Azze nasrühü duribe Novaber(de) sene 982/  
(double-strike)

32-217/4a-b, Akche, ø 12 mm, 0.66 g

Obv. Sultan (Murad bin )Selim (Han)/ (double-strike)

Rev. (Azze nasrühü) duribe Novaber(de sene 982)/  
(double-strike)



33-217/7a b, Akche, ø 14.5mm, 0.68 g

Obv. Sultan Murad bin Selim Han

Rev. (Azze nasrühü)duribe Novaberd(e) sene 982

**ساقز**  
*Sakız (Sāqiz)*

34-217/26a- b, Akche, ø 12 mm, 0.67 g

Obv. Sultan Murad binSelim (Han)

Rev. Azza nasrühü duribe Sakiz sene 982

**سدره قپيسي**  
*Sidrekapsi (Sidre Qapisi)*

35-217/28a-b, Akche, ø 11.5 mm, 0.66 g

Obv. (Su)ltan (Mura)d bin Selim (Han)

Rev. Azza nasrühü duribe Sidrekapsi (982)

**اسکوب**  
*Üsküb (Usküb)*

36-217/17a-b, Akche, ø 12.5 mm, 0.53 g

Obv. (Sultan M)urad bin Selim Han

Rev. (Azza nasrühü)duribe Üskü( b)sene 982

37-217/18a-b, Akche, ø 13.2 mm, 0.56 g

Obv.Sultan Murad bin Selim (Han)

Rev. (Azza nasrühü duri)be ( Üs)kü(b) 982

38-217/37a-b, Akche, ø 13 mm, 0.48 g

Obv. worn therefore illegible

Rev. worn therefore illegible ..... Üsk(ub) 982

*Very worn, almost undecipherable but very probably Sultan Murad III coins*

39-21/20a-b, Akche, ø 12 mm, 0.39 g

Obv. Sultan Murad (bin) Selim Ha(n)

Rev. Azza nasrühü duribe Sr ...?.. undecipherable (9)82

40-217/32a-b, Akche, ø 12 mm, 0.50 g

Obv.Sultan Murad (bin) Sel(im) Ha(n)

Rev. illegible

41-217-35a-b, Akche, ø 11 mm, 0.64 g

Obv. Sultan Murad bin Selim(Han)

Rev. illegible

### Nine very worn, almost undecipherable Ottoman akches

42-152/3a-b, Akche, ø 11 mm, 0.60 g

Obv. ----- worn Rev. AzzeNasa(rahu)

..... worn

43-153/2a-b, Akche, ø 10 mm, 0.20 g

Obv. worn

Rev. worn

44-158a-b, Akche, ø 10 mm, 0.53 g

Obv. .... Han illegible

Rev. illegible

45-217/5a-b, Akche, ø 13 mm, 0.44 g

Obv. Sultan .....? (worn)

Rev. undecipherable

46-217/30a-b, Akche, ø 13 mm, 0.46 g

Obv. worn

Rev. worn

47-217/33a-b, Akche, ø 11.5 mm, 0.68 g  
Obv. illegible  
Rev. (double-strike) illegible

48- 217/38a-b, Akche, ø 11.5 mm, 0.41 g  
Obv. worn illegible  
Rev. Azza nasrühü duribe .....? (worn)

49-217/39a, Akche, ø 10.5 mm, 0.66 g  
Obv. worn  
Rev. undecipherable

50-217/41a, Akche, ø 12 mm, 0.22 g  
Obv. worn  
Rev. worn

### *Note*

- 1 For more information about the subject of this contribution it is suggested to see Artuk and Artuk (1974), Codrington (1904) and Pere (1968). Plates 4.22 and 4.23 photo: R. Mosković, HRZ archive.

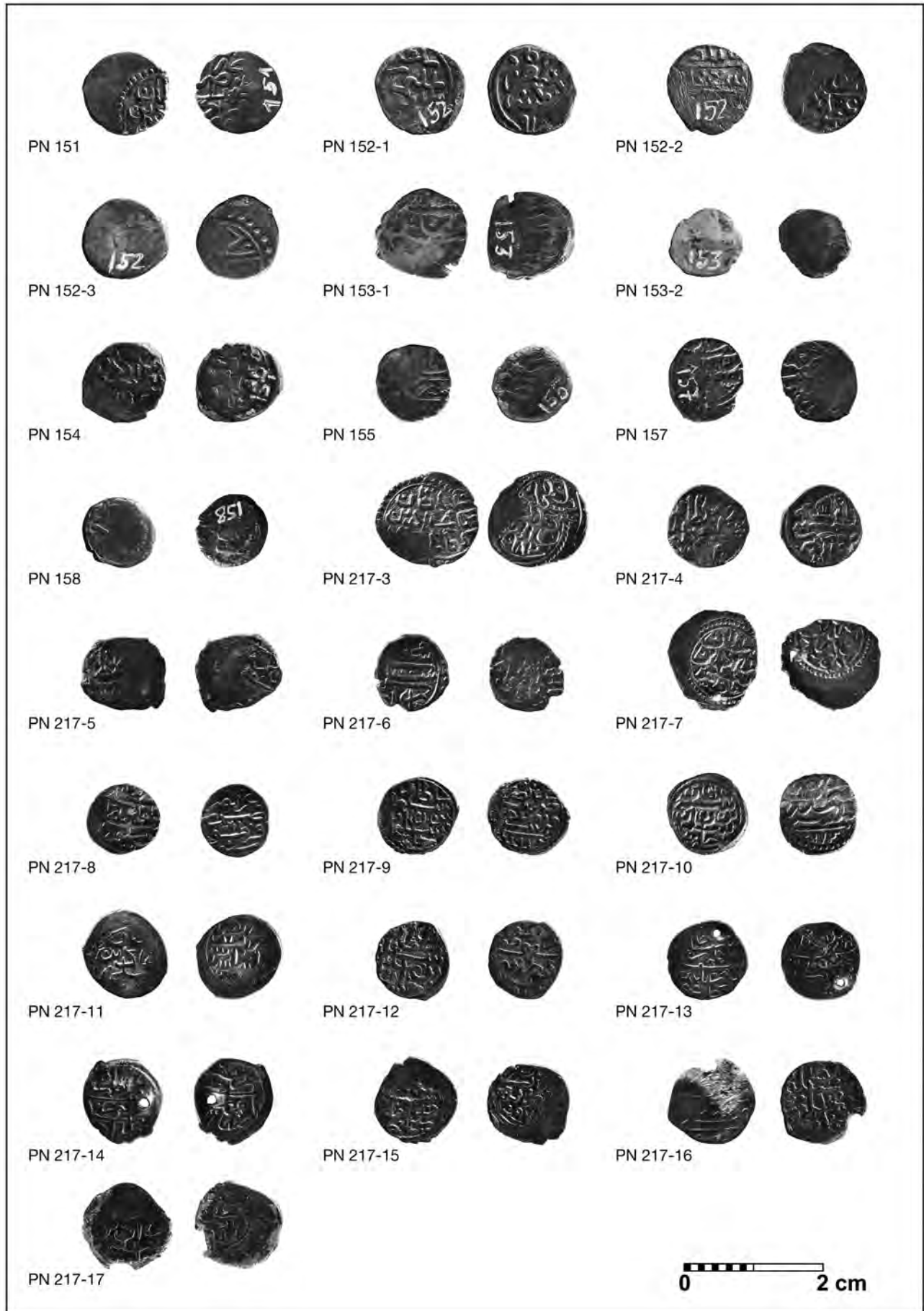


Plate 4.22. Ottoman akches.

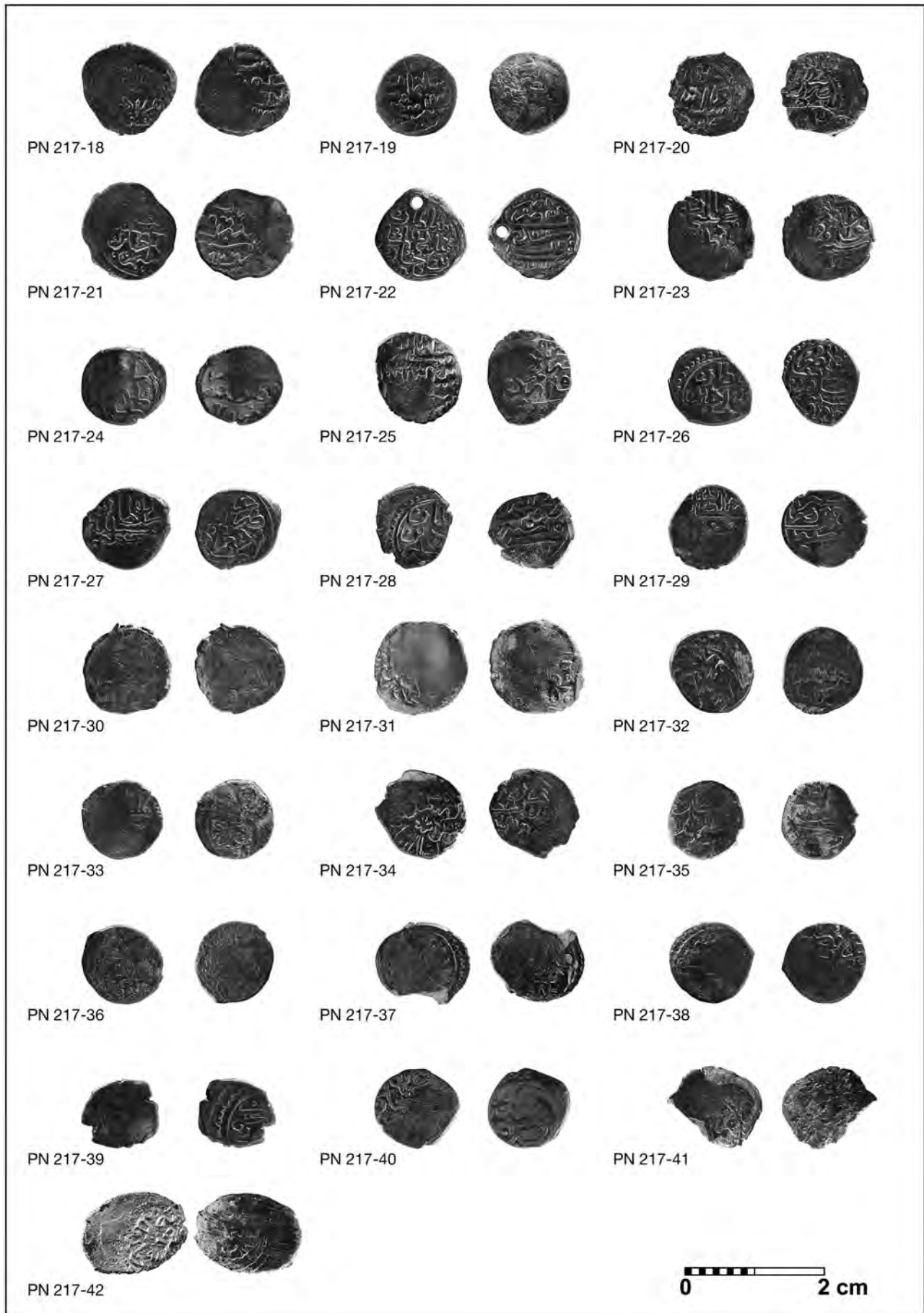


Plate 4.23. Ottoman akches.

