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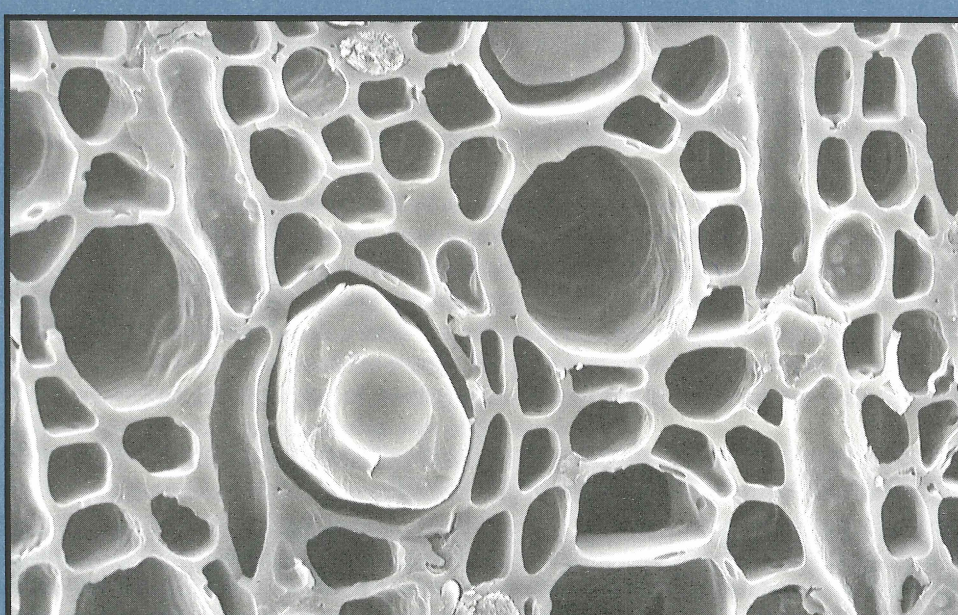

The INA Quarterly

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On the cover: Cross section magnified view of wood treated with silicone oils. Photo: C. Wayne Smith.

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The *INA Quarterly* was formerly the *INA Newsletter* (vols. 1-18). Editor: Christine A. Powell

Developmental Research and the Need for Science in Archaeology

C. Wayne Smith,
Assistant Professor and Director of the Archaeological Preservation Research Laboratory

Scientists have repeatedly challenged the discipline of artifact conservation by introducing new technology, information, and research paradigms. Since 1996, the Archaeological Preservation Research Laboratory (APRL) at Texas A&M University (TAMU) has pursued two goals: First, to adapt conventional conservation strategies to better suit our conservation needs. Second, to evaluate new materials and methods for expanding the conservation tool kit. In May of 1998, the United States Patent Office awarded Drs. Wayne Smith and Donny Hamilton of TAMU and Jerome Klosowski of Dow Corning Corporation a patent entitled *Methods of Conserving Waterlogged Material.*

The research leading to this patent shed new light on the implementation and adaptability of polyethylene glycol (PEG) in the treatment of waterlogged materials. Polyoxyethylene polymers combined with crosslinkers and catalysts are very useful in the preservation of waterlogged organic materials. PEG is a form of polymer, so the addition of cross-linking chemicals and catalysts routinely used in polymer chemistry can make it more stable for use as a bulking agent within the damaged cell structure of waterlogged wood. By making PEG less soluble, conservators can better ensure the structural stability of the artifact.

Research has proven that PEG can not be completely removed from the cell structure of waterlogged wood. We can consider the material introduced into an artifact as two subgroups. PEG that is in direct contact with the cell walls of the artifact tends to polymerize naturally with the starches, sugars, and lignum that are present in the artifact. We cannot remove this PEG from the artifact without causing extensive damage.

The second subgroup of PEG is not in direct contact with cell walls. This free-flowing PEG in the voids between and in cells can be susceptible to changes in temperature, humidity, and exposure to ultraviolet light (fig. 1). As atmospheric changes occur, the physical characteristics of this PEG fluctuate. If environmental factors are not controlled, the unbound PEG migrates within the cellular structure of the artifact. Eventually, the surfaces of the artifact become pooled with PEG. This can cause structural instability within the artifact and, all too often, the loss of the very diagnostic attributes that needed to be preserved. In the case of ships in museum displays, the loss of PEG forms a drip line around the vessel, indicating that structural problems may soon follow.

Additional research at APRL has proven that we can successfully remove unbound PEG within the cell structure of the wood without losing the diagnostic attributes of the artifact (fig. 2). This aspect of our research has been particularly useful for the re-treatment of artifacts previously treated using single or blended PEG treatment strategies.

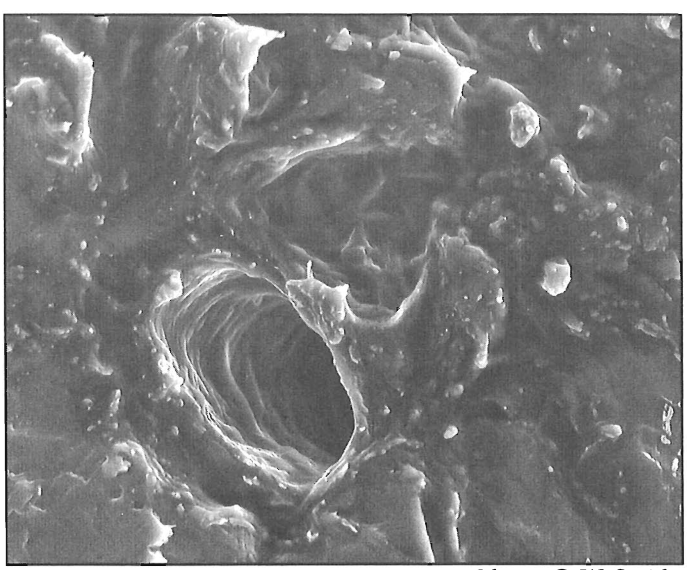

Photo: C. W. Smith

Fig. 1. *Cross-section view of the cell structure of PEG-treated wood. The majority of cells are filled with PEG.*

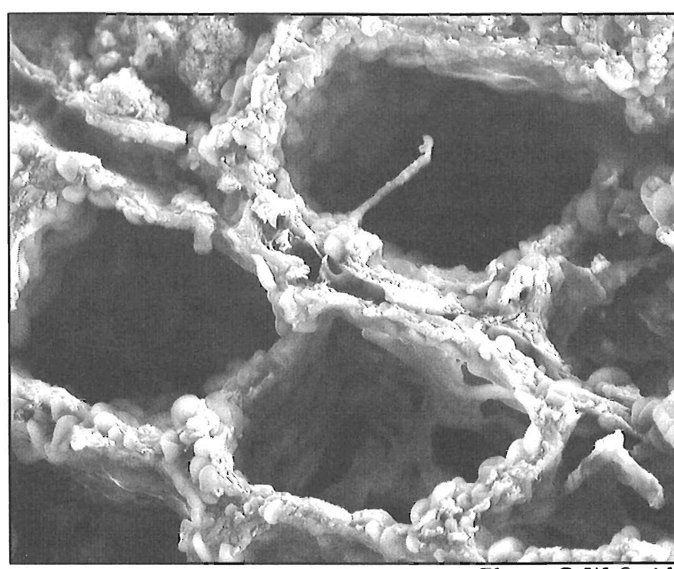

Photo: C. W. Smith

Fig. 2. *Similar cross-section view after CR-20 re-treatment. PEG has been removed from cell voids although PEG is visible on cell walls.*

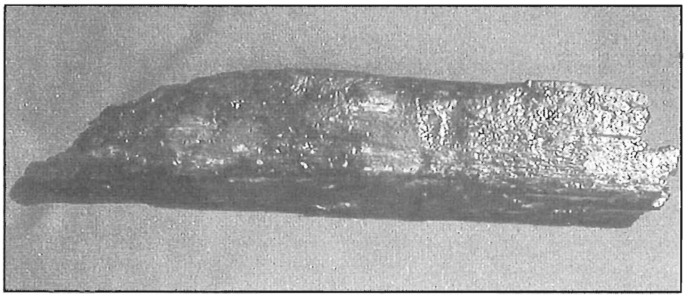

Photo: C. W. Smith

Fig. 3. *Section of* Vasa *wood before re-treatment using CR-20 extraction. Note the waxy surface texture and appearance.*

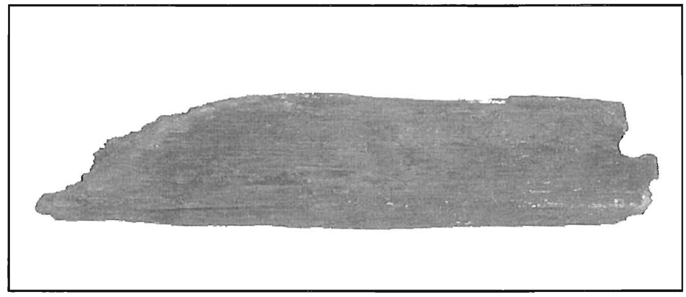

Photo: C. W. Smith

Fig. 4. *The same wood sample after treatment. Surfaces of the wood are dry and feel like wood. After treatment, this artifact is not affected by changes in humidity or temperature.*

New Conservation Technologies at Work

On February 8, 2000, the team received a second patent. The scope of research covered in this patent is much broader than the first, and included fifty successfully defended claims. Entitled *Conservation of Organic and Inorganic Materials*, this patent outlines ways to preserve artifacts using curable polymers cross-linked with trialkoxysilanes. This aspect of APRL's conservation work is known as silicone research.

During the fall of 1999, Ingrid Hall-Roth of the Vasa Museum and Carl Hemlin of the National Heritage Commission of Sweden conducted research at APRL. The aim of their joint research was to evaluate aspects of TAMU's silicone technologies for use in re-treating PEG-preserved timbers from the great ship *Vasa*. Before re-conservation, the two samples of wood were weighed, photographed, and traced. Extensive documentation was needed for post-treatment evaluation of the dimensional stability of the samples.

The aim was to determine whether CR-20 silicone re-treatment could preserve the structural and aesthetic aspects of the samples. The researchers treated both sections of wood by immersing them in a warm solution of CR-20, in a vented fume hood, for three hours. They then removed them from the solution and allowed them to air dry in a vented fume hood for several hours. In a matter of minutes, both samples were very natural in appearance. Neither sample had the waxy surface texture often associated with PEG-treated wood (figs. 3 and 4). Because free-flowing PEG had been extracted, the samples were substantially lighter after treatment. A comparison of pre- and post-treatment tracings indicated that no shrinkage or surface checking occurred as the result of treatment. The technique is outlined in Report Two on APRL's web pages.

