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Article: From Book to Breechblock: A Preliminary Study of the Conservation of Waterlogged Paper Fragments from Site 31CR314, *Queen Anne's Revenge/La Concorde*

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## From Book to Breechblock: A Preliminary Study of the Conservation of Waterlogged Paper Fragments from Site 31CR314, *Queen Anne's Revenge/La Concorde*

### INTRODUCTION

North Carolina archaeological site 31CR314 was discovered in 1996 by salvage firm Intersal Incorporated, which was operating under a permit from the North Carolina Office of State Archaeology (OSA) to search for shipwrecks in the vicinity of Beaufort Inlet. During a magnetometer survey, a large debris field with heavy concentrations of iron was located. Since the wreckage lies within state waters, the management of the remains falls under the jurisdiction of OSA in accordance with state law (NC General Statutes Chapter 121, Article 3). Staff of OSA's Underwater Archaeology Branch examined the wreckage and dug exploratory excavation units to determine the extent of the debris field, the size of the ship, and a relative date based on artifact finds. This evidence coupled with historical research firmly established the identity of the shipwreck as that of *Queen Anne's Revenge* (QAR), the lost flagship of Blackbeard the pirate, which ran aground in June 1718.

Prior to its brief stint as a pirate ship, QAR had a much longer history as the French slave trade vessel called *La Concorde*. Over the course of three transatlantic slaving voyages from 1713 to 1717, *La Concorde* transported 1265 captive Africans from West African ports to the Caribbean to be sold into slavery. Blackbeard attacked and seized the vessel in November 1717 near Martinique at the end of the Middle Passage on its third slaving voyage. After renaming the ship, the pirate, with at least 300 men under his command and a purported 40 guns aboard his flagship, ransacked other vessels in the Caribbean before sailing north toward the mid-Atlantic. The ship eventually struck a sandbar outside the small town of Beaufort, North Carolina, and was abandoned to its fate.

In the three centuries since the vessel's loss, much of the organic matter constituting the ship proper has degraded due to the natural environment in the inlet. Warm water, dredging

activity, climate change, strong currents, large storm events, and the teredo nautilus, also known as the ship worm, have all contributed to the almost total loss of the hull structure, leaving behind a wreck mound comprising several hundred thousand individual artifacts that were once on board. Metals are the most abundant surviving material type, with the overwhelming majority being related to arms and ammunition, including lead shot, grenades, and cannon and their associated projectiles.

OSA established the QAR Conservation Laboratory (QAR Lab) in 2003 in partnership with East Carolina University in Greenville, North Carolina. The QAR Lab is tasked with conserving this unique collection while also conducting academic research and providing opportunities for student training and faculty collaboration. In recent years, the QAR Lab staff has developed outreach initiatives, such as lab tours, a project blog, classroom show-and-tells, virtual events, and public lectures, to broaden the project's reach. Following conservation, artifacts are transferred to the North Carolina Maritime Museum in Beaufort as the official repository. More than 400,000 artifacts have been raised from the wreck, with more than 112,000 objects having completed conservation and transferred for exhibit and curation.

### QAR1445.000

The 29 cast iron cannon from the site are muzzle-loaders, meaning that the powder charge and projectile must be loaded from the front. Two wrought iron breechblocks, or reusable gunpowder chambers intended for use with breech-loaders, were found among a cluster of other objects relating to ammunition and may indicate the placement of a munitions locker (fig. 1). Breech-loading cannon are loaded from the rear and have a slot to accept the breechblock; no breech-loaders have been found on the wreck to date.