## 4.8. Two Saxony *talers*

*Vesna Zmaić Kralj*

### Abstract

*Durante la campagna di scavo del 2010 è stato trovato un gruppo di monete d'argento tra loro concrezionate. Tale ritrovamento era costituito da due talleri e da alcune decine di monete Ottomane. Si trattava probabilmente del contenuto di un unico portamonete in materiale deperibile, ormai disintegrato sul fondale per effetto dei processi bio-chimici. In seguito alla pulitura delle monete è risultato che si trattasse di due talleri Sassoni e di quaranta monete Ottomane (Akçe). Questo gruppo di monete rappresenta un importante indicatore cronologico per datare il naufragio della nave e, allo stesso tempo, fornisce nuovi interessanti spunti sulle relazioni economiche e commerciali dell'epoca.*

*Tijekom istraživanja 2010. godine pronađena je skupina srebrnog novca inkrustiranog u grumen. Bilo je očigledno da je riječ o sadržaju vrećice od organskog materijala a koja se pod utjecajem biokemijskih procesa na morskom dnu raspala. Nakon čišćenja i odvajanja novčića ustanovljeno je da se grumen sastojao od dva saksonska talira i četrdeset otomanskih akči. Ovakav nalaz na brodolomu ima veliku vrijednost pri utvrđivanju vremena potonuća broda te osvjetljava kronološke odnose, gospodarstvo te trgovačke veze u drugoj polovici 16. stoljeća.*

### Introduction

In May of 2010, during excavation in the part of the site with the highest concentration of movable artefacts (Sector 1, Plan 2), two silver *talers* were found encrusted in a clump with Ottoman *akches* (217/2010). The clump of coins was lying at a depth of 40 m, close to the group of perriers (perrier 2–4) and other movable artefacts that belonged to the crew, passengers, galley or cargo and weapon storage. The clump was a conglomerate made of two silver *talers* fused together and encrusted along with more than a dozen *akches*, partly covered with thin layers of organic and calcareous origin. The shape of the clump of coins clearly indicated that they were the content of a coin bag made of organic material, which had completely disintegrated at the sea bottom under the influence of biochemical processes. Sedimentary calcite layers served as a binding agent so that the *akche* stayed encrusted on the *talers*' surface even after the coin bag had disintegrated (Fig. 4.84). After cleaning and separating the coins it was

established that there were two 'Saxony *talers*' and 50 'Ottoman *Akches*' that belonged to the period from Sultan Selim I (1512–1520) to Sultan Murad III (1574–1595).

All silver coins were complete and in a relative good condition, except for the obverse of the *talers* that were not protected by sediments. For the same reason the obverse of one *taler* was visible even before conservation and, according to the description and the inscription, it was dated to 1559 and attributed to the mint of Saxon Duke Johann Friedrich I sons (Davenport, 1979: 308; Zmaić, 2011: 341), while the other example was determined only after it was cleaned and separated from the other coins. It was established that the cast was older and belonged to Saxon Duke Johann Friedrich I and Moritz, minted in 1544 and 1545 (Davenport, 1979: 303).

*Talers* represent large silver coins introduced to Europe at the end of the 15th century because of the decreasing value of small silver coins. Parallel with the increase in amount of silver and the improvement of mint technology

grew the need for the production of a larger nominal. The first production of that money was in Tirol during the reign of Grand Duke Sigismund and it was named *guldengroschen* because it corresponded to the gold *Gulden*. In Joachimstal, the first systematic production of the silver coins named Joachims – *taler* or just *taler* began in 1518. The clarity of silver, high artistic achievement and the weight of 27.20 g (later 26.39 g) contributed to the fact that the *talers* were accepted as nominal in all German countries, including Saxony. In the beginning the *taler* had the value of 60 *Kreuzer*, then 68 (*reichstaler*) and 72, and from 1580 its value was 90 *Kreuzer*.

Saxony, a name originally designating much of north-west Germany, was limited to the territory in east Germany bordering with Bohemia and Silesia in the 16th century. Based on the old duchy of Saxe-Wittenberg, whose ruling family became extinct in 1422, modern Saxony with all its territory really begins its history with the investiture of Friedrich (1532–1547), margrave of Meissen and Thuringia. The lands, which gradually accumulated, were known as Saxony and were ruled by the Wettin family until 1918 (Davenport, 1979: 291).

#### **Taler of Johann Friedrich I and Moritz of Saxony (Fig. 4.85a)**

This well preserved specimen represents 1½ *taler* minted in 1544 and 1545 in Germany, during the reign of Johann Friedrich I (1532–1547), Duke of Saxony and Elector of the Holy Roman Empire in alliance with Moritz (1521–1553), Duke of Saxony (1541–1547) and later Elector of Saxony (1547–1553).

Obv: bust of Johann Friedrich I turned to the right with a sword in the right arm. The Latin inscription is: JOHAN.F.(arms).ELE.DUX(arms).SAX.BV(arms)

R.MAG(D)Z(arms); *Johannes Fridericus, elector dux Saxoniae, Burggravius Magdeburgensis* (Elector Johann Friedrich, Duke of Saxony and Burgrave (german *Burggraf*) of Magdeburg (Haupt, 1974: 270).

Rev: Armoured bust of Moritz turned to the right.

The inscription is: MAVRI(TI).D (arms) VX.SAX.

(arms) FL.IVS 15(arms)46ANB (arms); *Mauritius, Dux Saxoniae, fieri iussit 1546 Annaburgensis* (Moritz, duke of Saxony, ordered (this coins) 1546 in Annaberg) (Haupt, 1974: 275).

Diam: 4.1 mm, weight: 28.11 g.

#### **Taler of Johann Friedrich II and his brothers (Fig. 4.85b)**

Another Saxony *taler* was in somewhat worse condition, since the obverse was uncovered and exposed to the influences at the seabed. Its surface was damaged but still readable. It represents the nominal of two *talers* minted during the reign of Johann Frederick I sons in 1559. After the year of 1547, Johann Friedrich II, along with his brother Johann Wilhelm, succeeded Johann Friedrich I as the regents of Saxony. After the death of their father in 1554, the brothers amicably divided the lands that they inherited; even so, Johann Frederick II (1554–1566) remained the exclusive regent for the family possessions (Klein, 1974: 530).

Obv: Bust of Johann Friedrich II in shield turned to right with a sceptre in the left arm. The Latin inscription is: MO:NO (arms) FRATRV (arms) M:DVC (arms):SAXO (arms); *Moneta Nova Fratrum Duces Saxoniae* (New Currency of brothers Dukes of Saxony).

Rev: Armoured busts of Johann Wilhelm und Johann Friedrich III. The inscription is: LANTG: (arms)

THVRI: (arms) ET.MAR (arms):MISN:(arms);



Fig. 4.84. Silver talers incrustated in clump with Ottoman akches (photo: R. Mosković, HRZ archive)

A



B



Fig. 4.85. a) Taler of Johann Friedrich I and Moritz of Saxony; b) Taler of Johann Friedrich II and his brothers (photo: R. Mosković, HRZ archive)

*Lantgravii Thuringiae et Markgravii Misioniae*  
(Landgrave of Thuringia and Margrave of Misionia).  
Diam: 4 mm, weight: 24.47 g.

Saxony *talers* minted during the period 1544–1559, found on the shipwreck, in the original archaeological units together with Ottoman *akches* of later period (see Kürkman in this volume) suggest that these coins served as money for trading, and were circulating in the last decade of the 16th century. Having the European coins in the same context with Ottoman *akches* that belonged to the era of

four sultans, from Sultan Selim I (1512–1520) to Sultan Murad III (1574–1595), implies that the money belonged to someone from the West, because it would be contrary to the Ottoman tradition to use of older coins of previous sultans. Therefore, the Ottoman *akches* that were used during a longer period of time and that represent artefacts of the latest date from the shipwreck are very important for establishing a relative chronology of the sunken ship. On the other hand, two Saxony *talers* greatly illuminate the chronological relations, economy and trade connections of that period.

## 4.9. Animal bones

*Tajana Trbojević Vukičević*

### Abstract

*Durante gli scavi del relitto sono venuti in luce diversi resti osteologici di animali. In totale sono stati raccolti 80 frammenti, appartenenti a tre diverse specie di animali: bovino, suino e cinghiale. La determinazione tassonomica è solo parziale, visto che 64 frammenti appartengono a vertebre caudali, possibilmente di bovino. Benché le vertebre caudali rappresentino probabilmente resti di macellazione, non vi sono tracce che possano realmente supportare questa ipotesi. Segni di taglio sui processi cornuali di bovino e l'osso ioide portano a concludere che si tratti di resti di macellazione della cambusa.*

*Tijekom istraživanja brodoloma pronađeno je više koštanih ostataka životinja. Ukupan se uzorak sastoji od 80 fragmenata među kojima su definirane samo tri vrste - govedo, svinja i divlja svinja. Taksonomska je determinacija samo djelomična obzirom da 64 fragmenta pripadaju najvjerojatnije goveđim rebnim kralješcima. Iako navedeni fragmenti predstavljaju ostatke nastale nakon obrade mesa na njima nisu pronađeni tragovi koji bi podržavali ovu tvrdnju. Tragovi rezanja na rožnim izdancima i jezičnoj kosti goveda odgovaraju pretpostavci da je riječ o ostacima iz brodske kuhinje.*

A small assemblage of animal bone was recovered from the wreck site. Only three animal species are present: cattle, domestic pig and wild boar. The Minimal Number of Individuals (MNI) for cattle is four (according to the left *processus cornualis*), MNI for domestic pig is one (hind limb bones and a rib) and MNI for wild boar is two (two left canine). Bone frequency is low, probably because food remains were thrown overboard, which is common on shipwrecks (e.g. Heinrich, 2002).

Taxonomic determination is only partial, because the 64 fragments recovered belong to caudal vertebrae (*vertebrae caudales*) (Fig. 4.86). Since the caudal vertebrae gradually decrease from the first to the last and show progressive simplification of their shape, losing the characteristics of the vertebrae (Koenig and Liebich, 2006), it is difficult to distinguish them at the species level. Size and presence of hemal processes on ventral surface indicate that some certainly belong to cattle. However, on the majority of vertebrae the most typical anatomical elements are missing, so they can be classified only as caudal vertebrae,

although according to the size and location of the finds they most likely belong to cattle.

The parts of the skeleton regarded as slaughter waste include: cranium, caudal vertebrae, carpals, tarsals, metapodials and phalanges (During, 1986). The notably high percentage of tail vertebrae, primarily of cattle, could be considered slaughter waste; however, no traces of butchery were found on the analysed vertebrae. In archaeozoological reports, caudal vertebrae are entirely lacking or occur in very small numbers. For example, Agenbroad (1978) mentioned that the lack of third phalanges, complete crania, and caudal vertebrae was interpreted as resulting from human selection in the process of transporting the carcasses from the kill to the processing locality. In this case, one possible explanation is that the ship probably transported cattle tails that were most likely salted, dried and/or smoked for the purpose of preserving them or, longer duration. In fact, throughout the history of cooking, the use of oxtails is known for the preparation of various soups, stews and pies. Cutmarks



Fig. 4.86. Fragments belonging to caudal vertebrae (vertebrae caudales) (photo: R. Mosковиć, HRZ archive)



Fig. 4.87. Horn remains found on the site (photo: R. Mosковиć, HRZ archive)

are visible on the remains of horns (Fig. 4.87) and on the fragment of hyoid bone, thus suggesting that they are slaughter waste. The bone remains might originate from the ship's galley, but the location in which they were found cannot be defined as the kitchen with certainty, and is considered to be the place in which the bone remains settled on the bottom. The existence of these remains confirms the above-mentioned assertion.

Cattle and pig are typical dietary elements on ships, together with sheep and chickens (Armitage, 2013). Heinrich (2002) along with cattle and pigs, mentioned parts of wild boar, which were possibly also sometimes eaten, together with chicken, goose and fish.

Considering that the report covers only six years of

research, that the number of the items is not large and that statistic analysis cannot be made on such a small assemblage, we can hope that new bone samples will give a more detailed picture about diet on the ship and will improve the statistical analysis.