Apart from developing PEG technologies, conservators at Texas A&M University have been working with silicone oils for purposes of preserving archaeological materials. This has been an exciting area of research. Like PEG, silicone oils are polymers. Research has indicated that these oils may have some benefits over PEG for the conservation of some organic waterlogged materials. Apart from the fact that preservation treatments using silicone oils can be completed in a fraction of the time required to preserve similar artifacts using PEG, there are other advantages. During treatment with PEG, individual cells of the wood are filled with the bulking agent. This makes post-treatment analysis of the wood difficult. In contrast, silicone oils treatments tend not to fill cells with polymers. Instead, the oils bond to the cell walls of the artifact and the interior voids of teach cell tend to remain empty. This makes post-treatment genus and species identification possible. In this cross section view, the anatomy of the wood sample is well defined (cover).

Intercellular migration is not a concern with silicone oil treated wood. The polymerization process ensures that the bulking agent is chemically bonded to cell walls. In this state, the artifact is not affected by environmental factors and the artifact is easier to store and display in a museum environment.

Joint Research with Western Australian Maritime Museum

Recently, APRL has been conducting joint research with Dr. Ian Godfrey, artifact conservator and scientist at the Western Australia Maritime Museum. We have been working on preservation of ivory recovered from the *Vergulde Draeck* (Gilt Dragon) wreck, lost in Western Australian waters in 1656. The vessel was part of the Dutch United East India Company fleet, commonly known as the VOC.

A twofold experiment was designed in conjunction with Dr. Godfrey. Because of their ability to deeply penetrate organic compounds and tightly bond with the cellular structure of organic materials, silicone oil processing was viewed as a potentially good treatment strategy for the badly deteriorated ivory. A test section of ivory, treated at the museum, confirmed that silicone oils effectively stabilized the delicate tusk. With such positive results, two sections of tusk were sent to TAMU for additional study and preservation using different silicone materials.

The beginning stages of delamination were visible in both sections of tusk (fig. 5). To prevent additional deterioration, the artifacts were wrapped in cotton string prior to treatment. After four days, both artifacts were completed. Preservation with silicone oils did not affect the color or the dimensional characteristics of the tusks (fig. 6). More importantly, after more than three hundred years, these artifacts are can now be displayed with other artifacts from the VOC's expeditionary fleet to Batavia.

New Perspectives—New Technologies

Conservation research at TAMU in the past five years has contributed a number of useful techniques and materials. These will assist in preserving waterlogged artifacts for future generations to enjoy. As we answer questions raised by our data, we learn to ask better questions. Advances have been promising, but the long-term best interest of the artifacts must always be our primary concern.

The notion of complete reversibility is probably unrealistic. In many cases, the act of trying to remove materials that have been introduced into artifacts causes more damage than can be justified. Indeed, testing has proven that PEG, which was once thought to be a completely reversible process, is not. Chemical bonding of PEG occurs with polysaccharides, polyphenolics and water to form complex bonds within the artifact. Like the bonds formed with silicone oils, these chemical structures are not reversible. Research is showing that the issues of longer stability and re-treat ability better address the conservation mandate of long-term well being of artifacts.

We have conducted repeated experimentation using accelerated weathering testing to evaluate the stability of waterlogged archaeological glass that has been treated using silicone oils. These experiments indicate that the glass will remain stable for better than 250 years. Within this period, re-treatment of the glass with silicone oils or technologies that are more conventional will restart the stability time clock.

There is no single ideal approach to the conservation of our archaeological resources. Each artifact has a unique history to reveal and presents the conservator with a different problem. At TAMU, we continue to seek new solutions to these conservation challenges. We also commend the conservation community for undertaking the monumental tasks of preserving our historical past for future generations to appreciate.

Suggested Readings

Smith, C. Wayne

1997 *Re-treatment of PEG Treated Waterlogged Wood,* Archaeological Preservation Research Laboratory (APRL) Report 2. World Wide Web, URL: http://nautarch.tamu.edu/APRL/report02.htm

1998 "The Re-Treatment of Two PEG-Treated Sabots," *Proceedings of the 7th ICOM-CC Working Group on Wet Organic Archaeological Materials Conference.* Grenoble: ARC-Nucléart Publishers.

The three patents: Methods of Conserving Waterlogged Material (5,789,087), Methods of Conserving Waterlogged Material. (6,022,027), Conservation of Organic and Inorganic Material (6,022,589).

Photo: C. W. Smith

Fig. 5. *End view of two sections of tusk conserved at APRL. Prior to treatment, delamination was noted in both artifacts.*

Photo: C. W. Smith

Fig. 6. *Side view of tusks after treatment using low viscosity silicone oils.*

Survey of the Valletta Harbors in Malta 1999

Ayşe Atauz

Geographic and historical setting

INA conducted the first phase of a systematic survey of the Valletta Harbors in Malta between October 2–18, 1999, with the permission of the Maltese Ministry for the Environment and under the auspices of the National Museum of Archaeology in Malta. The Maltese Islands are situated in the central Mediterranean between Sicily and the coast of North Africa (fig. 1). The archipelago consists of three main islands (Malta, Gozo, and Comino), and three uninhabited islets (Cominotto, Filfla, and St. Paul). The archipelago trends northwest to southeast and is approximately 45 km in length, the largest island having a surface area of 246 sq. km. The island of Malta has no lakes, rivers, forests, or mineral resources apart from salt. Fresh water is scarce, extracted from the aquifer below its layers of limestone or created from the sea by reverse osmosis. However, Malta has played a significant part in international affairs throughout history because of its strategic importance and its fine natural harbors.

Although there are remarkable prehistoric structures, we know little about the island before it was colonized by the Phoenicians at the second half of the eighth century BCE. It was then successively colonized by the Carthaginians, Romans, and Arabs. The Normans of Sicily took over Malta about 1090 CE, the beginning of a long period of calamity for the island. In the fifteenth century, Malta suffered piratical raids and pestilence as well as a disastrous famine, in addition to the first attack by the Turks in 1488.

Malta was offered to the Knights of the Order of St. John of Jerusalem in 1530 by Emperor Charles V as their new base in the Mediterranean. They had been expelled from Rhodes in 1522. The Knights turned Malta into a naval bastion and trade center. In addition, they fortified the island, as they feared another assault by the Turks. Their apprehension was justified when, in 1565, the Turks launched an attack that is known as the "Great Siege." Although the Knights were outnumbered, they succeeded in holding their positions and came through the battle. The Knights built a new fortified town, Valetta, after Jean de la Valette, the Grand Master who had led the Knights to victory against the Turks in 1565. Successive grand masters continued to improve the island's fortifications and built new settlements, particularly around the Grand Harbor. The Knights' wealth brought prosperity to the island and led to the expansion of the Maltese settlements.

This period of prosperity came to an end when Napoleon confiscated the possessions of the Knights in France in 1792, which was followed by the French invasion of the island and the departure of the Knights in 1798. French rule was very unpopular and led to a rebellion of the Maltese, who sought help from the British in 1800. Two years later, the Maltese asked to be placed under British sovereignty. Under the Treaty of Paris (1814), Britain formally annexed Malta, having refused to hand the islands back to the Order of Knights of St. John, then under suzerainty of its new but short-lived Grand Master, the Russian Czar Paul.

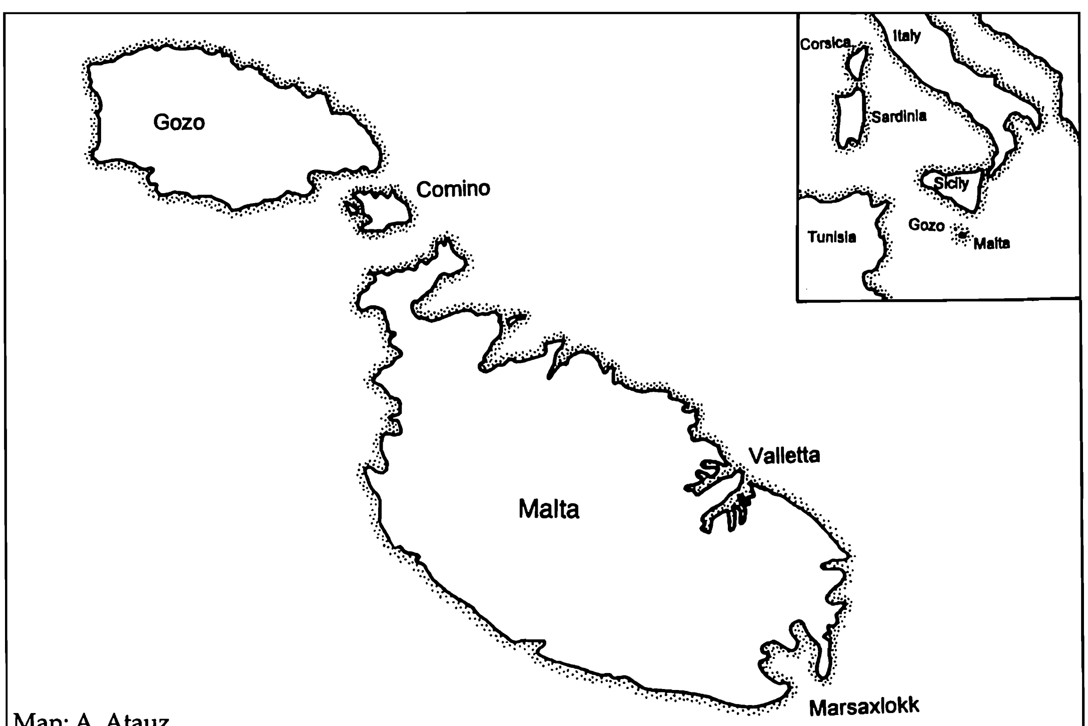

Fig. 1. *Malta and neighboring islands, showing the location of Valletta's harbor.*

