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Balchin's *Victory*: Bronze Cannon Conservation Report

Frederick Van de Walle
Director of Conservation, Odyssey Marine Exploration, Tampa, USA

In 2008 Odyssey Marine Exploration recovered two bronze cannon from the shipwreck of Admiral Sir John Balchin's *Victory* in the Western English Channel in cooperation with the UK Ministry of Defence. A conservation program was subsequently initiated within Portsmouth Naval Base before both guns were formally handed over to the MOD in March 2010 after concluding a transaction with Odyssey, which gave the MOD possession of the artifacts. Conservation is currently continuing at the Mary Rose Trust under MOD management.

This report outlines the conservation strategy developed by Odyssey Marine Exploration and also details the theory that was recommended to be put into practice to complete the conservation. This theory is also relevant to any future recovery of cannon from the wreck of Balchin's *Victory*.

1. Introduction

In April 2008 Odyssey Marine Exploration examined an interesting target in the western English Channel using side-scan sonar and a magnetometer as part of its ongoing Atlas Shipwreck Survey Project. Subsequent visual investigation using the Remotely-Operated Vehicle (ROV) Zeus, complemented in September and October by an ROV pre-disturbance survey, identified a substantial concentration of wreckage covering an area of 61 x 22m comprised of disarticulated wooden planking, iron ballast, two anchors, a copper kettle, rigging, two probable gunner's wheels and, most diagnostically, 41 bronze cannon (Figs. 17-18).

Two of these guns were recovered in October 2008 (Cunningham Dobson and Kingsley, 2010: 248, 261, 262). An examination of the site and its material culture in relation to a desk-based assessment led to the conclusion that Odyssey had discovered the long-lost wreck of Admiral Sir John Balchin's First Rate Royal Navy warship, HMS *Victory*, lost in the Channel on 5 October 1744. Elaborate royal arms of King George I and George II, as well as the founder's dates of 1726 on the recovered 42-pounder cannon and 1734 on the 12-pounder, place the wreck precisely within the timeframe of HMS *Victory*'s construction and operation.

The dimensions of the recovered cannon are:

- Cannon C33 (42-pounder): L. 3.4m and muzzle and trunnion diam. 17.8cm (7in). Decorated with the royal arms of King George I and inscribed with the founder's name SCHALCH and the date of 1726. Elaborate dolphins (Figs. 4-5, 10-12, 14-16).
- Cannon C28 (12-pounder): L. 3.12m and muzzle and trunnion diam. 11.5cm (4.5in). Decorated with the royal arms of King George II and inscribed with the founder's name SCHALCH and the date of 1734. Elaborate dolphins (Figs. 6-9, 13).

2. Pre-Treatment Conditions

Following recovery from the seabed the cannon were kept submerged in fresh water on the research ship the *Odyssey Explorer* and during relocation to a conservation facility in Portsmouth Naval Base, where they were immersed in stainless steel tanks supported on wooden blocks to prevent scratching and movement (Fig. 1). The bores were flushed with a water hose to remove loose sand and debris.

The two cannon are both in a similar state of preservation (Figs. 4-16). They have not undergone severe degradation in terms of corrosion processes and physical damage. Both are intact, with only small pieces of bronze fractured away from the surface. Upon recovery, little marine growth was observed on the cannons' surfaces. Cuprous chloride (CuCl) and cuprous sulphide (Cu_2S) are usually the prevalent corrosion products identifiable on bronze immersed in a marine environment. Smaller amounts of cupric

Fig. 1. The 12-pounder bronze cannon C28 undergoing conservation in its tank at Portsmouth Naval Base in 2009.

chloride, $CuCl_2$, cuprous oxide, Cu_2O, malachite, $Cu_2(OH)_2CO_3$, and azurite, $Cu_3(OH)_2(CO_3)_2$, are likely to be found (Gettens, 1964: 550-57).

The first stage in the electrochemical corrosion of copper alloys is the production of cuprous ions. These, in turn, combine with chloride in the seawater to form cuprous chloride as a major component of the corrosion layer on the surfaces. Cuprous chlorides are highly unstable mineral compounds that will continue to corrode chemically when exposed to air. In the presence of moisture and oxygen, cuprous chlorides are hydrolyzed to form hydrochloric acid and basic cupric chloride (Oddy and Hughes, 1970: 188). The hydrochloric acid, in turn, will attack the metal to form more cuprous chloride. This process is commonly referred to as 'bronze disease'.

3. Conservation Treatment Theory

Desalination is the process whereby soluble salts are removed from a find, typically through repeated immersion in distilled or deionized water. Certain salts, such as some chlorides, nitrates, and sulphates, are easily soluble in water and can be absorbed into porous materials. Desalination is necessary when finds derive from environments known to have a high level of soluble salts, such as marine contexts, privies, areas of brackish water and certain terrestrial sites.