### Catalogue by findspot

1. 74/08. Two fragments of cattle cornual process (both from the left side), one stylohyoid process with a few shallow, short cutmarks, one rib fragment with cutmarks and thirty caudal vertebrae, probably also from cattle, without any marks.
2. 81/2008. One left canine teeth (tusk) from wild boar; according to today's trophy standards by CIC, trophy value would be from silver to the gold medal; two caudal vertebrae probably from cattle.
3. Trench A. One left tibia diaphysis from pig and two caudal vertebrae probably from cattle.
4. Unknown trench. Five caudal vertebrae probably from cattle.
5. 124/2009; trench F. One cattle cornual process from the right side.
6. 16/2007; trench I. One cattle cornual process from the left side with traces of oxidised iron.

7. 149/2009; trench F. One left canine teeth (tusk) from wild boar aged about 7 years; according to today's trophy standards by CIC, trophy value would be from bronze to the silver medal.

8. 195/2010; trench M. Ten caudal vertebrae probably from cattle and one rib fragment of pig.

9. 220/2010; trench J. One proximal rib fragment of cattle and nine caudal vertebrae probably from cattle.

10. 19/2007; trench K. Six caudal vertebrae probably from cattle, one left pig calcaneus (due to unfused *tuber*

*calcanei*, at the time of death animal was younger than 2 years), one right pig talus, one unfused distal epiphysis of femur (at the time of death animal was younger than 3–5 years)

11. 37/2007; trench L. One caudal vertebra probably from cattle.

12. 04/2012; trench AA. One cattle cornual process from the left side with visible notch that is probably emerged because of cutting off the horn and one right cattle cornual process with deep cutmark at the ventral side.

## 4.10. Considerations of dating and the historical context of the Mljet shipwreck

*Carlo Beltrame*

### Abstract

*I documenti conservati nell'Archivio di Stato di Venezia testimoniano gli intensi traffici tra Venezia e Costantinopoli. I beni menzionati negli atti notarili sono principalmente lana ed indumenti in seta, che sono materiali deperibili che non si conservano sott'acqua. Ciò significa che probabilmente la maggior parte dell'evidenza archeologica marittima di questa rotta commerciale è impalpabile. La presenza di pirati documentata dalle fonti è al contrario confermata dalle scoperte nei relitti di artiglierie utili a difendere le imbarcazioni.*

*La datazione del relitto di San Paolo è piuttosto precisa. L'anno 1567, presente sulla campana, testimonia il momento del varo della nave mentre una moneta ottomana, coniata per la prima volta nel 1574, ci offre una datazione postquem. Possiamo quindi affermare che la nave naufragò probabilmente nei primi anni ottanta del XVI secolo.*

*Dokumenti sačuvani u Državnom arhivu Venecije svjedoče o intenzivnoj trgovini između Venecije i Konstantinopola. Trgovačka roba se, prema navodima u notarskim zapisima, uglavnom sastojala od vune i odjeće od svile, nepostojanih materijala koji se ne mogu sačuvati pod vodom. Zbog toga je veći dio podvodnih arheoloških dokaza koji bi potvrđivali postojanje trgovačke rute nestao. Nasuprot tomu, prisutnost gusara koja je dokumentirana u izvorima, potvrđena je na olupinama pronalaskom artiljerije koja je služila za obranu brodova. Datiranje brodoloma kod Plićine Sv. Pavao prilično je precizno. Natpis "1567" na broskom zvonu svjedoči o vremenu porinuća broda, dok primjeri otomanskog novca kovani 1574. godine, datiraju period nakon kojega je brod potonuo. Prema tome, možemo tvrditi da je brod vjerojatno potonuo početkom 80-ih godina 16. stoljeća.*

It is well known that Venice's trade with the Levant was very well developed, and was the main source of her wealth. This does not mean that Venice did not also have strong commercial interests with the western Mediterranean and Atlantic routes. In the Levant she was, of course, the leading actor thanks to her bases, logistic support for her ships, and policing by her galleys along the eastern routes. She was for centuries the privileged partner of the Sublime Porte, although crises between the two states led to war. In Constantinople, Venetian merchants were respected, and could be represented and helped by a "Bailo" (a sort of ambassador), a doctor, and other forms of assistance (Tucci, 1985).

Normally, Venetian ships, on the basis of bilateral

agreements, were protected against Ottoman pirates, but attacks occurred, especially when far from Constantinople. The presence of ordnance aboard the Mljet ship and other wrecks of Venetian merchant ships is, indeed, well justified by the danger of attacks by pirates which, at least at the end of the 16th century, were the cause of the loss of one Venetian ship in every four (Tenenti, 1959: 27–45).

Along the route from Constantinople to Venice there was not only the danger of Ottoman pirates who, for example, in 1600 burned the galleon *Gottardo* (Tenenti, 1959: 257–258), but also of the *Uscocchi*, who operated in the Adriatic. It seems that the Venetian military galleys could not do much against this plague, both because of their small number and the large area they were attempting

to control, but also because they were often moored in harbour or in the lagoon of Venice. According to Tenenti, lone cargo ships, although armed, were rarely able to resist a pirate attack (Tenenti, 1959: 49–50).

According to the documents of the notaries Spinelli and Catti, collected by Tenenti (1959), regarding insurance policies of ships lost during voyages to the Levant, we can see how, at least in the last decay of the 16th and the first years of the 17th centuries, Constantinople was the most important destination for Venetian ships after Candia, followed by Smirna. His research – considering only two notaries – shows that there were almost 40 shipwrecks along the route Constantinople–Venice in 17 years; that is at least two per year.

Notarial documents show us that the main goods exported to Constantinople were wool and silk cloth and, also according to Tucci (1985: 41), glass and glass beads. This last evidence is supported by the cargo of glass of the Gnalić shipwreck, which also offers us a more heterogeneous range of trade in the last 20 years of the 16th century than that indicated by the documents (Beltrame in this volume and references). Documents also show that the main goods imported were wool in sacks (15 shipwrecks), leather (6 shipwrecks),<sup>1</sup> and, much less frequently, other items, such as sugar cane, soya, lamb, cotton, copper and, according to Tucci (1985: 41), also salt fish, poultry, and alum. From Smirna came cotton (10 shipwrecks). It is important to note that all these goods (except copper, which, in any case, was very rare) are very perishable under water; that is to say, that there is very little chance of future discoveries of cargoes of this kind. The types of cargoes mentioned in the documents of this period indeed lead us to assume that the discovery of other Venetian cargoes from the Ottoman world will depend on the few transports of non-perishable merchandise carried in that period. This means that the Mljet shipwreck is of extreme importance because it provides a unique opportunity to study a cargo of goods coming perhaps from Constantinople, or another Ottoman harbour in the eastern Mediterranean, directly to the northern Adriatic, probably with Venice as its destination.

We have to make some observations about the actual dating of the sinking of the ship. The first is that, according to written documents, the useful life of a cargo ship (*nave tonda*) was about ten years: that only very rarely did ships sail for 18–19 years and that, because of the numerous risks of navigation, the average life of a vessel was ten years, during peace, and less than six years, during wartime (Hocquet, 1991: 336–338; 1999: 142). This means that if we believe that the bell dated 1567 was installed when the

ship was launched – as is traditional, but which cannot be considered a universal rule, at least for a private ship – the vessel could not have sunk later than 1585, but probably much before, as an age of 18 years would probably have been a record at that time.

The presence in the site of many bronze Ottoman coins of Sultan Murad III, who reigned from 1574 to 1595, fixes a date for the sinking after 1574 (see Kürkman in this volume). If we compare the dating on the bell, the logical lifetime of the ship, and the dating of these coins, we could date the sinking to between 1574–1575 and 1585, but most probably 1580.

So this sinking, but curiously also that of one of the ships sunk off the small island of Gnalić (1583), occurred after the conclusion of a very critical period for navigation by Venetian ships in the eastern Mediterranean. Already in 1560 there was a reduction of trade with Constantinople, partly because of competition by Jewish merchants (Tucci, 1985: 42). The end came with the crisis with the Sultan in 1570, when he first confiscated Venetian ships and imprisoned Venetian merchants, and then attacked Cyprus. This led to the Battle of Lepanto in 1571, and was resolved only in March 1573 with the peace which sanctioned the loss of parts of Venice's maritime empire, including Cyprus and other territories. Regarding the season, considering that in 1569 sailing was prohibited between November and January (Tenenti, 1959: 47), we can be quite sure that it occurred in one of the other nine months of the year.

According to both Lane (1983: 30) and Tucci (1985: 43), the last 20 years of the 16th century, but especially the last ten, saw an increase in the movement of goods and ships in the Adriatic, which would also correspond with the dating of both this ship, and that of one of the Gnalić ships: one coming from, and the other probably going towards, the eastern Mediterranean (probably Constantinople).

The last 20 years of the century were also when new ships – including warships – arrived from England and Holland. Their lower costs engendered competition with the Venetian shipyards, and merchants of these nations then began to undercut the Venetians (Tenenti, 1959: 15; Hocquet, 1999: 186). However, our ship and her crew are too early to experience the upturn of trade and the arrival of English and Dutch vessels in the lagoon of Saint Mark.

### Note

- 1 Two cargoes of leather (*cuoi*) are mentioned also in a *cessio* written by Catti on 15 November 1579 *more veneto* (Archivio di Stato di Venezia (ASV), Notarile atti, 3350).

# 5. Conclusions

*Carlo Beltrame, Sauro Gelichi, Igor Miholjek  
and Vesna Zmaić Kralj*

Before the first season of underwater investigation of this ship, wrecked on the Sveti Pavao shallows off the island of Mljet (the ancient Meleda); the shipwreck of the Venetian ship *Gagliana Grossa*,<sup>1</sup> off the island of Gnalić, was considered the only important archaeological evidence of Venetian trading in the 16th century in the Adriatic Sea. Now the Mljet shipwreck has opened another window on the history of Venetian trading in this period (the dating of these two shipwrecks is close), in particular between Venice and the Ottoman Empire. The Gnalić shipwreck is evidence of an outward cargo, but the Mljet cargo is that of a Venetian ship returning from the Ottoman Empire. Although, because of the rocky seabed, the wreck site of the Mljet ship, in contrast to that of the Gnalić shipwreck, has preserved few perishable items, it includes many and important (in some cases unique) finds for the reconstruction of the dynamics of trade in the 16th century along this route.

The place of production of the pottery used aboard, the style of the ship's bell, some details of the ship's construction, and especially the typology and weight of the bronze ordnance, tell us that both the crew and the owners of the ship must have been Venetian. The finding of pig bones precludes, in any case, the possibility that the crew was Muslim. The bronze bell and the 50 Ottoman coins allow us to identify both the presumed date of the launch, which should correspond with the date 1567 engraved on the bell, and the estimated date of the sinking, which can be fixed at between 1574 (date of the first minting of the most recent coins of Sultan Murad III) and 1585, but more probably before 1580 considering the lifetime of a ship in that period. It is probably not a coincidence that this voyage took place after the peace treaty was signed between Venice and the Ottoman Empire in 1571, two years after the Battle of Lepanto. This was a period when Venetian ships could resume trading without great risk,

except from pirates. Probably because of the presence of pirates along the route, the Mljet ship carried at least eight small pieces of bronze ordnance, comprising one muzzle-loading weapon (*esmeril*) and seven breech-loading swivel guns (two *petriere da braga* and five *moschetti da braga*). The weight engraved in the bronze casting, which corresponds with *libbre grosse alla veneta* (Venetian pounds), and the initials of the Venetian founder Tommaso di Conti, indicate that they were manufactured in Venice, although, curiously, the weapon made by di Conti must have been cast before 1540 (the date of his death). Other weapons carried aboard were two arquebuses, now still under conservation treatment.