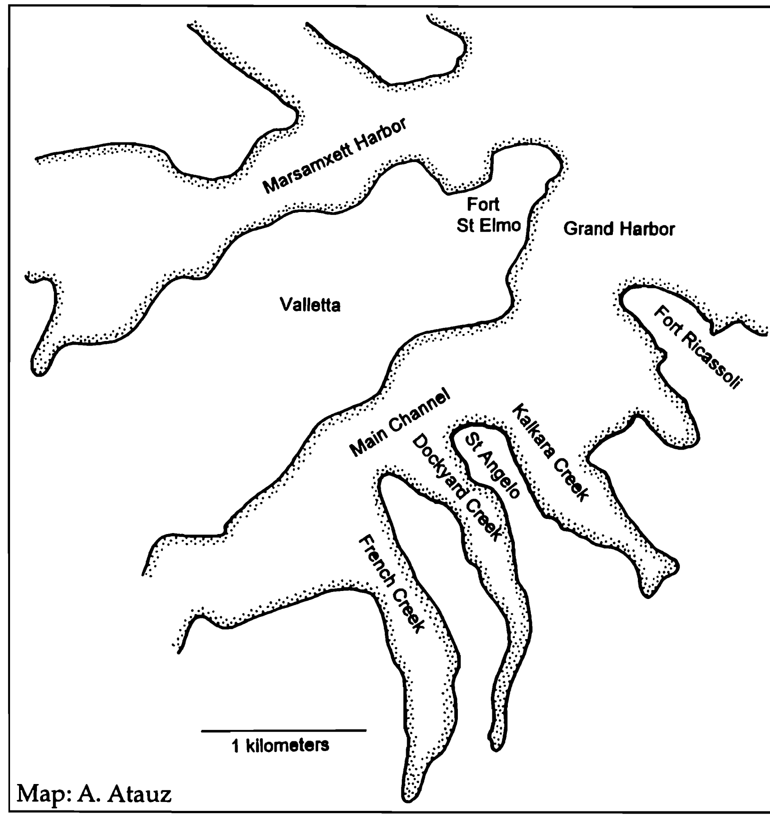

Fig. 2. *Valletta Harbors, detailing the area surveyed.*

Malta was extremely valuable to Britain throughout the nineteenth century because of its strategic position in the Mediterranean. New military bases were installed, the shipbuilding industry was expanded, and the harbor facilities were improved. During this period, a succession of constitutions brought varying degrees of local representation to the governing council as the islanders advocated greater political freedom. In 1921 Malta was granted a constitution giving the country considerable self-rule, although Britain remained responsible for the islands' foreign affairs. The dominant position of the Roman Catholic Church in Malta was acknowledged by the British authorities, but was also a major source of tension in local politics as well as ongoing constitutional negotiation. During the Second World War, Malta played a crucial role in the Allies' Mediterranean strategy and was subjected to very heavy bombing and a naval blockade by Italy and Germany. In 1964, the British Government agreed that Malta should become independent under the constitution approved by referendum.

Previous Work

Previous underwater investigation of Maltese archaeological material included a French survey in 1984. In 1988, a British-based archaeological group (Specialist Archaeology Technology) carried out a survey in the Grand Harbor area. The survey included dredging and the use of side-scan sonar and sub-bottom profilers, in addition to scuba-diving to investigate anomalies. Although a number of irregularities, corresponding to possible wreck sites, were identified, the group was unable to come back the following year and continue their exploration.

Objectives

The 1999 INA Survey in Malta was a preliminary reconnaissance. Objectives included the general examination of the Valletta Harbors: the Grand Harbor and Marsamxett Harbor (fig. 2). The focus of this short project was the investigation of the areas within the confines of the marina project that involved construction activities on parts of the Valletta waterfront, including the placement of bottom hugging pontoons. Previous research indicated that parts of the harbor slated for marina construction were likely to contain shipwrecks, and priority was given to the selected sections of the harbor that have not been dredged. Therefore, Dockyard Creek, the main channel of the Grand Harbor, and Marsamxett Harbor were the pre-determined survey areas.

Surveying Techniques

The survey was accomplished with a Sea Scan PC high-resolution side-scan sonar, coupled with a Geometrics cesium magnetometer. The remote sensing system is designed to locate large and small objects underwater in zero visibility, and was chosen for this survey due to the poor visibility and silty bottom conditions. INA Director George E. Robb and INA Research Associate Ayşe D. Atauz operated the system. A GPS unit, used to give longitude and latitude of the sonar targets, provided precision navigation for the survey. Other elements of the survey included diver inspections of selected areas of the sea bottom to examine some of the sonar and magnetometer targets, or anomalies. Unusual features noted in the sonar images were reviewed and the more promising targets were identified for diver verification. The diving team, equipped with hand-held magnetometers and surface communication units, consisted of George E. Robb, Christian Swanson, Andrew Wilson, Kevin Milligan, Ayşe D. Atauz, Timothy Gambin, Reuben Grima, Edmond Cardona, and Michael Spiteri.

Tentative results

Area 1: Dockyard Creek: Previous research indicated that the Dockyard Creek, an area slated for marina construction, was likely to contain archaeological material and possibly shipwrecks (fig. 3). A coarse sand bottom covered by a thick layer of silt characterizes the seafloor. Sonar systems are generally ineffective for finding materials buried beneath sand, and we had doubts about how well a magnetometer would function in an environment with a very high concentration of modern debris, including chains and other metal features. Consequently, a few track-lines were first executed to test the equipment on October 6, 1999.

The initial results seemed promising. In general, the targets within the survey area appeared to be flat, with no acoustic "shadow," and most were crescent-shaped features with associated magnetic anomalies, interpreted as chains or pipe fragments that did not require further investigation. However, one target southeast of the ferry terminal off Vittoriosa was designated as a diving location due to the sonar image. It appeared to be an area consisting of a pile of uniform ovoid features (of about 0.25 meters in diameter) and with an associated magnetic anomaly. Piles of rounded rocks are characteristic of shipwrecks since hulls are often preserved under the ballast. The extent of this site, 9 meters long and 4 meters wide, bolstered the idea that it might be a shipwreck site.

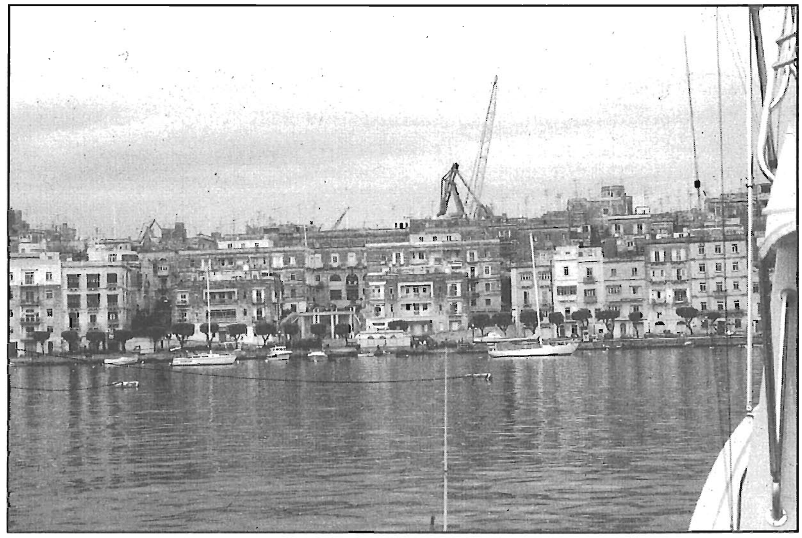

Photo: A. Atauz

Fig. 3. *Dockyard Creek may contain archaeological material and shipwrecks.*

We first dived on the target on October 7, 1999. The team thoroughly investigated the area, though unfortunately without much success. The very low visibility within Dockyard Creek, further degraded once the divers' movements disturbed the silt bottom, prevented identification of the target anomaly. This would continue to be one of the most significant drawbacks for diving operations in the area throughout the survey. However, the dives did yield an important result: the rock-pile/anomaly in the sonar image was apparently not on the surface of the seafloor and visible to divers; the side-scan sonar/magnetometer was detecting features present under the protective layer of mud and silt. Although, this compounds the difficulty of locating wrecks with alacrity, it provided comfort in the knowledge that they may at least be well preserved and available for inspection at a later date.

The next day continued remote sensing defined another target in the confines of Dockyard Creek, located on the southwest of the bridge between the Vittoriosa Wharf and the Angelo Wharf. Divers confirmed that the anomaly was an anchor stock, just as it was determined to be in the remote sensing record. Much to our disappointment, it was not ancient. Still, we forged ahead.

The last area examined in the Dockyard Creek was the site of a test trench excavated during the survey by a French archaeological team in 1984. The objective was to ascertain the extent of silt accumulation in the creek. The French team worked the site previously by siphoning silt and sand out of the creek, and recovered pottery dating to the sixteenth and seventeenth centuries. Our investigation determined that the site has been completely re-covered by silt in the past fifteen years. Only one fragment of possibly seventeenth century pottery, typologically similar to the finds of 1984, was recovered.

Area 2: Main channel of the Grand Harbor: The second survey area was the waterfront of Pinto Wharves (no. 1-no. 5). However, the track-lines in this area were usually extended towards the Ricassoli Point in order to cover the central part of the Grand Harbor area (fig. 4). Therefore, the entire area between the innermost part that was dredged in 1981 and the breakwater on the northwest of the Ricassoli Point was examined. Although extensive boat traffic interrupting the survey presented an obstacle, two possible shipwreck sites were located and defined as diving targets, between Senglea Point and Saint Angelo Point. Most other anomalies in the area surveyed were known shipwreck sites. These confirmed that the equipment functioned effectively, and were used as a tool with which to compare new anomalies and to calibrate the equipment.

Another set of track-lines in Area 2 on October 9 1999, yielded an area of concentrated "rock-piles" around the location of a previously located target, slated to be revisited. In general these mounds of rocks are spaced about 50–100 meters from each other, some having clearly associated magnetic anomalies. The area is close to Senglea Point, and (among the eleven targets detected) three were identified as worthy of investigation. Unfortunately, it was impossible to dive at this location due to heavy boat traffic.

Area 3: Marsamxett Harbor: The scope of the remote sensing survey in Area 3 included the entrance of Lazaretto Creek, the area to the southeast of Fort Manoel, and between the southernmost end of the Quarantine Hospital building and the easternmost tip of the Ta'Xbiex (fig. 5). Clay pipes, musket balls, and various terra-cotta artifacts

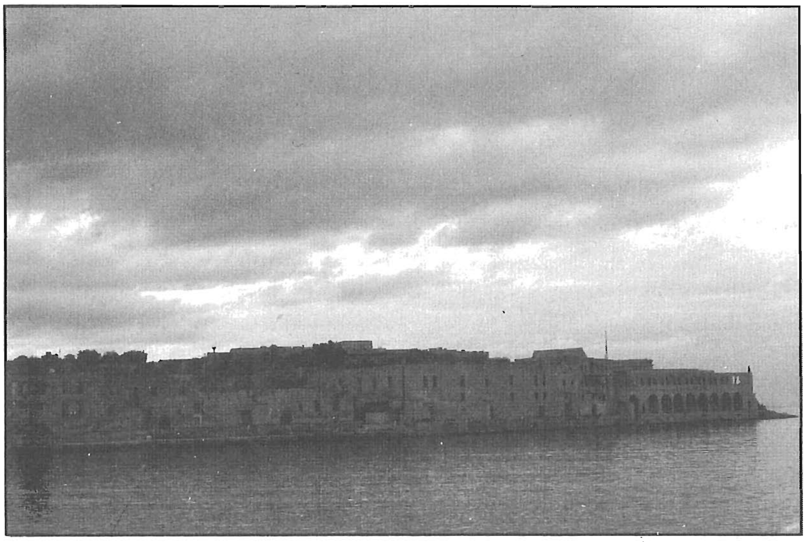

Photo: A. Atauz

Fig. 4. *The second survey area off the Pinto Wharves.*

constituted the major groups of underwater finds in this area. The artifacts were transfered to the National Museum of Archaeology in Malta for further study. However, no shipwrecks were located in the area.