Even when soluble salt contamination is obvious, complementary treatment may be required if the soluble salt crusts hold a fractured object together, support vulnerable pigment or otherwise create unstable conditions. In such cases other forms of conservation treatments may be necessary before desalination can be carried out. For metals that require desalination, it may be necessary to use chemical baths other than water, since water itself can stimulate rapid corrosion.

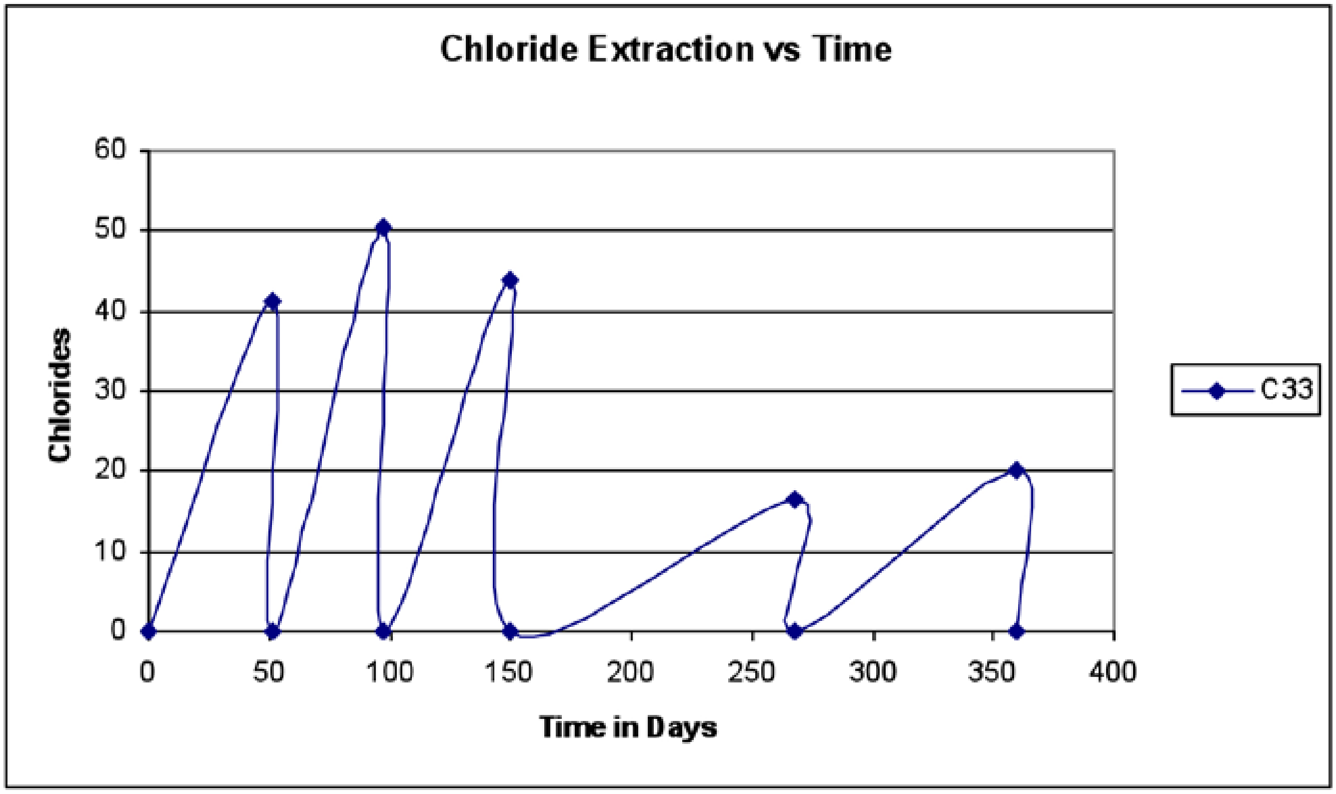
If desalination is carried out poorly or incompletely the treatment can cause damage; the surface can crack and the patina can change color. Additionally, in cases where the salt content is very high, osmotic pressure caused by the differences in salt content between the find and the desalination bath can damage the find unless steps are taken to reduce these differences.