The remains of the hull are evidence of a strong ship built with double external pine planking, which is a technique attested for the first time in the Mediterranean, but already known outside, where it was used by the VOC ships, engaged in long voyages in warm seas where strong and *Teredo*-resistant hulls were necessary. Evidence of an oak mast step and of a distinctive system of joining oak frames, largely used in the Venetian shipyards, belong to a ship which could have been about 24 m long. The few remains of the rigging, represented by deadeyes, parts of blocks, iron bars and a chain plate, are rare evidence of 16th century nautical equipment. The living conditions of the crew, which (as suggested, among other things, by the use of glazed and *sgraffito* pottery produced in the Veneto region), was of Venetian origin, are testified by objects from the galley, such as a copper cauldron, a copper food warmer, a copper frying pan, a pewter flagon, and pottery, composed not only of Venetian plates and bowls, but also amphoras and jugs of Ottoman production, and perhaps a dish from southern Italy.

Although no trace of a stove was found on the site, its existence is indicated by many logs and pine cones used for fuel. The diet aboard could have included cattle tails,

and pig and wild boar meat testified by slaughter waste from the galley. Personal belongings were represented by parts of three brass candlesticks, a scale pan used to measure the weight of precious metals, and the 50 silver Ottoman *akches*, already mentioned, which must have been contained in one perishable coin bag together with two silver Saxon *talers*, minted in 1544–1545 and 1559, and which, for their heterogeneity, could only have been owned by an European merchant (the new Sultan recalled all coins of the previous reign).

The quite precise chronology of this site, dated to the last quarter of the 16th century, can be supported by Iznik pottery found among the ship's cargo. On the other hand, several other examples of Iznik production traditionally attributed to the first, second and third quarters of the 16th century were also found. These were blue and white dishes decorated in “*tuğrakeş* spiral style” and with “flower scrolls” of Chinese influence, which traditionally appeared from 1520 to 1550, and dishes with the elements of the “*Saz*” style (from 1540 to 1560). However, *tuğrakeş* spiral ware is the first Ottoman ware which is known to have been exported to Europe, mainly to clients of today's Italy, which dominated maritime commerce in the Mediterranean basin. The *tuğrakeş* spiral style flourished during the first half of the 16th century, but it appears that it was so famous and widely distributed that its motifs, such as bunches of grapes and peony scrolls, continued to be used together with other groups of ceramics even later. This can be confirmed by a shard of a dish with a bunch of grapes motif, in cobalt blue and emerald green pigments, characteristic of the palette developed after the middle of the 16th century. The Mljet shipwreck represents the most important site of Iznik fritware in the Adriatic area. In general terms, the great importance of the shipwreck lies in the fact that it represents a closed context, and as such, it is of great importance in defining the phases of Iznik production chronology. Until now, the development of Iznik fritware production has been divided into five phases, mostly based on painted tiles preserved in Ottoman architecture, manufactured in the same workshops, and using the same motifs and style as Iznik pottery.

Unfortunately, finds of this kind of pottery in well-dated archaeological contexts are rare. Only the discovery of the Iznik kilns, and the excavations in Istanbul by the Department of Archaeology and History of Art of Istanbul University, which have been going on for more than 20 years, have corrected the chronology and the attribution of the specific styles to Iznik production. Now the closed context of the shipwreck offers a major contribution to the better understanding and correction of the chronology of this production. The associations in the shipwreck do not demonstrate that all the traditional chronologies of the Iznik pottery are wrong, but they do show that all these forms had to be available on the market in the same period, that is the last quarter of the 16th century.

This cargo is important not only because it is, at the moment, one of few cargoes of pottery documented in

shipwrecks of the Adriatic area, but also since it is rare evidence of trading of Iznik pottery in the post-Medieval period in the Mediterranean. Considering the limited amount of this kind of pottery found at the shipwreck, we must suppose that most of the cargo had to be of perishable goods which were not preserved. Venetian documents, after all, are evidence of trade from Constantinople and Smirna consisting mainly of wool and silk cloth, which are goods that have a poor chance of survival underwater.

At least 18 glass bottles and jugs of Ottoman production could have contained unknown substances, a possible secondary part of the cargo. Iznik pottery and the glass bottles show that the ship was coming from an Ottoman harbour, probably Constantinople itself. The destination is not known, but, because of the origin of the crew, it could have been Venice, where Iznik pottery was held in high regard. The popularity of this kind of pottery is demonstrated not only by the fragments found in excavations (so far very few have been published), but by the fact that, at least from the first half of the 17th century, production of maiolica, which clearly imitated the Iznik pottery, started in the Venetian area (and probably also in Padua and Bassano).

The sinking and tragic end of the voyage happened in the shallows off the southern side of the island of Mljet, which are, especially during storms, hardly visible. This very dangerous reef caused the rapid sinking of the ship, whose crew probably dropped one anchor to try to save it, while the position of the other two anchors, found close by and probably over the bow, suggests that there was no time to use them. The ship sank to a depth of about 40 m, spilling its cargo and ordnance on the western side, and resting on a sandy slope with the bow pointing downwards, as suggested by the location of the anchors.

Although the research is not yet complete, we have already collected enough evidence to reconstruct the function, the route, and the estimated dimensions of the ship, some characteristics of the ship's construction, the type of cargo preserved, a precise date of its sinking and its dynamics, and some information about life on board. This allows us to conclude that this shipwreck, which is the first one from post-Medieval period to be published in such great detail, represents one of the most significant archaeological sources for the study of navigation in the Mediterranean during the 16th century.

### Note

- 1 However, recently, its latest excavators are calling its origin into question because it would not have been registered in Venice. In our opinion, considering that the ship was built in Venice, its captain was Venetian, it was insured with Venetian merchants, it left Venice with a cargo of Venetian window panels and other Venetian goods, and its cargo was partially recovered by a Venetian salvage mission (Radić Rossi *et al.*, 2013), the fact that the ship could have been not ‘registered in Venice’ is absolutely irrelevant to its true identity.

# The Conservation and Restoration of the Finds<sup>1</sup>

*Mladen Mustaček, Martina Ćurković, Antonija Jozić and Anita Jelić*

### Abstract

*Tutti i reperti provenienti dal relitto di San Paolo sono stati sottoposti a trattamenti di restauro conservativo, in particolare i pezzi di artiglieria, la ceramica, gli oggetti in metallo e quelli in materiale organico. Il restauro è stato finanziato dal Ministero della Cultura, della Repubblica Croata, grazie al quale è stato possibile raggiungere dei buoni risultati in breve tempo. Il presente articolo è costituito da quattro distinti contributi che descrivono le diverse fasi del restauro sui vari tipi di materiali rinvenuti. Sono qui presentati e documentati sia i metodi e le tecniche impiegate sia i risultati delle specifiche analisi. Tutte le tipologie di reperti sono state prima analizzate e poi sottoposte al processo di desalinizzazione, pulitura chimica e meccanica, consolidamento, stabilizzazione e protezione finale; inoltre, sono state effettuate delle analisi chimiche sui campioni metallici prelevati dai pezzi di artiglieria.*

*Otto pezzi di artiglieria sono stati sottoposti a trattamenti conservativi dopo un'accurata analisi e documentazione di ciascuno. Al fine di valutare il loro stato di conservazione e determinare quindi la presenza o meno di parti della braga di ferro al di sotto dello spesso strato di concrezioni, i suddetti pezzi sono stati tutti sottoposti a radiografia. I frammenti ceramici sono stati innanzitutto desalinizzati, puliti e suddivisi per classi tipologiche, dopo di che sono stati ricomposti tra loro così da ricostruirne la forma originale completa. Il restauro dei manufatti in metallo ha seguito un processo conservativo molto simile. Infine, gli oggetti in materiale organico erano costituiti da legno e osso e differivano tra loro per dimensione, funzione, umidità e grado di conservazione. Intervenire tempestivamente con il restauro dei reperti archeologici provenienti dall'acqua significa rallentarne il naturale processo di degrado e permetterne quindi uno studio ulteriore e più puntuale nonché una loro fruibilità al grande pubblico.*

*Proces je konzervacije i restauracije proveden na svim nalazima pronađenima na brodolomu kod Plićine Sv. Pavao, s naglaskom na topovima, keramici, metalnim nalazima i nalazima organskog porijekla. Restauratorske je zahvate financiralo Ministarstvo kulture Republike Hrvatske, o kojemu je ovisila i dinamika izvođenja radova. Tekst se sastoji od četiri poglavlja koja opisuju restauratorske procese na različitim vrstama arheološkog materijala, metode i procedure koje su upotrebljavane prilikom restauracije i rezultate raznovrsnih analiza. Svi su nalazi pregledani prije restauracije i podvrgnuti desalinizaciji, razvrstani, očišćeni mehaničkim i kemijskim tehnikama, konsolidirani, stabilizirani i zaštićeni. Analize metala provedene su na uzorcima metala s topova. Osam brončanih topova je također prošlo navedene restauratorske procese. Nad sedimentnim nakupinama na topovima je provedeno i radiografsko snimanje s ciljem utvrđivanja prisutnosti elemenata željeznog zatvarača i procjene njihovog konzervatorskog stanja. Metalne su nalaze pratili slični restauratorsko-konzervatorski procesi. Keramika je također desalinizirana, očišćena i razvrstana u skupine nakon čega su ulomci spajani i (ukoliko je to bilo moguće) restaurirani u originalne oblike posuda. Nalazi su organskog porijekla bili od drveta i kosti te su varirali po veličini, funkciji, stupnju očuvanosti i postotku vlage u materijalu. Svi navedeni konzervatorsko-restauratorski postupci usporavaju prirodni proces propadanja i omogućuju daljnje proučavanje i prezentaciju nalaza.*

## Conservation and restoration of bronze artillery pieces

*Mladen Mustaček*

### Condition of the artillery pieces upon receipt

Eight bronze artillery pieces are of different size and different manner of loading. Artillery piece number 06/2007 was the only muzzle loaded weapon, while others were breach-loaded (Miholjek, 2009: 276). Barrels of artillery pieces 01/2007, 04/2007, 05/2007 and 07/2007 are around 90 cm long. Artillery pieces 02/2007 and 03/2007 are identical, with the barrels being 145.5 cm and 147 cm long, respectively. Artillery piece 06/2007 is 120 cm long with a polygonal barrel, and is the only one loaded at the muzzle. (Mihajlović, 2009: 269). Barrel length of artillery piece 08/2009 is 85.6 cm.

Preliminary examination was conducted in order to assess the conservation condition and the state of preservation. Barrels were covered in deposits of marine and organogenic sediments 0.5 cm thick, while the sediment found on artillery piece 08/2009 was thicker and measured more than 2 cm. Amorphous sediments of completely degraded remains of iron powder chamber and chamber holder block were located on the rear end of artillery pieces 01/2007, 04/2007, 05/2007 and 07/2007, while the middle and rear end of artillery piece 08/2009 contained a sediment deposit 5 cm thick in the shape of the iron yoke and peg and iron chamber holder (Mihajlović *et al.*, 2009: 51).

Probing all the way to the surface of the metal established that the condition of the bronze barrels was good, while the iron elements of the breach block were completely corroded and degraded. A higher degree of preservation of the iron chamber holder and iron yoke and peg was expected on the artillery piece number 08/2009 considering it was completely covered and shrouded by sediment which protected it from the damaging effect of the sea (Scott and Eggert, 2009: 123). After the initial documentation of the artillery pieces, the sediment deposits were removed and the pieces were well prepared to undergo the process of desalination.