Future Prospects

The Maltese islands, especially the Grand Harbor area, are extremely promising locations for further underwater surveying. For instance, a French (Angevin) fleet was completely destroyed by the Spanish (Aragonese) fleet in 1283 within the Grand Harbour. According to historical sources, there is a possibility that at least two vessels that reflect characteristics of warships of the period could be preserved in the harbor mud. The archival manuscripts studied by Fr. Eugene Teuma record that a number of vessels anchored in the harbor were lost during a 1557 hurricane. The harbor had less than adequate facilities at the time, and the Knights of St. John were completely unprepared for such a disaster. Therefore, they salvaged part of the perishables from the ships and abandoned the vessels as total wrecks.

Another incident registered in the archival material studied by Fr. Eugene Teuma includes information about the wreck of an Ottoman warship flotilla in the harbor. During the Great Siege in 1565, the Ottomans sent a flotilla to attack the fortifications of Isla Point from its unprotected side. However, the fleet was completely destroyed by a hail of fire from hidden gun platforms. Chroniclers tell of swimmers who recovered jewelry and silk clothing from the creek during the months following the incident. The existence of these "boats," each carrying some thirty or forty armed and equipped men, is well documented. Since the recovery of the wrecks—which contain information about Ottoman shipbuilding techniques, weaponry, and artifacts from the time of the Great Siege—was never previously feasible, it is most probable that these vessels are preserved beneath the ubiquitous silt and mud in the harbor.

Most promising is the likely presence of a large vessel in the harbor area, the *Gran Carracca Sant' Anna*. This enormous vessel was built in Nice in 1523 and was of 2333.5 tons capacity. She carried 50 guns, a crew of 300 men and an armory for 500. It is known that she was decommissioned in 1548 but its bakery continued to provide bread for the Order of St. John and the navy until 1751. As Fr. Eugene Teuma brought to our attention, there are representations of a large vessel anchored inside Cottonera creek on the Palace frescoes. The same vessel is marked on a number of sixteenth century Great Siege maps, both from Christian and Turkish sources. It is highly likely that these are representations of *Sant' Anna*. A detailed survey of the area might serve to recover at least part of this important hull.

In addition to the ancient archival information, the presence of at least 30 sunken wrecks of sizable ships (and a number of aircraft) from World War II are recorded and documented in other sources. The 1999 Survey was just the beginning of what we hope will be a long and fruitful association of INA and the Maltese Ministry for the Environment. This island, crossroads of trans-Mediterranean shipping for the past five thousand years or more, offers an unparalleled opportunity to study the developments in shipbuilding technology, seafaring practices, trade, and

Photo: A. Atauz

Fig. 5. *Area 3 concentrated on the vicinity southeast of Fort Manoel.*

naval warfare. The Maltese government hopes to protect its underwater heritage by beginning a comprehensive program of research. It wishes to inform its people and the world at large about its rich submerged cultural resources. Malta has a dedicated group of professional and avocational archaeologists and historians willing to carry out the scientific work of investigating and recording the underwater patrimony. We plan to continue joint INA-Maltese surveys and wreck assessments over the next several years in the Grand Harbor, and throughout the Maltese islands to that end.

Acknowledgements: I would like to thank Reuben Grima (Curator, Archeological Site Management Unit), for his contributions, Fr. Eugene Teuma for providing the background information regarding the possible shipwreck sites in the survey area, and Edmond Cardona and Michael Spiteri, from the National Museum of Archaeology, who also joined the INA team on the survey. Thanks are also in order for the crew of the *Robo* (Cristian Swanson, Andy Wilson and Kevin Milligan), for their contribution to the survey, unending good humor, and being there first in the morning and last home every night. Special thanks to Capt. Cristian Swanson for "driving the boat" into all the difficult spots we wanted to survey, and diving with zest to investigate targets.

The Survey of the Valletta Harbors in Malta originated through the effort of Timothy Gambin, who contacted INA through the U.S. Navy Historical Center. He deserves special mention for the many ways in which he facilitated the survey and sought to make the INA team comfortable in Malta, and indeed in his own home.

Sincere appreciation is extended to Brett Phaneuf, director of the project, for his contributions regarding the technical and scientific aspects of the survey and equipment, as well as logistical support. Lastly, George Robb, Jr., INA Director, for providing both the funds, equipment, and, most importantly, the enthusiasm needed to undertake this and all the other projects with which is involved on behalf of INA. Thank you.

Suggested Reading

D. M. Boswell and B. W. Beeley

1988 *Malta* (World Bibliographical series Volume 64). Oxford.

INA Quarterly Submission Guidelines

The Editor invites all readers of the *INA Quarterly* to consider submitting material for possible publication. Preference will be given to articles closely related to the work of the Institute of Nautical Archaeology or the Nautical Archaeology Program at Texas A&M University. Please remember that the *Quarterly* has both professional and general readers. Neither excessively popular nor highly technical treatments are appropriate for this journal. Articles should comply with the following guidelines, and will be edited to meet style and length requirements.

Authors are required to submit a complete typed manuscript, together with illustrations, well in advance of the publication date. Preliminary drafts should not be submitted, as it may not be possible to incorporate later revisons. Whenever possible, article should also be submitted in electronic form, as a formatted file from a common Macintosh, DOS, or Windows word-processing program on a 3.25 inch diskette or by e-mail attachment to the address on page 2. Disks and original artwork will be returned to the author after publication.

Spelling should conform with the standard American dictionary. Foreign words, ship names, and book titles should be italicized (or underlined, if using a typewriter). Measurements should be metric, when possible. However, items built or recorded in feet and inches may be given in that fashion, with a metric conversion in parentheses following. Drawings, tables, and other graphic means of presenting information are preferable to long lists of measurements in the text.

Footnotes and formal in-text citations should be avoided, except when essential. Any necessary citations should follow the form of the *American Journal of Archaeology*. A suggested reading list of at least three works (including all those quoted in the article) may be included at the end.

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Grapes, Wine, and Olives: Commodities and Other Cargo of the Bozburun Byzantine Shipwreck

L. Dillon Gorham

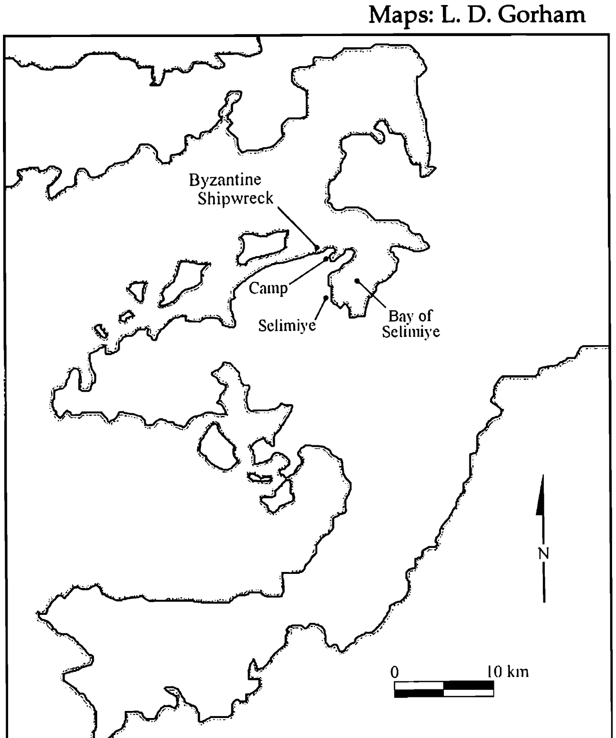
Plant remains provide an exceptional source of evidence about the ninth-century CE Bozburun Byzantine shipwreck. This site was found off the southwest coast of Turkey and excavated by INA from 1995 to 1998 (see *INA Quarterly* 25.2 and fig. 1). The archaeobotanical assemblages identify plant-derived cargoes and provisions, as well as materials used to make ropes. We recovered fruits, seeds, pollen, phytoliths (silica-bodies), and epidermal tissues (fig. 2). Preliminary analyses indicate that these botanical assemblages are significant and valuable for the interpretation of medieval subsistence, trade, and economics in the eastern Mediterranean basin.

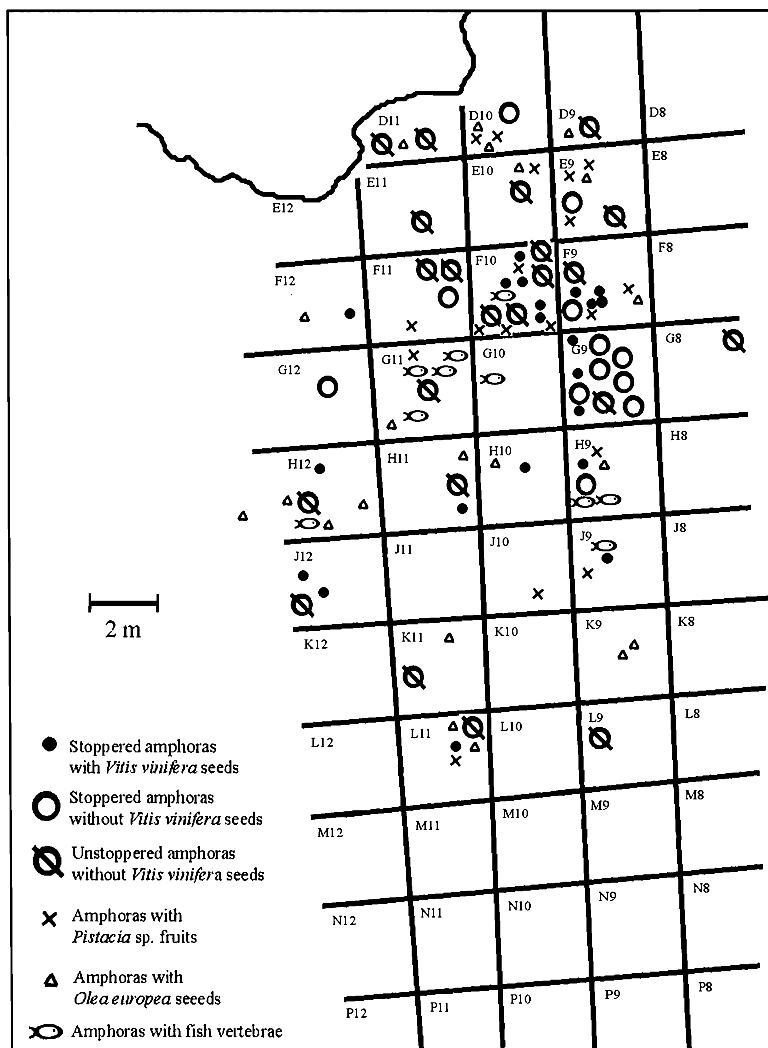
The Byzantine ship was a merchant vessel that carried a primary cargo of over one thousand amphoras. Of these, 970 were sufficiently intact for analysis, and are being studied in detail by Christine Powell (see *INA Quarterly* 25.4, 4–6). Greek graffiti on many of the containers, the style of their manufacture, the location of the site, and dendrochronological analysis of the hull suggest a ninth-century Byzantine context. The majority of amphoras appear to have held wine. Other items of potential archaeobotanical value were recovered, including eight ceramic jugs, nine ceramic pots, two copper jugs, three glass goblets, one oil lamp, fragments of plates and bowls, and rope.