After x-raying it to assess its condition, conservation of the first breechblock (QAR1445.000) began with mechanical removal of the enveloping encrustation, typical of iron

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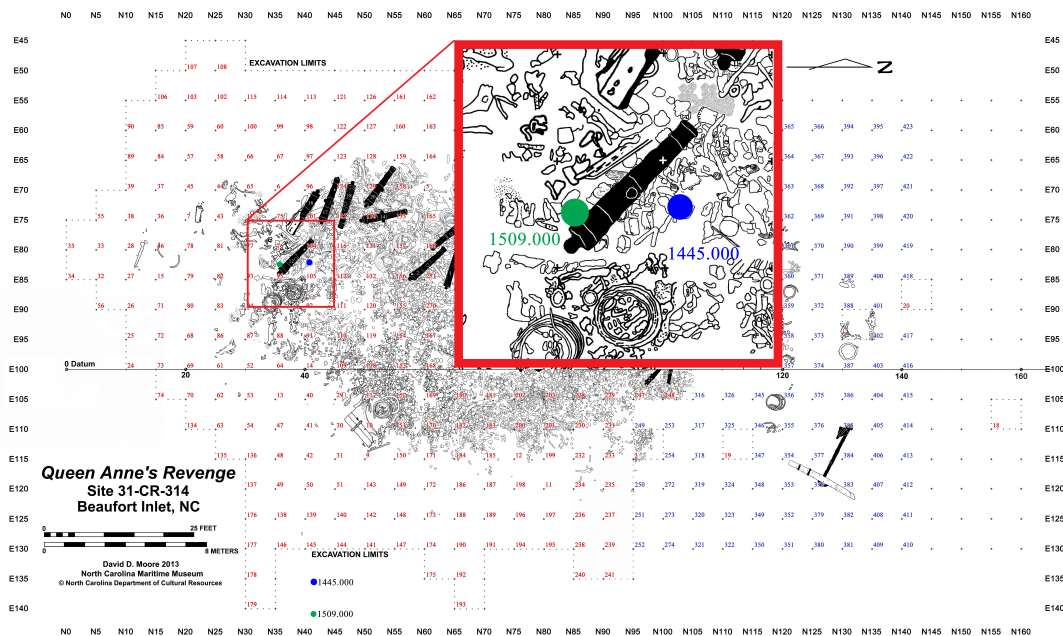


Fig. 1. Map of archaeological site 31CR314, showing location of two brechblocks. Courtesy of NC Department of Natural and Cultural Resources.

recovered from a marine environment. Once the underlying metal was exposed, further investigation revealed that the chamber was still sealed with a well-preserved wooden plug, or tampion. Despite the otherwise poor survival of organics from the site, excellent organic preservation is often seen within iron concretions, thanks to iron corrosion products effectively impregnating nearby fabric, bone, rope, leather, and, in this case, wood, and working to preserve them.

The sealed chamber indicated that the brechblock was still loaded with gunpowder and ready for use at the time of grounding. When the tampion was extracted, roughly woven fabric resembling canvas sailcloth was discovered acting as a gasket to further protect the chamber from water ingress, which would have ruined the gunpowder (fig. 2). The textile then began desalination to prepare it for impregnation and controlled drying. No attempt was made to flatten or unfold



Fig. 2. Cleaned brech block (left) and textile gasket as discovered in mouth (right). Courtesy of NC Department of Natural and Cultural Resources.



Fig. 3. Printed paper while still wet. Courtesy of NC Department of Natural and Cultural Resources.

the textile, due to its fragility and retention of the shape of the chamber's mouth. After several months of desalination to remove harmful salts, a secondary material appeared in the water bath alongside the textile. Mild agitation of this extremely delicate mass of fibers revealed fragmentary text, signifying the discovery of printed material. Investigative microscopy confirmed the identity as paper (fig. 3).

Paper in any archaeological context is exceedingly rare, since most burial environments with moisture, acidity, and bacterial activity are not conducive to its survival. Archaeological paper from submerged sites, however, is almost wholly undocumented with very few exceptions, and no sufficiently detailed conservation reports could be located. Pages from a German bible were uncovered on a mid-17th-century shipwreck off the coast of Florida in 1964 (Harnett 1965), but present-day conservators at Florida's Bureau of Archaeological Research had no knowledge of their current disposition or previous treatment. A Dutch book on etiquette was found on the wreck of *Curaçao* (1729) in 1972. This was sent to the British Museum for treatment by Dr. Alfred Emil Anthony Werner, whose partial notes on their treatment were published (Sténuit 1977). Despite these sparse leads on the conservation of waterlogged paper, training as an archaeological conservator did not include discussions of paper; thus, it was deemed critical to speak with paper conservators for guidance on its proper treatment.