### Desalination

The process was carried out in pools with a capacity of 2000 litres and lasted for 18 months. The process employed tap, demineralised and distilled water. The water was exchanged every 30 days, so in total it was exchanged 16 times. Desalination was monitored by taking samples of the solution and measuring the salinity and the chloride concentration within the sample. Artillery pieces were submerged in tap water for the first six months and in the demineralised water for the following ten months. During the remaining two months of the process the water inside

the pools was replaced with distilled water. The results were very vague for the first 16 months since large discrepancies in the concentration of the dissolved salt were found, what might be the consequence of temperature and air pressure change as well as the salt settling down at the bottom of the pool. To precisely measure the concentration of chlorides, the artillery pieces spent a final two months in pools filled with distilled water. Last measurement by means of potentiometric titration showed the value of 3 mg/L after which the desalination process finished.

### Removal of sediment and corrosion deposits

This method of cleaning the bronze artillery pieces was conducted by applying mechanical and electrochemical methods. Mechanical method removed larger depositions of sediment which were larger on the locations of the degraded iron breach blocks on the rear parts of the artillery pieces. Removing the deposit from artillery piece 08/2009 was the most demanding since the thickness of the deposit on some parts measured more than 7 cm. Apart from the thickness of the sediment, the other issue was the hardness of the deposit which made the removal process slower than expected. Surface sediment deposits were removed using various types of chisels, while small calcareous clusters and corrosion products were removed by scalpel and ultrasonic needle (Huet and Memet, 2010: 406; Fig. Appx1).

The uncovered surface of the artillery piece was partially coated with various corrosion products. The front and middle sections, which included the iron breach block, were covered by characteristic corrosion products of bronze, usually a layer of copper carbonates and copper oxides, while the rear sections were additionally covered by corrosion products of iron resulting from the electrochemical reaction between two metals. Removal of the corrosion layers was performed to the layer of the original surface which was preserved on all artillery pieces as copper oxide cuprites whose colour varies from red to brown (Jozić, 2011: 46). The structure of corrosion products on the surface of all artillery pieces was mainly stable, whilst the presence of active corrosion characterised by a powdery structure of light green colour was present at a smaller scale. The powdery structure is characteristic for the presence of atacamite and paratacamite (Jozić, 2011: 46).

The toughness of the sediment and the confined space within the barrel prevented the efficient removal of sediment deposits using mechanical methods, therefore the cleaning of the inside of the barrel was carried by means of electrolytic reduction on artillery pieces 02/2007, 03/2007, 04/2007, 05/2007 and 07/2007. Preparing the method of electrolytic reduction<sup>2</sup> the anode was put inside the barrel and connected to the positive pole, while the cathode was attached to the artillery piece and connected to the negative pole of the outer power source. The method also used the electrolyte made of a 5% solution of sodium carbonate ( $\text{Na}_2\text{CO}_3$ ) in tap water.

At a specific strength of the electric current and at a



Fig. Appx1. Mechanical removal of sediment deposits from the barrel (photo: HRZ archive)

specific corrosion potential, hydrogen began developing inside the barrel and caused a gradual weakening and cracking of the sediment deposits therein (Domenech-Carbo *et al.*, 2009: 136). The value of corrosion potential was monitored during the procedure to ensure that the process happened only in the area where hydrogen started to develop (Huet and Memet, 2010: 410). The artillery pieces were taken out of the bath from time to time to monitor precisely the cleaning process. After the barrels were completely free of sediment deposits, the artillery pieces were placed into a pool filled with distilled water, where the neutralisation process was carried out by regularly changing the water.

The cleaning of the artillery pieces revealed signs, incised marks for specifying weight, decoration in relief and initials. A piece of cloth  $4 \times 1$  cm in size was found inside the barrel of artillery piece 01/2007, within the sediment in the rear part. A wooden cork and a small amount of powder were found in the rear section of the 05/2007. A corroded iron shot with a diameter of 4 cm was found inside 06/2007, the only artillery piece which is loaded from the front. A partially preserved form of iron chamber holder and iron yoke and peg were found within the sediment on artillery piece 08/2009, attached to the barrel. The iron elements were in poor condition, since the exposure to oxygen accelerated the degradation processes which manifested

in falling of the surface corrosion crust, which, in turn, additionally endangered the partial preservation of the form (Degrigny and Spiteri, 2004: 317). In order to implement stabilisation of the iron elements in time, the breach block and the iron yoke and peg were detached from the artillery piece and submitted to the process of active stabilisation.

### Active stabilisation and surface protection

The procedure of active stabilisation with an alkaline solution of sodium sulphite was applied on the iron elements of 08/2009. It is still underway. This procedure fosters the release of harmful chlorine ions (chlorides) which are situated on the items within the deposits of corrosion products (Scott and Eggert, 2009: 139). The exchange of sodium sulphite was carried out four times during the process, while the total duration of the process depends upon achieving a satisfying level of chlorides. After exchanging the water, a sample was analyzed in order to monitor the pH level and assess the concentration of released chlorides. After the treatment by sodium sulphite the expected pH level will be high so the process of neutralization is carried out in the last phase of treatment by exchanging the distilled water in the bath in a regular interval. The procedure of active stabilization on the barrels of bronze artillery pieces was carried out

by applying a corrosion inhibitor. After the process of cleaning the barrels was finished, the formation of oxide patches of white powdery structure were seen on certain locations and they alone pointed out the importance and need to carry out this process. The stabilisation procedure involved Benzotriazole, a corrosion inhibitor for items made of copper alloys (Rocca and Mirambet, 2007: 312). The artillery pieces were treated with a 3% solution of Benzotriazole in distilled water, after which they were dehydrated using covers soaked in acetone. After the active stabilisation was carried through it was followed by applying the final surface protection<sup>3</sup> which was also the last phase of conservation. The final conservation was carried out by applying a thin layer of previously prepared solution to the surface of the artillery pieces. A 2% solution of thermoplastic acrylic resin Paraloid B72 in toluene was used for that purpose. In order to achieve the effect of toned surface, a 5% of microcrystalline wax was added to the solution which also inhibited the unnatural glow or buff of the surface (Rocca and Mirambet, 2007: 309–311).

## Results of the analyses

The radiographic recordings of artillery pieces 05/2007, 07/2007 and 08/2009 were conducted during the conservation work. Analyses of metal samples from all eight artillery pieces were completed, as well as the analyses of samples from the corrosion layer, sediment, powder and cloth.

## Radiographic recording

Radiographic recording<sup>4</sup> was carried out on artillery pieces 05/2007, 07/2007 and 08/2009 which had substantial sediment depositions on the back section of the chamber holder. The radiographic recording was carried out in order to establish the presence of the remains of the iron chamber holder and assess their condition and position (Stuart, 2007: 77). The recordings from 05/2007 and 07/2007 unfortunately showed only vague misty outer silhouettes of certain elements of the chamber holder without the preserved iron core, which is completely destroyed. The recordings of artillery piece 08/2009 showed the existence of partially preserved iron form and the position of the iron chamber holder and iron yoke and peg. The approach and the methodology of work were determined on the basis of the results gained from the radiographic recording. The results helped determine further procedures of removing the sediment depositions, helped in avoiding possible damage and aiding in preserving the iron elements as much as possible.

## Analyses of metal composition

The method of X-ray fluorescence (XRF) determined the metal composition on artillery pieces 01–07/2007, while the

Cannon No.	Cu	Sn	Pb
1	90,755	7,712	1,015
2-F	85,458	0,781	13,856
2-C	81,362	0,719	17,401
2-R	78,178	0,61	20,649
3-F	95,154	1,207	4,265
3-C	89,733	1,535	8,452
3-R	80,921	1,64	17,178
4	86,441	9,002	3,847
5	80,995	8,194	10,853
6	91,048	7,078	1,655
7	89,208	8,664	0,946
8	75,96	4,97	6,76

Fig. Appx2. A table showing the concentration of elements within the samples taken from the artillery pieces

sample from artillery piece 08/2009 was analysed by EDX method.<sup>5</sup> Three samples were taken from artillery pieces 02/2007 and 03/2007. These samples were taken from the front, middle and rear sections while only one sample was taken from each of the other artillery pieces. The analysed samples usually contained three elements: copper, tin and lead, so we may determine that the artillery pieces were cast from copper alloy, which we call tin bronze, with a share of added lead (Fig. Appx2). The smallest amount of lead was registered in the sample taken from 07/2007 and totals 0.9%, while the largest amount of lead was registered in the sample from 02/2007 which totals 20.6%. Comparative analysis of the samples taken from 03/2007 shows a disproportional share of lead in the sample depending on the position from which it was taken. The amount of lead from the muzzle of the gun totals 4.2%, from the middle section 8.4%, while it totals 17.1% at the breach of the artillery piece. Similar trend can be observed on 02/2007 where the amount of lead from the middle part is 17.4% and from the breach is 20.6%. The high amount of lead might be explained by the procedure of taking samples (see Mihajlović in this volume).

## Analysis of the sediment sample

EDX analysis was carried out on a sample of very hard sediment structure which covered the iron breach block of artillery piece 08/2009. Apart from the characteristic presence of by-products from degrading sea organisms, calcium (Ca) 26.92%, oxygen (O) 46.75% and carbon (C) 7.68%, the presence of iron (Fe) 11.70% and sulphur (S) 3.72% was also recorded, which indicates possible formation of iron sulphide. Accordingly, we can conclude that the rise in the structural toughness of the sediment on artillery piece 08/2009 is a result of a process of infiltration of the products of iron degradation into calcareous deposits, where the presence of iron in the sample totalled 11.7%.<sup>6</sup>

### ***Analysis of the powder***

Results of analyses conducted by SEM and EDX methods on the black powder from the 05/2007 indicate that it is most likely gunpowder. That conclusion is strengthened by the presence of sulphur, carbon (coal), potassium, nitrogen and oxygen; gunpowder is, by its chemical composition, a mixture of sulphur, carbon and potassium nitrate. The recorded amounts of potassium and nitrogen were smaller than expected which is probably a direct outcome of contact with water which probably dissolved and carried away these elements. A presence of silica and magnesium was also recorded in the sample, but they might originate from the sediment deposits, as well as a large amount of iron and oxygen which probably originate from the corrosion products. This is actually expected considering the age of the sample and the surroundings in which it was found.<sup>7</sup>

### ***Cloth analysis***

A sample of cloth found in the rear mouth of the barrel from artillery piece 01/2007 was also analysed. The FE-SEM analysis<sup>8</sup> has shown that the cloth consists of long parallel fibre in clusters. Each fibre or thread consists of a few thick or few thin threads. The SEM images reveal that the thread thickness does not change in relation to its length. Every thread's transitional elements with characteristic appearance are also visible, which might indicate that the cloth sample is, in fact, a sample of linen fibres.<sup>9</sup>

### **Conclusions**

The eight post-Medieval bronze artillery pieces from the Sv. Pavao site represent very valuable specimen of cultural heritage, and are also a very attractive find. Long term exposure to the conditions of specific seawater conditions, the activities of micro- and macro-organisms and other influences, brought about various harmful changes to the material. Since the biological toxicity of copper prevented a larger growth of organisms, the surface of the barrels did not sustain a large amount of damage and they are, in fact, well preserved (Memet, 2007: 164). Completely and unfortunately damaged and weathered remains of iron chamber holder elements were also found. The sea environment acted very destructively and aggressively towards them. The cause of their degradation lies in the fact that iron is not bio-toxic and is suitable for the development of various organisms whose products of metabolic processes stimulated the damaging processes of degradation (Memet, 2007: 156).