Fig. 1 (below). *The region surrounding the Bozburun Shipwreck.*

Fig. 2 (right). *Distribution of the most common seeds, fruits, and fish vertebrae from the Bozburun wreck.*

Maps: L. D. Gorham





Amphora contents

The amphoras were of four major classes with volumes ranging from eleven to fifteen liters (see *INA Quarterly* 25.4:5, fig. 3). This is similar to the capacities of the small type 2 amphoras from the seventh-century Yassıada shipwreck. Among the 456 whole amphoras at Bozburun with contents, we analyzed 410. Of these, 332 produced seeds or other visible organic material. Sixty intact amphoras were stoppered, twenty-three of which contained seeds. The in situ stoppers themselves included three that were ceramic, but the remaining fifty-seven were cambium, or bark, of Pinaceae family trees. Fortunately, the Bozburun Project recovered at least one stoppered container from each of the four classes. Seeds were present in the majority of amphoras with graffiti. Two stoppered amphoras contained red, pulpy liquid, and several amphoras, both stoppered and unstoppered, contained purple, pulpy, organic sediment (lees). Grape seeds were the most abundant organic contents found. A single stoppered amphora contained 7,585 seeds, while several contained only one grape seed each. Grape seeds occupied 297 of the unstoppered amphoras and were the primary contents of the two stoppered jugs. If the amount of grape seeds in wine is a measure of refinement, the Bozburun cargo of wine was quite diverse. Olives (*Olea* sp. [Tourn.] L.), were the next most frequent seed type, occupying twenty-two amphoras, followed by *Pistacia* sp. L. (*terebinthus* type) fruits, which were present in eighteen amphoras, but always accompanied by grape seeds.

Class 1 amphoras dominated the site, representing 929 of the 970 discrete containers recovered. Of the 302 unstoppered amphoras with organic contents, 298 were of the Class 1 category, as were all but one of the twenty-three stoppered jars that contained seeds. Parallels for the Class 1 amphoras are known from medieval sites in Turkey, Greece, and Italy. Similar ninth- and early tenth-century containers are known from kiln sites in the Crimea (see *INA Quarterly* 23.4: 14–17).

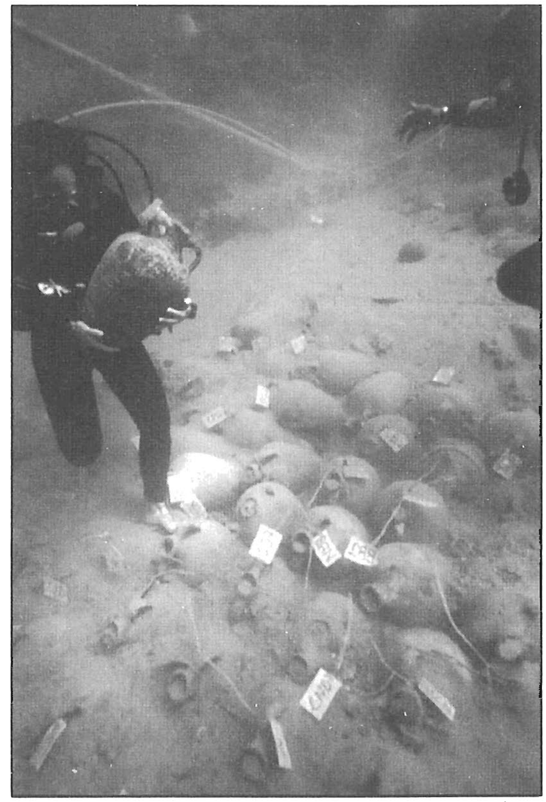


Photo: D. Frey

Fig. 3. *Amphoras stacked in rows, probably as they were in the hold of the ship at Bozburun.*

The majority of Class 1 amphoras did not have graffiti. Unmarked (complete) amphoras comprised 20 of the stoppered and 235 of the unstoppered Class 1 containers with organic contents. Thirteen unmarked amphoras were still stacked in rows, probably as they were in the hold of the ship (fig. 3).

A well-stoppered amphora that contained red, pulpy liquid also contained several grape seeds (*Vitis vinifera* L., fig. 4) and a small, possibly immature, carob or bean fruit (Fabaceae family, fig.5). Pliny, in the first-century CE text *Natural History*, notes that wine was made from carob. Other notable plant remains from unmarked, stoppered containers include four that held only liquid (no apparent sand, etc.), two with grape "skins" in addition to grape seeds, and three with *Pistacia*

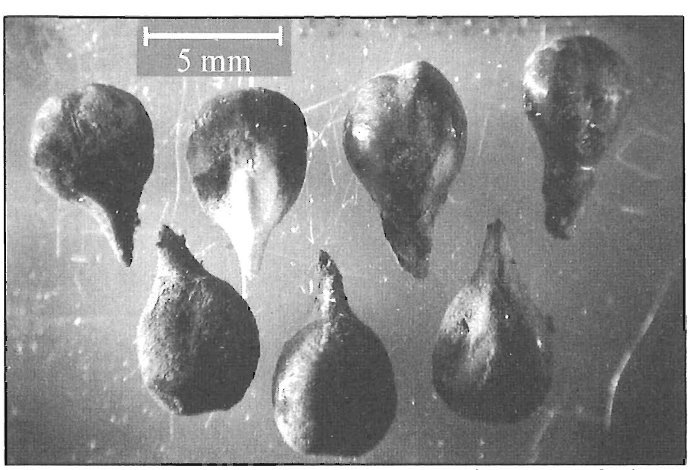


Photo: L. D. Gorham

Fig. 4 (left). Vitis vinifera *seeds.*

Fig. 5 (below). *A Fabaceae fruit from stoppered amphora Lot 9047.*

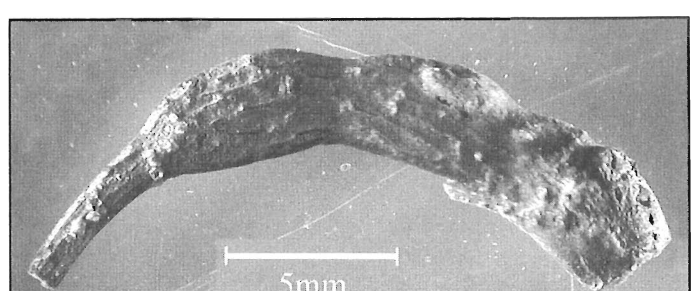


Photo: L. D. Gorham

sp. fruits (L.) accompanying the grape seeds. Pedanios Dioscorides, born in Anazarbus in Cilicia, describes medicinal drugs in the years 60–78 CE. In this work, *De Materia Medica,* he states that *Pistacia* fruits were used to flavor wine. A few unstoppered jars contained olives, grape seeds, and *Pistacia* fruits together in the same container. Comparatively, four amphoras from the seventh-century Yassıada shipwreck also contained both grape and olive seeds.

One unmarked, unstoppered Bozburun amphora contained 917 grape seeds. Another unstoppered container (with a symbol similar to a reversed "K") contained 1,575 olive pits. Still another unstoppered amphora contained fifty-eight *Pistacia* fruits. We recovered all three from the area of the stern. Most unmarked, unstoppered jars, however, contained fewer than ten seeds, usually of grape. Dr. Fred Hocker suggests that the provenience of the amphora with 1,575 olive seeds near the stern may indicate olives as a shipboard ration, while Dr. Cheryl Haldane, citing several medieval documents, suggests that shipboard diets usually excluded olives. A compromise solution may be that olives were consumed on board the Bozburun vessel, but by officers (or passengers) other than the lower-class crew.

Graffiti found on Class 1 amphoras includes Greek letter combinations such as AN, EPIS, GE, LE, LEON, and NIKITAS, and a symbol that resembles a tree. Amphoras marked AN (Anastasius?) and GE (Georgios?) represent the most numerous categories of containers with graffiti, and were the only types that frequently contained seeds. The only stoppered amphora marked AN contained four grape seeds and one *Pistacia* fruit. Twenty unstoppered AN containers had a range of grape seeds from 192 to a single seed, while one contained no seeds. Like some of the unmarked amphoras, nine marked AN were also still stacked in recognizable rows. One stoppered amphora with graffiti type GE contained thirty-five grape seeds. Nine unstoppered GE amphoras contained grape seed quantities ranging from sixty-three to a single seed. An unstoppered GE amphora produced a single almond (*Prunus amygdalus* sp. [Tourn.] L.).

Amphoras marked with LE, LEON, and the "tree" symbol were represented in the seed assemblage by only one jar each, and those contained only grape seeds. An unstoppered amphora marked LE had two seeds, while an unstoppered amphora marked LEON contained 423 grape seeds. The "tree" symbol is known from contemporaneous sites in Greece and the Crimea. An unstoppered container at Bozburun with this symbol contained 195 seeds. Amphoras marked NIKITAS and EPIS did not contain seeds, but an amphora marked EPIF contained 94 grape seeds.

Hocker suggests that the graffiti represent ownership, and, in the case of graffito type AN, possibly even a passenger on board the ship. A similar interpretation of ownership is suggested by Dr. Fred van Doorninck for amphoras found with the seventh-century Yassıada shipwreck, and amphoras of the eleventh-century Serçe Limanı shipwreck, some of which were clearly marked LEON. It is worth noting that Byzantine *commerciarii* and warehouses are known from lead seals to have existed at least until the eighth century. These institutions may have evolved in the ninth century into more privatized organizations that facilitated the purchase of agricultural produce by "middlemen." Peacock and Williams note that graffiti in capital letters on the shoulders of Dressel 20 amphoras name the *navicularius*, or shipper.

Only five containers from the other three classes of amphoras (out of almost one hundred total) are included in the seed assemblage, and these only contained grape seeds. A stoppered Class 2 vessel contained 7,585 grape seeds, which was the highest count from the site. The extremely high quantity of seeds may indicate the former presence of grapes or raisins. According to Pliny, grape "bunches" (technically, "panicles") were stored in jars, grapes were preserved in must, and raisins were soaked in wine. An unstoppered Class 2 amphora held a single grape seed. It may be important that the Class 2 jars have significantly larger mouths than the other classes, which may have allowed the loss of seeds to water currents and other means.