#### EMERGENCY CONSERVATION MEASURES

OSA conservators sought advice from several paper conservators, including Pam Young of Colonial Williamsburg and Lawrence Houston from East Carolina University's Joyner Library. The consensus was that water is the most damaging factor, and contrary to everything archaeological conservators who specialize in waterlogged materials are taught, the fragments must be dried immediately. Staff worked quickly to carefully examine and photograph the fragments, separate successive pages while still wet, and dry them.

Sixteen individual fragments were noted and given their own unique identification numbers (QAR1445.013–1445.028) for ease of reference during treatment (fig. 4). Each was placed between pierced Tyvek sheets, with absorbent Kimwipes applied to the exterior surfaces of the Tyvek. The packages remained in ambient temperature (25°C) and humidity (ca. 50%RH) although shielded from light while drying. The Kimwipes were changed the following day, and the packages were placed within a low-density polyethylene box with silica gel buffered to 50%RH to complete drying.

Once dry, they were photographed again under normal lighting to document any changes. Additional photography was attempted using UV and transmitted light, with varying results. Although generally too iron-impregnated to elucidate



Fig. 4. Sixteen individual paper fragments. Courtesy of NC Department of Natural and Cultural Resources.

further information using either technique, two fragments (QAR1445.013 and QAR1445.019) under transmitted light revealed distinct lines indicative of laid paper.

#### PARTNERSHIP

The OSA and the State Archives are both part of the North Carolina Department of Natural and Cultural Resources—separate divisions but sister institutions. In June 2016, State Archives conservator Emily Rainwater was invited to the QAR Lab to examine the paper fragments, which were still in their Tyvek sandwiches, and to provide guidance on their care and treatment. The two divisions decided to collaborate on the project, joining conservation knowledge, equipment, and resources to stabilize, analyze, and work on a plan for their long-term preservation.

It was decided that the paper fragments would come to the State Archives, where they could be better assessed. This also presented the opportunity to temporarily store the fragments in one of the State Archives' two microfilm security vaults where the average environmental reading is 13°C with 35%RH, and they are alarmed if conditions stray too far outside of those parameters. The project team was concerned that the orange staining may be iron corrosion from being in contact with the breech chamber for 300 years and that it would progressively worsen without strict environmental controls, namely a low relative humidity environment. The fragments were first carefully separated from the Tyvek and placed on mat board. The fragments did adhere to the Tyvek, depositing fiber samples for further analysis. A temporary housing was constructed for the fragments that would help cushion them during the drive from the QAR Lab in Greenville to the State Archives in Raleigh, North Carolina, 80 miles to the west.

#### DOCUMENTATION AND CONDITION ASSESSMENT

When first viewing the fragments under a microscope, it is apparent that this paper is very different from other contemporaneous paper samples. The fragments are incredibly soft and fuzzy, which is not very surprising after their eight-month bath as part of the routine desalination procedure. Any time the fragments are handled or moved, fibers become detached. The paper itself is stained black and orange, and some areas appear very thick and crusty. When viewed through transmitted light, only two showed any kind of transparency; the rest were black and dark.

The first step in this project was to document the fragments as much as possible. With the help of State Archives' photographer Mathew Waehner, micro-photographs of all 16 fragments were taken. These initial photos provided a baseline for the corrosion and could be referenced later to check for changes in appearance. A printed copy of each photograph was marked and annotated during the microscopic examination for the condition reports, noting areas of discoloration, unusual fibers, grains of sand, and, on several of the fragments, tiny gold-colored flakes.

About nine months later, a second set of micro-photographs was taken. These were again designed to capture the condition of the corrosion at that moment in time, and also provided the opportunity to take images of all of the fragments under UV light and in transmitted light. Although most of the fragments appear opaque in transmitted light, the images were still helpful, as they show how thin some areas of the paper support actually are due to loss of fibers. Fragment QAR1445.016 looks fairly complete in ambient light, but in transmitted light it is apparent that the top two pieces on the right and left sides are incredibly thin and almost detached (fig. 5).