With the goal of preventing further degradation and preservation of the cultural heritage, the bronze artillery pieces underwent extensive conservation and restoration procedures. The work utilised many different techniques, methods and procedures, as well as an interdisciplinary approach. The artillery pieces were desalinated cleaned of sediment depositions and corrosion after which they were

stabilised and protected. The radiographic recordings of artillery piece 08/2009 showed the existence of partially preserved iron form and the position of the iron chamber holder and iron yoke and peg. The process of active stabilisation of these iron elements is still underway after which the remains of the iron chamber holder and iron yoke and peg will be reconstructed and returned to the artillery piece. A corroded iron artillery piece, 06/2007, with a 4 cm diameter ball inside is the only artillery piece which is loaded from the front. The analysed samples usually contained three elements: copper, tin and lead, so we may determine that the artillery pieces were cast from copper alloy, tin bronze with a share of added lead. The analyses of metal samples from artillery pieces 02/2007 and 03/2007 show that the amount of lead increases from the front to the rear of the artillery piece, which might be the result of a technological process of casting the artillery piece with the muzzle pointed upwards. The analysis of the sample from the hard sediment structure on artillery piece 08/2009 showed the presence of iron at 11.7%, so we can conclude that the rise in structural toughness of the sediment is a result of a process of infiltration of the products of iron degradation into calcareous deposits. Results of analysis conducted on the black powder found behind the wooden cork in the barrel of the artillery 05/2007 indicate that it is most likely gunpowder. A sample of cloth found in the rear mouth of the barrel of 01/2007 was also analysed and, according to its characteristic appearance, it may be established that the sample is, in fact, a sample of linen fibres.

Expert application of conservation and restoration practices restored the bronze artillery pieces to their former visual appearance and also preserved their structural stability which, in return, established a good prerequisite for their long-term protection.

## **Restoring the Iznik pottery assemblage**

*Martina Ćurković*

### **Introduction**

A large number of pottery items were received, some in complete condition and some fragmented. Finds were presented immediately after recovery from the sea and it was first paramount to carry out desalination and then continue with other conservation processes deemed necessary. Items were packed together or in groups in polypropylene nets with the associated number and placed into desalination tanks. Desalination was carried out using tap water which was periodically changed. During each water exchange the water conductivity was measured by a conduct meter, and the concentration of the extracted chlorides determined by potentiometric titration. The



Fig. Appx3. Iznik dish 55/08 before and after restoration (photo: HRZ archive)

goal was to achieve minimum constant values of water conductivity and chloride concentration. When the values reached the desired level, the desalination process was finished and the items were left to dry out in air.

The following phase included sorting numerous pottery fragments. They belong to various pottery types. A large number belong to the Italian slipped glazed pottery, Turkish glazed pottery, coarse Turkish pottery, and an assemblage of fine glazed pottery manufactured in the famous centre known for the production of the finest Turkish pottery – Iznik, as well as fine glazed pottery most likely originating from the area of present-day Syria (Pešić, 2009: 347–348).

The conservation and restoration processes carried out on the Iznik and Syria pottery assemblages are here described, emphasising the importance of the assemblage from the site of Sv. Pavao as the largest known concentration of Iznik pottery in Croatia (Pešić, 2009: 348), and specific conservation and restoration issues.

### Finds condition at the time of retrieval

Certain finds are here distinguished by their beauty which, at the same time, presented a particular problem due to their poor or discrete state of preservation caused by the infiltration of iron degradation products, deposits or by the activity of sea organisms or the harmful effects of the sea itself. These items are isolated from the whole assemblage of pottery which underwent the conservation and restoration process.

Conservation and restoration processes are described on Iznik items of various shapes: deep plates 238/2010 and 262/2010, shallow plates 113/2009, 242/2010 and 244/2010, lids 128/2009 and 129/2009, jugs 40/2007 and 200/2010, large plates 55/2008 and 58/2008, and small bowls 8/2011, 53/2008, 63/2008 and 108/2009 (see Chapter 4.3 for a full description and catalogue of the pottery items).

Pottery from the site was recovered in different degrees

of preservation. Although it originates from the same site, the degree of preservation of certain items depends on the micro- location of the item in relation to other finds from the shipwreck and on the exposure of the surface of the find to the activities of various sea organisms. The greatest amount of damage was caused by the degradation of iron items in the vicinity of the finds. Iron objects corrode when put into an anaerobic environment with the presence of anaerobic bacteria, creating iron sulphides (FeS) among other corrosion products. These iron sulphides are not soluble and are coloured black to brown (Hamilton, 1999). The black and brown mud infiltrated into the structure of certain pottery items turning them black. Lids 128/2009, 129/2009 and a large plate 55/2008 were completely saturated in iron sulphides, coloured black and had completely unrecognisable decoration. Other items were partially caught by infiltration of black iron sulphides, and in larger measure by infiltration of iron oxides coloured orange to brown (Jojić, 2011).

Most examples of Iznik pottery revealed the almost complete absence of glaze which left the painted layer on the white slip uncovered. Such items are rough on contact and very porous. The colour of the painted layer is smothered which is normally improved and enhanced by the glaze making the colour intensity stronger and glossy. The glaze is partially preserved on items 238/2010, 242/2010 and 58/2008, while it is almost completely preserved on a shallow plate 113/2009. Items without glaze are more pervious to the infiltration of iron sulphides and oxides, while those with preserved glaze which was fixed to the paste have lower infiltration. Items 242/2010, 262/2010, 200/2010 and 40/2007 contained infiltrations of iron oxides in the shape of orange and brown blemishes, and their surfaces were covered in calcareous and organic remains of sea organisms.

According to the description of the condition of the items upon their retrieval from the seabed, we can conclude that



Fig. Appx4. Iznik shallow dish 113/09 before and after conservation (photo: HRZ archive)

all items except 242/2010, 262/2010, 200/2010 and 40/2007 were located in the mud rich in iron sulphide because they were completely covered with black mud which penetrated into the porous material of the item. For that reason these items do not contain traces of sea organisms on their surface apart from the items from the other group which, along with infiltrations and traces of iron and iron oxides contain calcareous and organic remains of sea organisms, which indicates their exposure on the seabed.

The small bowls presented a different type of degradation since their glaze was preserved but punctured and separated from the background, and black mud of iron sulphide infiltrated through the fissures to the empty spaces under the glaze. The surface of the item is clean, smooth and shiny, while the impurities are unreachable and located under the glaze. In the case of small bowls 53/2008 and 63/2008 the infiltration completely covers the original colour of the item and painted decoration. Small bowls 8/2011 and 108/2009 also contain infiltrations of iron sulphides, but in smaller amounts. Small bowls are usually very fragmented and it is obvious they broke in the same places where the glaze also cracked. Glaze is present in a thick layer below which is the porous and soft pottery.

### Conservation and restoration procedures

Sorting of pottery fragments typologically followed the process of desalination. Fragments were photographed apart with their associated signature markings, and again with the rest of the fragments with which they make an object. The next phase of the process was cleaning, which was carried out employing various mechanical and chemical methods. Calcareous and organic deposits were cleaned mechanically. Soft organic deposits were simply removed using a surgical scalpel, while the calcareous

remains of sea organisms were often very rigid, strongly connected to the surface and therefore harder to remove. Calcareous deposits were removed by careful and localised cleaning using a pneumatic needle and ultrasonic chisel. Remains of iron oxide were removed from the surface in the same way as were smaller pieces of iron which were glued to some places on the surface of the pottery.

Infiltrations of iron oxides and sulphides were cleaned using chemical methods. Removal tests were made using diluted chloride acid, solution of EDTA, solution of hydrogen peroxide and detergent with surface active compounds New Des (CTS).

Small pottery fragments with metal salt blemishes were submerged in a 5% solution of chloride acid in distilled water. The method was partially successful, but a more sensitive chemical agent which would not act corrosively on the glaze and pottery needed to be found. The method of cleaning using a 3% solution of detergent with surface active compounds in distilled water proved ineffective after a longer period of submersion and brushing. Metal salt blemishes can be removed by cotton coating, cellulose pulp or absorbing clays (Sepiolite) soaked in the solution of disodium salt EDTA in distilled water. The solution of disodium salt EDTA has an acid pH which improves the dissolving of iron salts. It is applied as a 15–20% solution or by submersion. After treatment with the disodium salt EDTA, as in the case of the chloride acid, the item has to be copiously rinsed with water as long as necessary until the desired neutral pH (7) is reached. Iron salts can also be removed by submerging the item into a 15–25% solution of hydrogen peroxide. The time necessary to remove metal salts varies from a couple of minutes to a couple of hours, depending on the concentration of hydrogen peroxide and the amount of metal oxides (Hamilton, 1999).

After carrying out the cleaning tests using these methods, hydrogen peroxide was shown to be more

successful and adequate than the others, and was used to clean the pottery. Items were separated and submerged into the 15% solution of hydrogen peroxide until the metal salts were almost removed. Successful cleaning was carried on items 108/2009, 63/2008, 128/2009, 129/2009 and 58/2008, whose surfaces became much paler and whiter and only slight traces of iron salts remained. Other items were partially cleaned because the iron salts penetrated too deeply into the porous material of the vessel and its inaccessible spots, so their complete removal was impossible. Cleaning was stopped at the moment the decoration started to be readable without disturbing the condition of the object. Items were then submerged into tap and distilled water in order to remove the remains of the chemical agent and to neutralise them. After removal from the water and air drying, fragments were consolidated by immersing them in a 4% solution of acrylic dispersion (Dispersion K9, Kremer) in distilled water, and again left to dry out. In order to protect the harsh and frail surface of the items which did not contain glaze, the surface was coated with a 6% solution of PVA resin (Mowilith 50, Kremer) in acetone with the purpose of creating a protective layer. That layer improved the links between the pigments of painted decoration which amplified the colour intensity.

Fragmented items were glued together using Mecosan L-TR synthetic solvent-based glue. Sticky tape was also used to hold the fragments in place while the glue dried out. Excess glue was removed with cotton swabs soaked in acetone. Smaller and larger cracks and defects were filled and reconstructed using alabaster plaster. Alabaster plaster was applied to a mould made of plasticine which was removed after the plaster dried out and hardened. The plaster was roughly processed while it was still wet and additionally honed using fine sandpaper. Fugues between the fragments were also filled with plaster and additionally processed to the level of the preserved pottery. All manufactured parts made of plaster were painted with water based acrylic paint to the tone similar, but a shade paler, than the colour of the pottery. In some cases it was the colour reached by a long term cleaning process, but which still considerably deviated from the supposed pottery colour after its production. A complete or partial reconstruction of the painted decoration was done on such a background, also a shade paler than the actual decoration. Another layer of finely sprayed colour in the shade of the background was applied on top of the reconstructed painted decoration, which made the reconstructed part a little softer and made the differentiation from the original surface of the item easier.

## Conclusions

The pottery from the Sv. Pavao site was, from the point of view of a restorer, in quite a poor shape. After carrying out the most important methods of desalination and removing the depositions of iron corrosion products, the

item had to undergo other procedures necessary to stabilise and preserve its condition and essential in recovering the readable part of the item, therefore allowing its interpretation and exhibition. A long term but controlled cleaning process removed most of the infiltrated deposits of iron sulphides, acquired readability and recovered the aesthetic value of the item. These procedures were followed by the consolidation process, gluing of the fragments, reconstruction and retouching of missing parts.

Applying all conservation and restoration rules and in respect to the condition of the item, the finds do not look “successfully” cleaned after the process, but their value must not be assessed by their current state. They are the only witnesses of a shipwreck and all those centuries spent on the seabed. Conservation and restoration enabled a better understanding of the objects that witnessed the luxurious trading habits between the West and the East at that time, and represent the richest site of this kind of finds in Croatia.