There were only two stoppered Class 3 amphoras, and neither contained seeds. However, we found seventeen grape seeds in an unstoppered Class 3 container. Parallels for Class 3 amphoras are known from Crimean kiln sites and from the southeastern Crimean coast. The only stoppered Class 4 amphora did not contain seeds, but two unstoppered containers held twelve and fifteen grape seeds.

The range of grape seed quantities in unstoppered amphoras is similar to that in stoppered amphoras. The upper range of seed quantities of grape, olive, and *Pistacia* in unstoppered amphoras is well beyond statistical probability for contamination. It is also possible that a "secondary in-situ condition" exists, meaning that intrusive elements, if present, originated from the ship itself, and not from the environment. The amphoras at the Bronze Age Uluburun shipwreck contained many small, inorganic artifacts. Cheryl Haldane explained these as originating from the ship, and entering the amphoras during the shipwreck's disintegration. Additionally, Haldane conducted an experiment in which she left an unstoppered amphora full of seeds on the seafloor for three months. She observed only the loss of a few seeds; no new seeds arrived. The comparative time scale, however, may be problematic. Environmental and biological causes for the loss of amphora contents were probably a factor at Bozburun, but probably only for the upper levels of amphoras, which, for the most part, were not intact. Even if a few seeds were lost in the lower levels of intact amphoras, it is not likely that this would affect our interpretation. Twenty grape seeds as the contents of an amphora are not dramatically different from thirty.

We have also discovered other seeds and fruits at Bozburun. One unstoppered amphora contained a degraded pine cone (*Pinus* sp. [Tourn.] L.), two contained single

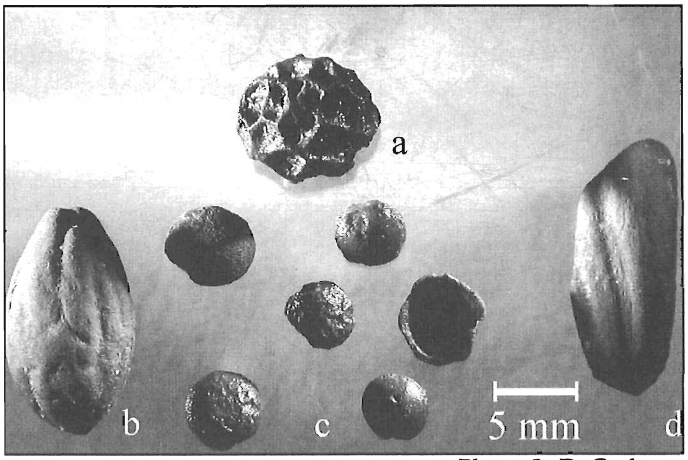


Photo: L. D. Gorham

Fig. 6. *Seed and fruits from amphora Lot 9969. A) cf.* Liquidambar; *B)* Olea europea; *C) Anacardiaceae (cf.* Pistacia terbinthus*); D) unidentified nut shell fragment.*

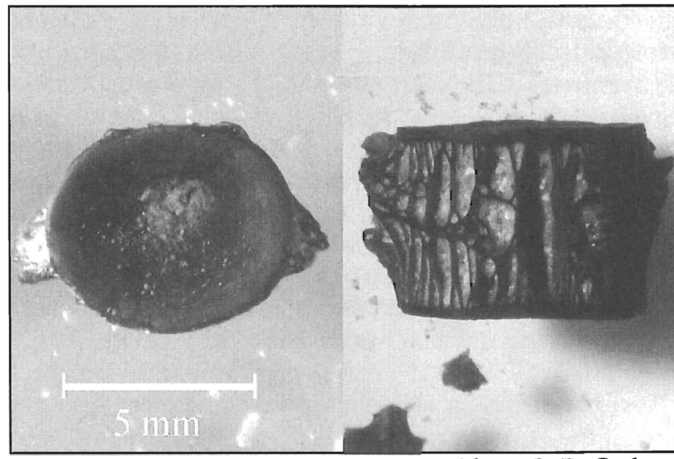


Photo: L. D. Gorham

Fig. 7. *Fish vertebra (two views) from amphora Lot 8319 at Bozburun.*

cypress cones (*Cupressus* sp. Tourn. ex. L.), two contained oak acorn cupules (*Quercus* sp. [Tourn.] L.), one contained a degraded sweet gum fruit (*Liquidambar* sp. L.), and three contained almonds (fig. 6). All except cypress cones were found in the site sediment matrix. However, the items in the amphoras could represent intentional additives. Pliny notes that wine was made from "fir-cones" and parts of cypress trees. Almonds were also added to wine in antiquity. Archaeologists found two almonds in amphoras at the eleventh-century Serçe Limanı shipwreck.

In addition to plant remains, small fish vertebrae were present in two stoppered and eleven unstoppered amphoras, including one with four vertebrae (fig. 7). One of the stoppered containers with fish vertebrae was marked TIMOTHL. Again, these may have been intentional additives. Pliny notes that *allex*, or sediment of garum (fish sauce), was made into a beverage. Casiano Baso's sixth century CE study of ancient Greek agricultural practices, the *Geoponica*, cites a contemporaneous recipe from Bithynia, on the southern coast of the Black Sea. This called for the addition of two parts wine to one part garum. A modern "fish wine" is also produced in Turkey today.

Preliminary analyses suggest that the majority of seeds found inside both the stoppered and unstoppered amphoras represent original contents. Aside from the well-known economic types (grapes, olives, and *Pistacia*), passages from the *Natural History* indicate that plant sources for wine and wine additives include seeds, fruits, flowers, and fibrous tissues of many woody and herbaceous species. However, it is possible that seeds found at Bozburun such as *Althea* sp. [Tourn.] L. (hollyhock, etc.), *Euphorbia* sp. L., *Poterium* sp. L. (thorny burnet), *Rumex* sp. L. (curly doc), *Vitex* sp. Tourn. ex. L. (chaste tree), and a single seed that resembles Aizoaceae *Tetragonia* sp. L. (mesembryanthemum family) are intrusive. Even stoppered containers might suffer accidental inclusion during the functional life of the amphoras, to say nothing of the possibility of post-submergence intrusion.

Thorny burnet seeds were also present in amphoras of the seventh-century Yassıada shipwreck, causing Fred van Doorninck to speculate on the use of this plant as dunnage, as in the Uluburun shipwreck. Thorny burnet may have been used in this manner at Bozburun, but there were no large, caches found among the amphoras. Other seeds suspected to be intrusive include *Vitex* (also known as the chaste tree). This was familiar to the Greeks and Romans for its medicinal uses, as a source for yellow dye, and as a drug to (supposedly) subdue sexual appetites.

One of the well-sealed amphoras containing red, pulpy liquid, like all the amphoras with purple, organic sediment, contained high quantities of *Vitis* (grape) pollen. This is not surprising, but it is significant, because grapes are insect-pollinated plants, therefore not producing large amounts of pollen. *Vitis* pollen is rarely found in environmental assemblages; when it is present, the quantities are extremely low. When *Vitis* pollen occurs in quantity, it indicates a concentration of grapes or grapevine derivatives. The deposition of *Vitis* pollen can be from the process of making wine from grapes alone, but Pliny also mentions wine manufactured by the addition of two pounds of wild vine flowers to a jar of must.

Several amphoras contained large quantities of pollen from plants other than grape. Pollen of the Cupressaceae family was abundant in two well-stoppered amphoras. This is unusual, due to the fragile, thin-walled nature of these pollen grains, which usually results in poor preservation at best. It is possible that this pollen type preserved well due to the protected, and formerly acidic, environment that promotes pollen preservation. Pollen of this size and shape (with a lack of ornamentation on the surface of the grain) represents trees that include cypress and juniper (*Juniperus* sp. Tourn. ex. L.). The abundance of this pollen probably indicates the addition of flowers or other parts of these plants to wine; three unstoppered amphoras each contained a cypress cone. Pliny notes that wine was made with cedar, cypress, and juniper shrubs, and from the flowers of other herbaceous plants. One stoppered amphora also contained a large quantity of cultivated grass pollen (*cerealia*), which may represent an additive as well.

However, it is also possible that all these pollen inclusions merely represent exposure of the wine to open air during the flowering season of Cupressaceae trees, common in the eastern Mediterranean and Black Sea regions. If the presence of this particular pollen type represents "background" vegetation and exceptional preservation, then it may not be accurate to assume intentional inclusion. Without knowing the preservation rate, we cannot compare these relative abundances to assemblages that represent environmental records in antiquity.

In addition to plant and fish remains, the majority of stoppered amphoras also contained small amounts (less than 100 ml) of sand, clay, and pulverized shell fragments that entered through spaces between the stopper and the amphora mouth. However, the two well-stoppered amphoras contained only liquid, grape seeds, and purple, organic sediment. The unstoppered jars held their seeds within a matrix of sand and clay that at times completely filled the containers.

Several unstoppered amphoras contained stratified sediments composed of gray layers of clay covering a purple organic layer in the bottom of the amphora. Pollen from the clay layer was typical of the site sediment matrix, while the purple organic sediment was dominated by grape pollen. This provides evidence of wine in these containers.

Some of the intact, unstoppered amphoras were observed to be dwellings for octopi, and were probably homes to many other marine animals, right up to the time when the amphoras were removed from the site. The "octopus amphoras" contained many crab and other shell fragments, and sediment with a distinct texture and odor. Crabs are the favorite food of the octopus. We analyzed sediments from two amphoras in this condition. The pollen from these amphoras was mostly from *Poterium* and *Quercus*, but the concentration values were too low to be considered accurate. Likewise, no seeds were found in amphoras that contained large amounts of crab shell fragments. Therefore, we avoided pollen analysis of sediments from the other amphoras with large quantities of shell fragments.