Fig. 5. QAR1445.016 in ambient, UV, and transmitted illumination. Courtesy of NC Department of Natural and Cultural Resources.

As part of the efforts to document, research, and create a plan for these fragments, the project team reached out to the Winterthur/University of Delaware Program in Art Conservation (WUDPAC) for advice. Dr. Melissa Tedone and Dr. Jocelyn Alcántara-García spoke with the project team first over the phone and then arranged a visit to North Carolina to view the fragments in person and get a better sense of their unique characteristics. The team discussed their concerns about the stability of the iron corrosion, the possibility that the golden flecks were evidence of iron pyrite that can lead to pyrite decay, and the risk/benefit of various treatment options.

In July 2017, the project team was able to bring a few selected fragments to WUDPAC for analytical testing and fiber analysis. Fortunately, the ED-XRF analysis did not show an overlap of iron and sulfur. Iron sulfide would have indicated the presence of pyrite and furthered concerns about pyrite decay.

The project team worked with other external partners to image and holistically document the fragments with a primary goal of bringing out as much text as possible to help identify the volume from which the fragments came. Dr. Erich Uffelmann of Washington and Lee University brought a portable multispectral imaging (MSI) device, as well as two different IR cameras, to the State Archives in November 2016. In March 2018, the fragments were taken to Duke University Libraries, which had recently purchased their own multispectral imaging system. The Duke MSI team was able to take images of the fragments at a much higher resolution than Dr. Uffelmann's portable setup, and they provided some interesting manipulations of the image stack in their report.

#### TEXT IDENTIFICATION

The visible printed lettering on each fragment was transcribed while wet during the initial salvage and then again following drying, in case of loss. In addition to legible text, italicization and capitalization were noted, as well as cases where print was visible but not legible, distinguished with question marks or possible iterations. Most fragments only held singular or partial characters or were entirely devoid of print. Three fragments (QAR1445.016, QAR1445.019, and QAR1445.021), however, included the distinct words "South," "(f)athom," and "Hilo," which would be beneficial in determining a source.

A directional term (South) coupled with a depth reference (fathom) suggested the source text was a navigational treatise, an important type of document in a time where years-long sea voyages were critical in expanding European interests. The search began with identifying English-language voyage narratives printed prior to 1718, a *terminus ante quem* established by the loss of the vessel. Armed with "Hilo" as a unique search term, this helped narrow the possibilities. Since it was italicized, capitalized, and the Spanish-language

word for "thread," Hilo was thought to refer to a place along the Spanish holdings in the Caribbean or Central or South America. The modern-day city of Ilo, Peru, was a good candidate and focused research to a specific location.

When no satisfactory results were forthcoming, assistance was sought from codicologist Dr. Johanna Green at the University of Glasgow. Dr. Green provided advice on relevant databases such as Early English Books Online and Eighteenth Century Collections Online, and in her own searches discovered a possible connection to the writings of William Dampier, prolific seafarer, pilot, naturalist, and geographer.

Although none of Dampier's works matched the QAR fragments, his travels to the South Pacific in the late 17th and early 18th centuries led to the discovery of many other published accounts of those same voyages written by his fellow crewmen. The village of Ilo, Peru, was ransacked by English buccaneers led by Bartholomew Sharpe in 1680, the tale of which was published by several crew members on that voyage and retold in the accounts of later expeditions to the area. The spelling of Ilo varied between authors (Ilo, Hilo, Ely, Ylo, Heloe, and He lo he), which further aided in eliminating sources.

After a year of research, the "Hilo" fragment (QAR1445.021) was found to match lines 17 through 21 on page 178 of the first edition of Captain Edward Cooke's *A Voyage to the South Sea and Round the World* published in 1712 (fig. 6). Cooke was the second captain of the ship *Dutchess* on a privateering voyage led by Woodes Rogers that departed Bristol in 1708. Once the "Hilo" fragment was placed, several other fragments could be matched with text on pages 183 through 188, from the same central location on each page, suggesting that the pages were ripped directly from the bound book before being used secondarily in an artillery context.