## Restoring the metal finds

*Antonija Jozić*

### Introduction

Metal items can be divided into several groups in relation to the type of material from which they were manufactured: items of copper, silver, lead and tin alloys. These types of material are in nature rarely found in their elementary state and are usually found in the shape of stable minerals. They do not convert easily to their elementary state once the refining process has taken place and are very pervious to corrosion processes (Filipović and Lipanović, 1995). Therefore, the recovered metal objects were transported to the restoration workshops immediately after retrieval from the site in order to start adequate conservation and restoration procedures and slow the process of their spontaneous mineralisation.

A total number of 65 metal objects were received. Nine objects were made of copper alloys, 53 of silver, 3 of lead and 1 of tin alloy (pewter). Bronze items are represented by the ship's bell with an embossed relief showing a year, a cauldron (14/2007) and rim fragment (18/2008) among which one is completely preserved while the other has perished only the rim survives (28.5 cm in diameter), two profiled lower parts (bottoms) of candle holders, two bowls, one item of unknown function, one scale tray and one round disc 24 cm in diameter with seven hemispherical slots, identified as part of an egg-fryer. Silver objects are represented by 2 *talers*, 40 Turkish *akches* and 11 other coins. Lead objects are represented by one pellet, one rounded plate and one object of unknown function. The only tin alloy (pewter) object is an interesting flagon with a handle, a wide foot and a lid.

## Conservation and restoration methods

The situation of the items at the date of their retrieval was documented in the preliminary stage of conservation. In order to reduce the unknown variables which might emerge in future conservation processes and to precisely assess the degree of accomplished intervention and its extent (Feilden, 1981), the ethics of conservation and restoration processes command documentation of the relationship between the original state of the item and all changes made as a direct result of the conservation and restoration processes. All retrieved items are therefore listed and photographed.

The documenting process was followed by the essential process of desalination. Desalination allowed the items to be cleaned of the harmful salts, especially chlorides,<sup>10</sup> since they were exposed to the sea environment for a long period of time. The desalination process started by isolating the items in polypropylene net/webbing and placing then into a pool filled with tap water. The water in the pools was exchanged depending upon the amount of extracted salts or with respect to the degree of saturation of the water with the salt released from the items.

The degree of saturation of water inside the pools was monitored through electrical conductivity<sup>11</sup> while the concentration of the extracted chlorides was determined by potentiometric titration. The exchange of water was carried out as long as the presence of chlorides could be traced in the water. Tap water was exchanged with distilled water in the last couple of exchanges in order to enhance the desalination process.

At the end of the process metal items were taken out of the water and left to gradually dry out in air, being cautious and not allowing big oscillations in the air temperature for the duration of the drying.

Since the correct choice of materials, tools and methods used in treating the item depends on the characteristics of the material each was manufactured from, items were arranged according to their respective material. Each item was then examined under magnification in order to analyse precisely any damage, the condition of the item and decide about the further course of conservation and restoration actions.

### Bronze items

All bronze items were received in their complete state and in relatively good state of preservation. Various calcareous, organic and corrosion deposits could be seen on the surfaces. The original surface<sup>12</sup> of all bronze items is damaged. Loss of metal was noticed on certain items as well as the activity of active chlorine ions.

Bronze items were cleaned mechanically, by combined use of various hand and electrical tools. The tools used were scalpels of various dimensions, an ultrasonic chisel and an electrical micro-motor with brushes of various rigidity. Using a microscope to clean the items precisely, the only deposits removed were those on top of the original

surface, therefore preserving the authenticity, the details and decorations of every item.

Active stabilisation<sup>13</sup> of bronze items was carried out after the cleaning process by submerging the items into a 3% alcohol solution of Benzotriazole.<sup>14</sup> After the small bubbles stopped emerging from the items, they were taken out of the solution and left to dry out. The excess of Benzotriazole was removed with cotton swabs dipped in acetone.

Partial reconstruction was carried out on only a few bronze items in order to maintain their structural stability. To make that possible, smaller defects and missing parts were filled with two-component epoxy resin and the addition of adequate pigment.

In the final phase of the process the surfaces of the items were protected by spraying a mixture of reversible varnish Paraloid B72 and Cosmoloid H80 in toluene.

### Silver items

Silver coins are whole and very well preserved. Their surfaces are only partly covered by a thin layer of organic and limestone origin. Silver Turkish *akches* and two *talers* were received in a conglomerated lump. Sediment and calcareous layers served as a binding agent so the *akches* were practically encrusted to the surface of the two glued *talers*.

It was necessary to boil the conglomerate in distilled water before cleaning in order to soften the deposit which bonded and glued the coins. Mechanical cleaning of *akches* and *talers* was carried out after separating them with an ultrasonic needle and scalpels of various sizes.

An electrical micro-motor with small rotating brushes made of natural hair was used to mechanically remove the organic deposits and sediment from the surface of the coins. The coins were cleaned using low rpm of the micro-motor and the brushing direction was frequently changed in order to avoid leaving traces of the brush and therefore reduce the damage on the soft silver surface.

The final protection was carried out by applying a 2% solution of Paraloid B72. Silver is a precious metal which, after the process of conservation and restoration, should not corrode anymore and can be held in appropriate microclimatic conditions.

### Lead items

Traces of corrosion caused by the influence of sea water and various organic and limestone deposits are seen on the surface of lead items. Lead items were received complete and in largely covered by characteristic corrosion of various deposits: lead oxides, sulphates and carbonates. After retrieving the items from the sea, these corrosion products will not be involved in subsequent chemical reactions and should be removed from the item for aesthetic reasons and to uncover the surface.

Since lead is a relatively soft metal, which is easily

damaged during the process of conservation, cleaning was conducted using a combination of mechanical and chemical methods. The encrustation of limestone and organic origin were successfully removed mechanically using scalpels of various sizes and profiles. Other corrosion deposits such as lead oxides or carbonates could not be removed mechanically without damaging the soft surface of the lead. They were softened with hot water solution of Kompleksone III (ethylenediaminetetraacetic acid disodium salt or EDTA) and removed by brushing with a soft brush. After chemical treatment traces of chemicals were removed by boiling the lead items in distilled water.

A 5% solution of Cosmoloid H80 in toluene was used for consolidating and final protection of lead items.

### ***Tin alloy (pewter) item***

The only received item made of tin alloy (pewter) is an interesting flagon with a handle, wide foot and a lid. The flagon was received in 12 fragments and was in a poorly preserved condition. The fragments were covered with sediment depositions. Grey to black spots were seen on some parts along with a powdery grey dust characteristic of an advanced state of corrosion caused by the sea water.

The procedure of removing hard sediments from the surface of the object required special attention since the corroded fragments were very brittle and prone to breaking. An ultrasonic chisel was used for that purpose along with scalpels of various dimensions. Supervising the removal through a microscope, most deposits were successfully removed from the surfaces. The remaining deposits were located inside small fractures, but they were also removed by polishing with brushes made of synthetic hair. The brittle fragments had to be strengthened after cleaning, and were treated and impregnated with a two-component epoxy resin Araldit 2020.

Reconstruction was possible since the collected fragments displayed the original shape of the flagon. They were first connected with a reversible acrylic glue and then reinforced with glass fibres and filled with a two-component epoxy glue with the addition of adequate pigment. Smaller defects on the surface were also filled to achieve good structural stability of the complete vessel. In the final phase of the process the surface was protected by spray painting the flagon with a mixture of reversible lacquer Paraloid B72 and Cosmoloid H80 in toluene.

A complete documentation was made after performing all conservation and restoration work on metal finds from the Sv. Pavao site. It includes a detailed description of all implemented procedures and methods, a list of all materials used and photographs for every item processed.

### **Conclusions**

The conservation and restoration process conducted on the metal finds from the Sv. Pavao wreck proved to be extremely

demanding and sensitive, although very interesting. The process was carried out on four different types of material with an individual approach to each in consideration of its characteristics. Interventions on each item were carried out in accordance with the authenticity of the item and the work ethics of the restoration process. The procedures described above slowed the process of spontaneous mineralisation or the natural process of degradation of metal items. In order to preserve the metal objects for posterity as long as possible, it is necessary to handle items with care even after they were fully restored, to take into consideration the conditions of their safekeeping and to continuously check the state of the items in order to anticipate possible unwanted changes.

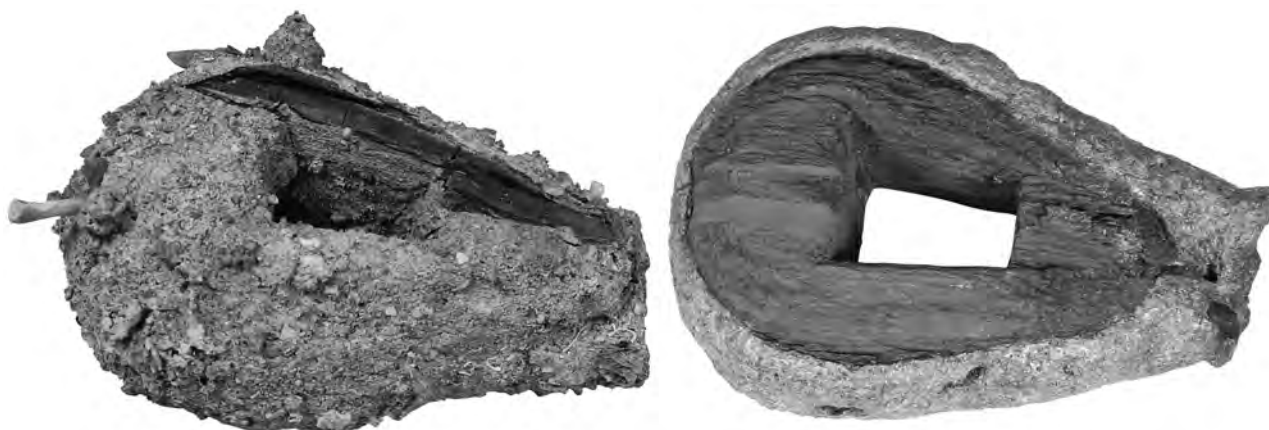
## **Restoration interventions on finds of organic origin**

***Anita Jelić***

### **Introduction**

Archaeological finds of organic origin, primarily bone or wood, often seem well preserved in underwater conditions. This is the result of the cold, dark and inorganic underwater conditions which delay biological degradation. Nevertheless, organic material can be worn and weak even if it is exposed to such conditions. There are many reasons for this. The construction elements of organic matter are soluble in water, and in time melt down when submerged leaving the organic structure more porous and water permeable, therefore more sensitive to impurities and salt. Anaerobic micro-organisms found underwater destroy the organic matter or the carbohydrates in the wood structure and the proteins in the bone structure, which significantly influences the degradation and deterioration of finds of organic origin. If the finds are submerged, water fills all cavities which develop during degradation of the item and maintains the original shape of the organic find (Smith, 2003; Rodgers, 2004).

Exposing underwater finds to air before putting them into conservation greatly increases and hastens the degradation of the material because of the evaporation of excess water during which the strength of surface tension causes extensive dimensional changes or shrinking, layering, breaking and deformation of the organic material (Rodgers, 2004). Complete degradation of the organic material and its metamorphosis into humus is the final result of evaporation or the uncontrolled drying of the find. Dimensional changes and the degree of decomposition depend on the degree of current degradation and the present amount of water in the material. These changes are permanent since the rehydration of the organic material will not turn the item back to its original condition (Malinar, 2007).



*Fig. Appx5. Wooden heart in combination with metal before and after the conservation and restoration process (photo: A.Jelić, HRZ archive)*

### The finds

A small number of finds of organic origin were found during the research conducted on the Sv. Pavao shipwreck.<sup>15</sup> The received finds are made of wood and bone and they differ in size, function and degree of preservation. We can differentiate a heart,<sup>16</sup> four pine cones and two different knife handles received in wet condition, and a heart in combination with metal and a cork received in dry condition, one wooden comb, a cylinder of unknown function and many small fragments of animal bones.