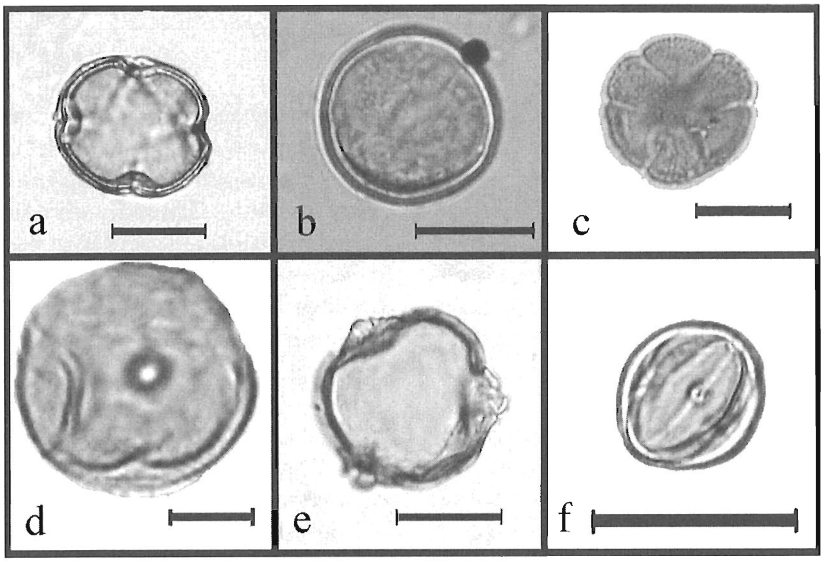


Photo: L. D. Gorham

Fig.8. *Pollen from Bozburun. A)* Ceratonia; *b) Cupressaceae; c)*Mentha; *d) Poaceae; e)* Poterium; *f)* Vitis. *Scale bars all equal 20* μ.

Jug contents

Two of the eight intact jugs were still stoppered. One jug contained 2,680 grape seeds, five whole grapes, and two *Pistacia* fruits (*terebinthus* type), while the second contained 3,362 grape seeds and fifteen whole grapes. The jugs were found near the stern, and are suspected to be part of the ship's rations, as were jugs of similar volume found in the same relative locations on the seventh-century Yassıada shipwreck. Pollen assemblages from the two stoppered jugs included *Vitis* and Lamiaceae (mint) (fig. 8). The amount of mint family pollen (compared to the local environment) suggests that spices were added to the contents of the jugs. Medieval Arabic authors mention the use of syrups made from raisins and other fruit. The Sassanid Persians used "sweet-sour" sauces and fruit juices as marinades for meat. Pliny's *Natural History* mentions wine made with wild mint, so the use of mint in condiments is a possibility for Bozburun.

Pitch

A large amalgamation of pitch, probably spilled from a container, was recovered from the hull. The copious *Poterium* pollen in the Bozburun pitch sample suggests that some part of the thorny burnet shrub, such as the papery fruits, may have been a principal component of the pitch found at Bozburun. We can make the same argument for the abundance of non-cultivated grass pollen present in the pitch, though the evidence is not as strong. Other pollen present included types not found in other archaeological samples, such as beech (*Fagus* sp. L.) and walnut (*Juglans* sp. L.). The environmental pollen assemblage in

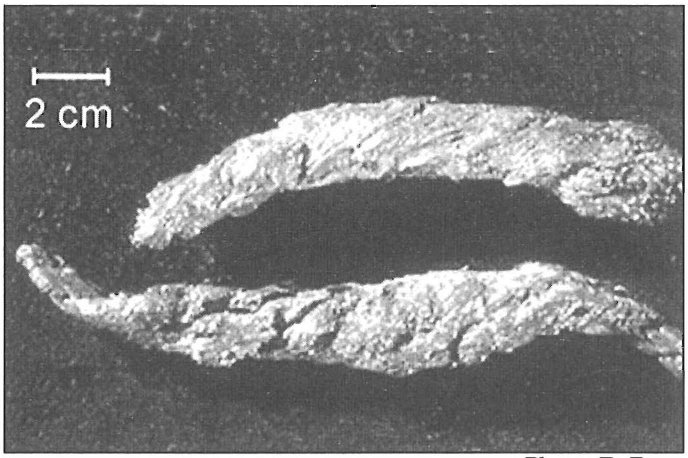


Photo: D. Frey

Fig. 9. *Rope fragments preserved underwater for over 1,100 years.*

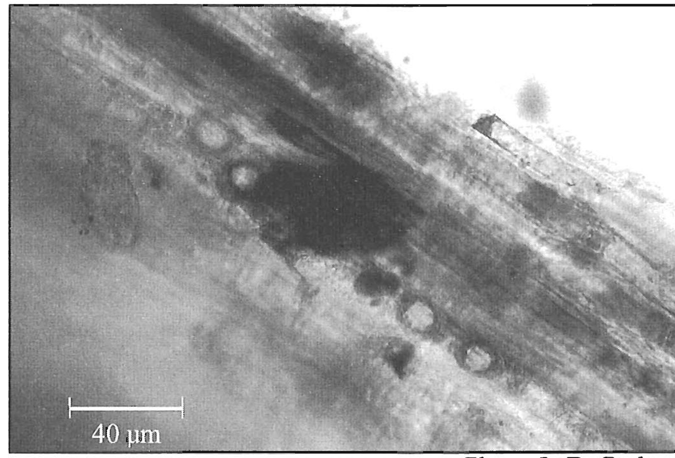


Photo: L. D. Gorham

Fig. 10. *A diagonal row of spherical phytoliths in the botanical tissue of rope.*

the pitch may indicate a particular geographic region, as was the case with resin from some Roman containers. The natural properties of pitch make it a good pollen "trap" that protects the grains from environmental degradation, and isolates pollen trapped in the pitch's liquid state from subsequent contamination. In the laboratory, we reduced a fifty-cubic-centimeter piece of pitch to twenty cubic centimeters by removing the outer layers, ensuring that the "core" had no surfaces in contact with the site sediments or seawater.

Pitch was also present on the inside rims of the mouths of many amphoras, and was the sealing agent for those that remained stoppered. In a few cases, we found pitch at the bottom of an amphora, but this appeared only to have dripped down when a stopper was sealed.

Other artifacts and environmental samples

Sediments from the remaining artifacts revealed patterns that were similar to the modern pollen assemblages for the site sediment matrix and for the region. These include high percentages of pine and thorny burnet, both common on the rocky cliffs surrounding the inlet. The abundance of thorny burnet and pine in one stoppered amphora illustrates the variations in "stoppered" states. In this case, the amphora was poorly stoppered. This allowed a dominance of environmental types, judging from the similar abundance of pine pollen and others in the site sediment matrix.

The sediments suspected to be bilge mud had similar texture and color to the site sediment matrix, together with its abundance of pine pollen. This indicates that the mud is probably post-depositional, and not composed of sediments that accumulated in the bilge during the functional life of the vessel.

In the absence of bilge mud and caulking, containers were the only source of environmental pollen assemblages that might be contemporaneous with the functional life of the ship. The only containers that do not possess pollen assemblages similar to the site sediment matrix are the well-stoppered amphoras. These contain assemblages that mostly reflect their contents, rather than a typical environmental "signature." Seven stoppered amphoras contain pine, oak, and thorny burnet, and six of these also contain olive. The two that contain *Ceratonia* sp. L. (carob) do not contain Chenopodiaceae/*Amaranthus* sp. L (goosefoot). Presently it is not clear whether these assemblages are useful for the identification of regional vegetation. However, the overall species composition does not conflict with modern or ancient local assemblages up to 3,200 years old.

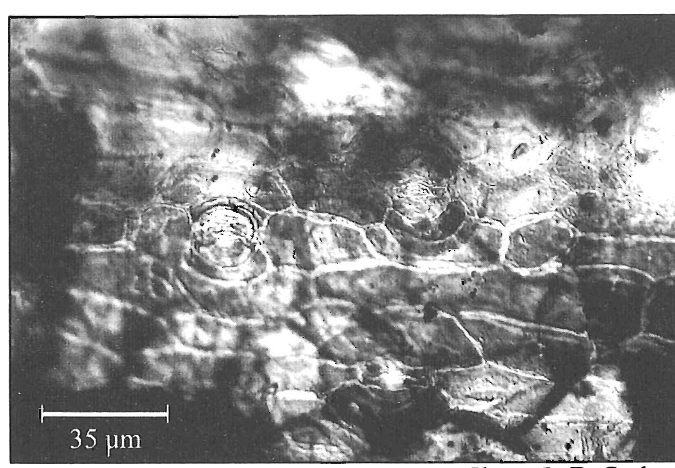


Photo: L. D. Gorham

Fig. 11. *Plant epidermal tissue from the rope.*

We collected three comparative, environmental sediment samples for pollen analysis. A modern environmental sample composed of approximately 20 "pinches" of sediment was collected from points along the roadside in Selimiye, the nearest town to the archaeological site. We took clay and sand samples directly from stratified layers of the site sediment matrix. Oak dominated the terrestrial sample versus Pine in the underwater sediments. This may reflect the modern (and ancient) dominance of pine trees on the slopes opposite the bay of Selimiye, and on a small peninsula on the Selimiye side of the inlet, versus the presence of oak in the town itself. The stratified layers of sediment on the site are significant for the environmental pollen assemblages they contain, and suggest that the regional vegetation has not changed significantly in the last eleven centuries.

Rope

The rope from Bozburun (fig. 9) is derived from genera of the palm family (Arecaceae), known for its use in ancient rope making). Hourani, in *Arab Seafaring*, states that rope was made from the coconut palm (*Cocos* sp. L.) in the Medieval period in the Maldives and Laccadives (modern Lakshadweep) in the south Arabian Sea and north Indian Ocean. The Bozburun rope appears to be of the sub-family Chamaedorea (fig. 10 and 11). Some taxonomists include the coconut palm in this sub-family, some do not.

Conclusion

The archaeobotanical assemblages reflect the function of the cargo ship found at Bozburun. The variation of graffiti that probably represent ownership of the amphoras, combined with the sheer quantity of items, suggests that this assemblage represents a commercial venture, interspersed with onboard rations of olives, grapes, and condiments. The Bozburun ship and cargo fit nicely into the predicted framework of long-distance exchange, and exemplify several aspects of trade. These include the relative abundance of amphoras compared to other ceramics onboard during a commercial trip. Amphoras are indirect indicators of economies driven by agriculture, since their organic contents are the real commodity. I plan more extensive analyses of the variation that exists in the quantities and types of seeds, pollen, and other archaeobotanical components. I will compare frequencies both among and between groups of amphoras defined by such variables as the presence or absence of graffiti, graffiti types, style of manufacture, and spatial analyses of the cargo in the ship. This may reveal more subtle aspects of viticulture and maritime commerce in the Byzantine Empire.

Acknowledgments: I would like to thank the following individuals and organizations: Fred Hocker (Director, Bozburun excavations), Oğuz Alpözen, George Bass, Amy Borgens, Vaughn M. Bryant, Jr., Gül Dölen, Esra Altınanıt-Göksu, Claudia Gorham, Matthew Harpster, John G. Jones, Xila Matthews, Arlene Miller-Rosen, Troy Nowak, Asaf Oron, Harun Özdas, Christine Powell, C. Wayne Smith, Phillip Sweeny, Ken Tretheway, Mina Weinstein-Evron, the Smothers Foundation, and the board, staff, and members of the Institute of Nautical Archaeology.