The significance of this discovery is multifaceted. The use of printed paper as ammunition is unparalleled in the archaeological record, and the presence of books on board ships, although not uncommon according to historical research, may speak further to the prevalence of literacy among sailing crews. Additionally, Woodes Rogers, leader of the 1708 voyage described by Cooke, arrived in the Bahamas in 1718 as the new royal governor. Rogers was dispatched to eliminate the rampant piracy gripping the colony, and historians have speculated that Rogers's arrival may have directly sparked Blackbeard's departure. Although it is highly unlikely that a motive will ever be established for the use of pages from this specific book as ammunition, a possible link between an infamous pirate, a pirate hunter, and the series of events leading to the book's use in this context has inspired much lively discussion and theorizing.

#### TREATMENT

The project team completed a risk assessment with various treatment options including no treatment, a consolidation

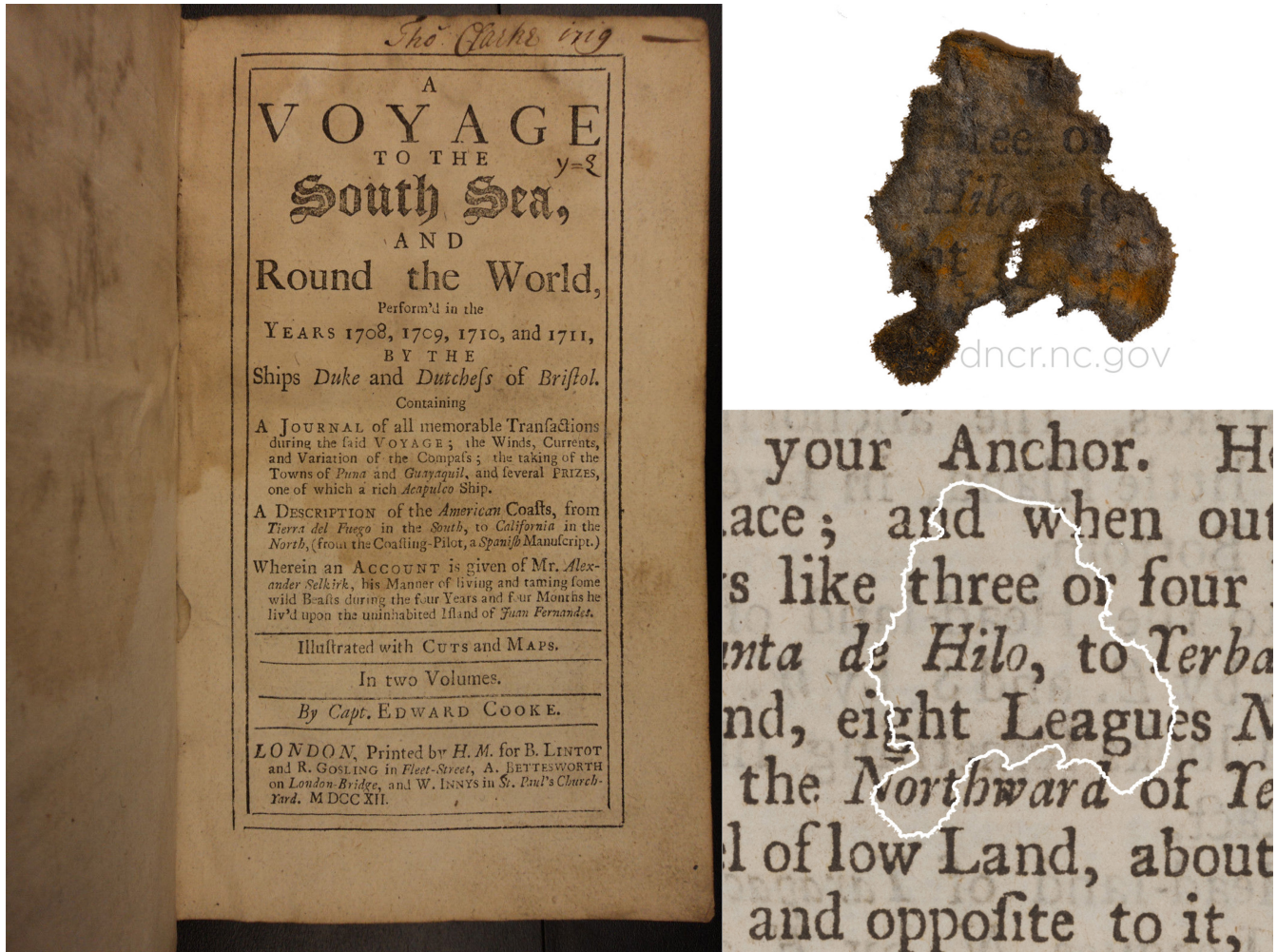


Fig. 6. Title page of *A Voyage to the South Sea and Round the World* (left) and the “Hilo” fragment with corresponding text on page 178. Courtesy of NC Department of Natural and Cultural Resources.

and/or sizing treatment, an aqueous treatment, and an aqueous complexing treatment. Although subjecting the fragments to any further aqueous treatment had already been ruled out, the project team wanted to document both the possibility and the reasoning against it. After further consultations with colleagues, it was decided to carry out a consolidation treatment with Klucel-G in ethanol on two of the fragments. Prior to the treatment, a set of color-calibrated images in a standardized setup was completed to provide as accurate and reproducible of an image as possible. QAR1445.014 was chosen because it was one of the smaller fragments without text that still had a good color variance; QAR1445.022 was chosen because of the heavy particulate layer, the slightly larger size, and the appearance of printing ink in one area that has not been tied to a known location in the text.

Before treatment, the fragment was first gently prodded with a paper point to assess current vulnerabilities. A 1% solution of Klucel-G in ethanol was applied with a 000

brush underneath the microscope (fig. 7). After drying, the fragment was again gently prodded with the paper point to assess friability and determine if a second coat of Klucel-G was needed. After-treatment images of both fragments were taken immediately (figs. 8, 9); after six months, the efficacy of the consolidation treatment will be assessed and another set of calibrated images will be taken to look for color shift. The project team can then decide if additional fragments will be consolidated in the same manner.