All finds were visually examined and there were not any sediment depositions present on the surface of the items. Thin sediment depositions were noticed only on the surface of the wooden cork, on one knife handle and between the comb teeth. Small amount of degradation was noticed on one side of the wooden sheave and as well as a partial absence of complete comb teeth. A complete heart in combination with metal (Fig. Appx5) can be isolated from other finds because its complete surface is covered with a thick and hard calcareous and sediment deposit. A fracture is present on one side of the sheave through which a cracked wooden part can be seen. This probably happened as a result of the uncontrolled drying of the item before submitting it to the conservation process. There is a thick layer of unknown metal surrounding the heart, which looks like a pipe with thick sides that goes around the heart and whose two ends join and end on its narrow part. The cross-section of the pipe reveals threads that can be seen to be covered in corrosion products and glued to the metal part, and were once probably part of the rope.

Since the finds differ by the type of material and as they were received in various states of preservation and humidity, the conservation and restoration procedures also differed in certain phases for most received finds.

### Conservation and restoration procedures

The purpose of these procedures carried out on underwater

archaeological finds is to slow down their degradation, to stabilise and reinforce their structure, to prevent physical damage and keep their authentic appearance and original dimensions. It is a complicated process which encompasses exchanging water with an impregnation agent that solidifies the organic structure and also removes water using a method which does not cause the shrinking or degradation of the organic material.

Nevertheless, the finds were retrieved from the sea and also contained dissolved salt<sup>17</sup> which had to be removed. Extracting the salt from the organic structure prevents mechanical and chemical degradation. On the contrary, the drying process would crystallise the salt and mechanically damage the organic structure because the volume of the crystal is larger than the volume of the dissolved salt. Salt is also hygroscopic<sup>18</sup> and reacts with the atmospheric humidity, which could set in motion a whole new strain of chemical reactions within the organic structure and hasten the degradation of the finds, which is in opposition to the conservation and restoration ethics (Smith, 2003).

Soluble salts were removed from all finds apart from the sheave with the metal part and the cork which were received in a dry condition. It was carried out by the process of desalination conducted in tap water with the addition of a disinfecting agent<sup>19</sup> in order to prevent the gestation of harmful micro-organisms. The concentration of extracted salts was monitored during the desalination process by employing potentiometric titration in measuring the concentration of chloride ions. This measurement was conducted once a month when the old tap water was exchanged with fresh. Once the measured values, or in this case the concentration of chloride ions, had been reduced to the level equivalent to that found in tap water, the tap water was replaced by distilled water for completion of the process, with more frequent exchange of water, but the same controlled measuring conditions. Using the distilled water provided maximum extraction of soluble salts from the structure of the finds so the concentration of chloride ions was reduced to a minimum.

After successful desalination the finds were free of calcareous and sediment deposits as well as other impurities. Deposits and impurities were removed with various mechanical tools such as scalpels of various sizes and profiles, brushes of various rigidity and even using a micro-motor. The cleaning process was carried out with care using a magnifying glass or a microscope depending on the find, and great care was taken not to allow the finds to dry out. The cleaning process differed only while cleaning the sheave in combination with metal and the cork because they were cleaned immediately upon reception with the presumption they were already desalinated. Other tools used to clean hard depositions were an electrical chisel and a micro-sand brush to remove deposits from the metal part. Desalinated and cleaned finds were afterward impregnated and consolidated.

### Consolidating wooden finds

The process of consolidating the sheave in combination with metal and the cork differed from the process employed for other finds. Since they were received in dry condition, there was no need to remove water from the wooden structure, and the process of consolidation was carried out immediately after cleaning of the finds. The consolidation of these items was completed and was carried out gradually using a solution of various concentrations of Paraloid B72<sup>20</sup> in acetone. The starting concentration was 2% and the final one 10%. The concentration was gradually increased while the solution was applied by a drop applicator. The surface of the metal part was consolidated applying a 2% solution of Paraloid B72 in acetone. The drying of the consolidating agent was followed by the integration of cracks which resulted from uncontrolled drying before the items were received for conservation.

Consolidation of other wooden finds was carried out using the acetone-resin method. Selecting the consolidation method follows visual examination of each find, and this method is recommended for conservation of small and important wooden items because the wood structure is completely stabilised after the process and the finds are not heavy and light-coloured (Unger *et al.*, 2001). The method is based on exchanging the water in the wood for a natural resin. The consolidation agent used was rosin<sup>21</sup> (tar from pine tree), and the solvent is organic, in this case acetone since rosin is not soluble in water. Nevertheless, in order for the method to be successful it is important to use only rigid, technical resin and pure acetone or other organic solvent, i.e. alcohol, and to take care of these details while conducting the process.

Because the rosin cannot be mixed with water, it was important to remove water from the wooden structure of the object first. The process of wood dehydration was carried out in three consecutive acetone baths. Since the thickness of finds varies, the dehydration process those 5–10 cm in diameter took four weeks (sheave and pine cones) and for finds thinner than 5 cm (knife handles) two weeks or until

the water was completely replaced by acetone. Dehydrated finds were then put into closed containers with a saturated solution of rosin in acetone. The resin part was 67% and the work temperature of the process was 52°C. The duration of the process depends on the thickness of the item, and took four weeks for thick items and two weeks for thin items, with continuous monitoring of the process. After the process was finished the finds were removed from the solution and the excess rosin removed from the surface with a textile cloth soaked in acetone (Hamilton, 1999).

### Consolidation of bone finds

Bone finds were consolidated with a solution of Paraloid B72 in acetone. The finds were dehydrated before the consolidation process in three continuous acetone baths of which each lasted for two days. In order to carry out a successful consolidation the process was carried out gradually. It began by submerging the finds into a solution with a small concentration of Paraloid B72 in acetone and was continued by submerging them in the solution of higher concentration, finishing with the 12% solution.

Small animal bone fragments were dried out in controlled environment before the consolidation process due to their good condition. Their surface was consolidated using a 2% solution of Paraloid B72 in acetone.

Gradual drying of the finds followed the consolidation process. Drying began by coating the items in paper soaked in acetone, placing them into polyethylene bags laid down in closed containers. This process allowed gradual drying of the items, and the acetone soaked paper removed any possible excess of the consolidation agent (rosin or Paraloid B72) from the surface. After initial drying the paper was removed and drying was continued in an appropriate controlled environment with a temperature of 18–20°C and relative humidity of 50–60% (Jones, 2003). The items were exposed to these conditions for two hours a day; they were weighed before and after exposure and returned to the polyethylene bags and closed containers. When the weight stabilised and a constant mass was reached, the drying process was finished. Drying items in this way was carried out to minimise various deformations and breaking of the wooden and bone structure that is the usual and inevitable result of inadequate consolidation and uncontrolled drying of organic material.

Nevertheless, in spite of the complete consolidation and gradual drying in controlled conditions, some wooden items still developed a few small cracks or fissures. The fissures were filled with a two-compound composite paste for wood, Araldit SV 427.<sup>22</sup> The excess paste was removed and the rest was toned using acrylic paint similar to the colour of the find in order to blend in the integration as much as possible into the original item and to keep its visual appearance authentic.

Technical documentation was made upon restoring all finds which includes photographs taken before and after restoration, and a detailed description of all procedures

applied to each object as well as the materials used during the process. Also listed are the storage conditions such as temperature, relative humidity of air and the illumination strength for both types of organic material with detailed instructions on how to handle the finds. Even though the finds should be kept in the appropriate micro-climatic conditions, it is advisable that their condition be monitored from time to time in order to prevent unwanted consequences, such as various deformations of material, breaking of wooden and bone structure, and to allow a timely response in the possibility of any issues arising.

Good documentation provides insight into all changes relating to the find made by a conservation or restoration procedure and prevents unknown variables from appearing in some future intervention.

## Notes

- 1 The conservation work on all items was carried out by the Department for Restoration of Underwater Archaeological Finds from the Croatian Conservation Institute. Some items were conserved in the workshops of the International Centre for Underwater Archaeology in Zadar (former Department within the Croatian Conservation Institute; the workshops were transferred to the International Center for Underwater Archaeology by the decree from the Ministry of Culture in 2013)
- 2 Before the process commenced, additional preparatory actions had to be completed; setting the artillery pieces into the pools, inserting and fixing the anode into the barrel, fitting and fastening of the catode clamp, connecting the anode and catode to the outer power source and connecting the reference electrode with a voltmeter and preparing the electrolytes
- 3 Since the atmospheric influence of high relative humidity, temperature extremes and poor handling can significantly influence the condition of the object and cause various harmful changes, surface protection has an important role in giving the item the best possible protection against these influences, therefore contributing to its long term preservation
- 4 Radiographic recordings were carried out by the Department for Welding and Thermal Technology d.o.o. from Zagreb
- 5 Energy Dispersive X-ray analysis
- 6 The results were taken from the report made by the Centre for Metal Research Metris from Pula, who conducted the EDX sediment analysis
- 7 The results were taken from the report made by the Research Centre for Materials in the Region of Istria-Metris from Pula, who conducted the SEM-EDX analysis of the black powder
- 8 Field Emission Scanning Electron Microscope
- 9 The results were taken from the report about the conducted FE-SEM fabric analysis made by The Research Centre for Material Metris.
- 10 The role of chlorides is very important in corrosion of metal items, and we can say that the problem of removing them is one of the most important issues when conserving archaeological finds made of metal. A high concentration of chlorides in sea water inflicts a strong corrosive attack which is even more intensified by removing the object from water and retrieving it to the surface
- 11 Electrical conductivity of water grows proportionally to the increase in the amount of salt released into the water (Filipović and Lipanović, 1995). When the value of electrical conductivity reaches its constant maximum, it is considered that the water has been saturated with the released salts
- 12 The original surface is one of the corrosion layers which outline the original shape of the item and can even be only a few micrometres thick, but is of great importance for the restorer and the archaeologist because it can hold information about the object from the time of its use (Doračić, 2000)
- 13 Active stabilisation of archeological finds implies procedures which directly intervene on the item in order to stop the process of degradation
- 14 Benzotriazole is a very effective inhibitor for the corrosion of copper and copper alloys. Binding itself for the cation  $\text{Cu}^+$ , Benzotriazole blocks the development of alkaline copper chloride and therefore further cyclic corrosive reaction (Hamilton, 1999)
- 15 Organic material, even though massively used in the past, is quite pervious to degradation during a long term effect of various atmospheric influences, fire or other destructive factors, and is preserved in a small percentage (Malinar, 2007)
- 16 A simple device used to transfer the motion or force, and to rise or pull heavy load using small force, frequently an integral part of wooden ships
- 17 Many various anorganic salts are dissolved in sea water. Most usual are chloride salts and the desalination process is monitored through the extraction of chloride ions
- 18 Hygroscopicity is a an ability of solid or liquid matter to soak in or keep the water from its environment (Filipović and Lipanović, 1995)
- 19 The disinfection agent was the 2% mixture of borax and boric acid in 3:2 ratio to reduce toxicity (Malinar, 2007)
- 20 It belongs to the group of thermoplastic acrylic resins which is often used as a consolidating agent for organic material. The copolymer is of methyl-acryllate and ethyl-metacryllate and is characterised by good resistance to light, it does not become yellow in time and stays permanently soluble in organic solvents (Hamilton, 1999)
- 21 Rosin is a rigid matter which lapses after distilling the removed volatiles from the tar excrement of conifer trees, soluble in stronger organic solvents (Punda, 2001)
- 22 According to the specification of the item Araldit SV 427 is a two-component epoxy resin which is mixed with the hardening agent HV 427 in the same proportion

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