Suggested Readings

Baso, Casiano
1998 *Geopónica o Extractos de Agricultura de Casiano Baso*, Translated by M. J. Meana, J. I. Cubero, and P. Sáez. Madrid: Ministerio de Agricultura, Pesca y Alimentación, monografías inia núm. 100.

Bryant, V. M. Jr., Murray, R. E., Jr.
1982 "Preliminary analysis of amphora contents." In G. F. Bass and F. H. van Doornick, Jr. (eds.), *Yassı Ada: A Seventh Century Byzantine Shipwreck, Volume I.* Appendix E: 327-331. College Station: Texas A&M University Press.

Haldane, C.
1991 "Recovery and Analysis of Plant Remains from Some Mediterranean Shipwreck Sites." In J. M. Renfrew (ed.), *New Light on Early Farming: Recent developments in palaeoethnobotany*, 213-223. Edinburgh: Edinburgh University Press.

Hourani, G. F.,
1995 Arab Seafaring in the Indian Ocean in Ancient and Early Medieval Times. Revised and expanded by J. Carswell. Princeton: Princeton University Press.

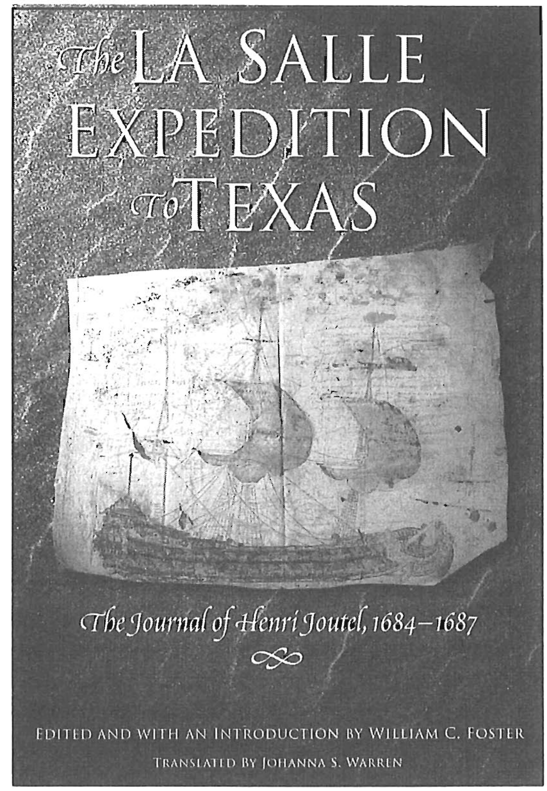
Pliny
1952 *Natural History*, Translated by H. Rackham. Cambridge: Harvard University Press.

Review

by Mark A. Feulner

The La Salle Expedition to Texas: The Journal of Henri Joutel, 1684-1687
Edited by William C. Foster and translated by Johanna S. Warren

Austin, TX: Texas State Historical Association, 1998
ISBN: 0-87611-165-7, 350 + x pages, 7 illustrations, 15 maps, index, notes, hard cover.



An important event in the history of a nation need not be a great success. In truth, what can be learned from even the most unsuccessful venture can be of enormous value and great interest. The doomed attempt by the Sieur de La Salle to establish a settlement at the mouth of the Mississippi River is just such an event. The story of this fated expedition is dramatic and interesting, but the journal of La Salle's associate Henri Joutel offers much more than an exciting tale. It provides a depiction of social customs during the late seventeenth century and of how Europeans functioned in the New World. The journal documents the hard work and difficulties faced by settlers during the colonization of North America. Perhaps most significantly, it details the environment of the early Texas coastal region by vividly describing the flora, fauna and native peoples of the area. These aspects of Joutel's story are greatly enhanced by William Foster's contributions to the book as editor.

Foster begins this work with an extensive introduction which sets the stage for Joutel's story. It provides a thorough biography of the main character–La Salle–and explains what brought him to the Gulf of Mexico. However, Foster takes his introduction even further: He presents a comprehensive description of the natural history of Texas and its ecology. He discusses the political climate in which the expedition took place, as France vied with Spain to establish itself in the New World. Foster also examines the geographical questions presented by this manuscript, and reviews the ethnographic contribution made by Joutel in documenting the native populations he encountered on the central Texas coast and along the middle Mississippi River.

Following the introduction, the book launches into Joutel's account. Beginning with the expedition's departure from France, the narrative follows its journey to North America and the establishment of Fort Saint Louis on the Texas coast. Joutel chronicles the daily life at the settlement and the troubles the colonists experienced with the local native population. He also provides a justification for his actions and decisions during La Salle's absence from the fort. The story then follows the fateful journey to the Mississippi, during which La Salle and several others were assassinated, and closes with Joutel and a few companions headed for Canada on that river.

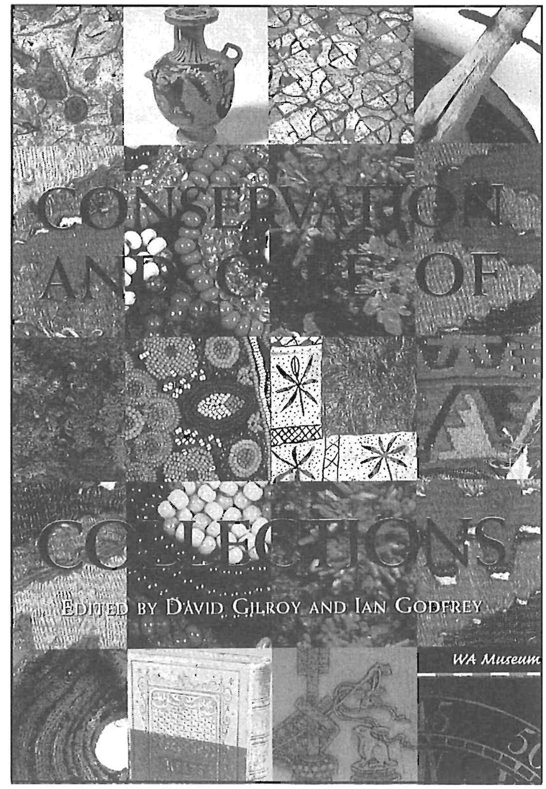
Throughout his narrative, Joutel appears to strive to maintain objectivity, even in the face of his obvious loyalties to La Salle. His dedication to keeping an accurate journal can be seen in the detail in which he describes the people, places and other things encountered on his journey, as well as the significant events. Joutel addresses the other accounts that were offered by his companions, using them to describe occurrences that he did not witness and explaining any discrepancies encountered.

Foster keeps pace with Joutel's narration with extensive footnotes. These notes help bring the story into focus by linking what Joutel writes to the observation of other explorers and to what is known today (whether it involves the local vegetation or the customs of a particular tribe of natives). Throughout the text, Foster points to particular passages supporting his ideas concerning geographical locations, while examining the opposing arguments. He also addresses other translations and accounts, justifying his editorial choices and divergence from these other texts. The book is further enhanced by Foster's selection of maps and illustrations. Foster provides several informative appendices, one of which includes the interrogation of one of the settlers captured by the Spaniards, as well as a daily travel itinerary and a comprehensive list of native tribes encountered by the expedition.

Henri Joutel provides a captivating story augmented by Foster's contribution. The two provide an engrossing account, the dramatic adventure of a French settler and the dutiful documentation of a Texas that no longer exists. Such a narrative is equally valuable to the historian, the anthropologist, and the layman.

Review

by Christine Powell



Conservation and Care of Collections
Edited by David Gilroy and Ian Godfrey

Western Australian Museum, 1998
ISBN: 0–7307–1215–X, 181 + viii pages, 82 color and 10 b/w plates, 17 drawings, references, bibliography, 9appendices, glossary, index, soft-cover.

The conservation and care of artifacts is a very specialized field but one that is continually expanding. As with many such areas of study, continued research provides new and innovative techniques for conservators. However, good, clear, and concise books that span the wide range of conservation problems are rare. This makes *A Practical Guide to the Conservation and Care of Collections* a real find. This valuable reference work is not for the full-time conservator alone, but also for those responsible for movable collections held in small museums, historical societies, and private collections. It will also inform students and the general public.

The format is well designed to be clear and easy to follow. This allows the reader to quickly find the information needed without reading the whole section on a given substance or treatment. The authors take great care to concentrate on the material of the item rather than on the item itself. The idea is to give a broad understanding to the treatment of a substance, rather than of an individual artifact. However, the book does not ignore specific artifacts. The final section on case studies shows hands-on methods for conserving a variety of specific items and aims to provide a guide to treatments.

The first chapter, "Preventative Conservation," may be the most valuable to those responsible for existing collections. It presents ways to avert damage and anticipate problems before they arise. It discusses light, humidity and temperature, biological pests, pollutants, dust, storage and display, handling, and packing in depth. Chapter two discusses mold and insect attack in collections. This gives detailed information on detecting problems, treatments and preventative measures, and monitoring collections afterwards. General artifact treatments and ethics are covered in chapter three. The discussion of when to conserve or restore provides excellent guidelines for those new to curation.

Each subsequent chapter deals with a single set of related items grouped by material. Included is an introduction that comprises a brief history of the item being discussed, general and specific information on the component, and details of how to identify processes and techniques to use on that particular material. Processes at work on the artifact are discussed in the deterioration section, while solutions to the agents of decay and the subsequent storage of artifacts are tackled in the preventative conservation and treatments sections. The summary gives a brief but adequate checklist to guide the would-be conservator. The authors subdivide several types of materials for the ease of the reader. They discuss metals, for example, generally and then individually. Each chapter in the book provides a bibliography of readings geared specifically to the material discussed in that chapter. These aids to further research are themselves a most valuable part of the work.

Nautical archaeologists will probably turn directly to the penultimate chapter of *A Practical Guide to the Conservation and Care of Collections*, which is devoted to wet materials. They might be disappointed. The chapter provides only limited information about the details of treating materials recovered from marine, freshwater, or saturated sites. However, the treatment of waterlogged artifacts is such a specialized field of conservation that a detailed discussion would require a volume of its own. The chapter does offer the most critical information for a field archaeologist, namely how to recover, protect, and transport wet materials until they can be treated by a trained conservator. Providing a "cookbook" of detailed treatments in a work like this might tempt amateurs to risk destroying valuable artifacts by attempting conservation treatments beyond their level of skill and experience.

Excellent photographs clearly illustrate important points discussed in each chapter, while simple but effective line drawings quantify different aspects of the materials. Tables aid the reader in rapidly absorbing technical details that can become tedious when incorporated in the main body of the text.

The editors provide the reader with several warnings. They are quick to point out that this is only a guide and that the reader should exercise caution before undertaking specific treatments. This is not the definitive work on the conservation and care of artifacts, but it is an excellent start. All collectors (whether of memorabilia or significant works of art), museums, conservators, and students should have this reference in their library as a stepping stone to further knowledge.