#### CONCLUSION

In January 2018, the QAR team announced the discovery of the fragments at the Society for Historical Archaeology conference, and the official department press release was published. The story got picked up by news outlets all over the world, and QAR conservators did multiple interviews. Once the news spread, staff spoke with several other conservators





Fig. 7. Applying a 1% solution of Klucel-G in ethanol to QAR1445.022. Courtesy of NC Department of Natural and Cultural Resources.



Fig. 8. QAR1445.014 after treatment. Courtesy of NC Department of Natural and Cultural Resources.



Fig. 9. QAR1445.022 after treatment. Courtesy of NC Department of Natural and Cultural Resources.

seeking advice on waterlogged paper, both within the United States and abroad. The discovery has also been published in the *North Carolina Historical Review* (Farrell et al. 2018) and presented at the Nautical Archaeology Society annual conference in the UK.

Since the initial paper discovery, remnants of paper cartridges have been recovered from 7 of the 12 cannon that have been fully cleaned and unloaded. This is clearly a different grade of paper, thicker and coarser. One cannon (QAR636.000) produced an extremely well preserved cartridge, representing about one-third of the original circumference. It retained the cylindrical shape of the chamber, as well as the thread used to sew the cartridge closed. Much like breechblock QAR1445.010, this cannon (C15) was well sealed with a tightly fitted wooden tampion, creating a protected environment that prevented extensive degradation of the organics within. Unloading and conservation of the second breechblock (QAR1509.010) produced neither textile gasket nor further paper.

With an established drying methodology in place, upon recovery, paper is now rinsed fully of gunpowder residue,

sandwiched between spun polyester and blotter paper, and placed in a desiccator buffered to 50%RH. The blotter paper is changed as soon as it is sodden. Most of these fragments are flat, but in the case of the cylindrical cartridge, a high-density polyethylene form covered in blotter paper was used to retain its original shape and provide support.

This project has proven to be a successful case study on collaboration across various subfields of conservation. The highest priority was always what was best for the paper, which led to building a qualified team of experts to achieve that goal. Collaborating with analytical scientists and paper specialists culminated in a firm strategy to progress the treatment of this unique find.

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