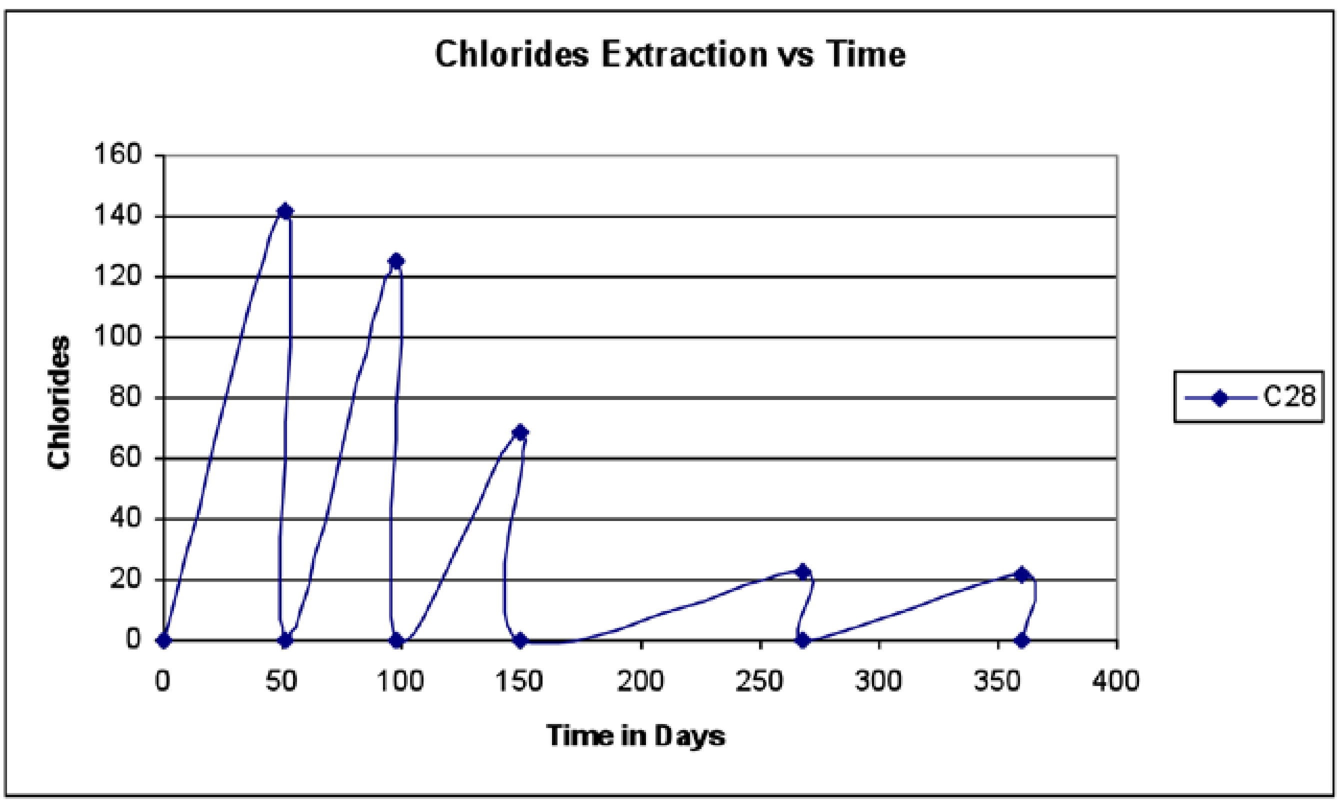
There are three different chemical treatments available that were appropriate for considering stabilizing the two cannon recovered from the *Victory*, while leaving the corrosion layers intact:

- Treatment with sodium sesquicarbonate
- Treatment with sodium carbonate
- Treatment with benzotriazole

Sodium sesquicarbonate treatment was chosen to treat the two guns from *Victory* because it has the desirable result of not removing the green patina on the surface of the cannon and is most suitable for treatment of marine copper alloys. Treatment with benzotrialzole is appropriate as a stage to follow the sodium sesquicarbonate treatment. The cuprous chloride components of copper and its alloys are insoluble and cannot be removed by washing in water alone. When bronzes or other copper alloys are placed in a 5% solution of sodium sesquicarbonate, the hydroxyl ions of the alkaline solution react chemically with the insoluble cuprous chlorides to form cuprous oxide and neutralize any hydrochloric acid by-product formed by hydrolysis to produce soluble sodium chlorides (Organ, 1963: 100; Oddy and Hughes, 1970; Plenderleith and Werner, 1971: 252-53).

These chlorides are removed each time the chemical solution is changed. Successive rinsing continues until all the chlorides are removed. The object is then rinsed in several baths of de-ionized water until the pH of the last immersion is neutral. For the initial immersion, the sodium sesquicarbonate is mixed with tap water. De-ionized water is used for subsequent immersions. If the chloride contamination is extensive, baths prepared with tap water can be used until the chloride level in the solution approximates the chloride level of standard tap water. De-ionized water is then substituted. This procedure is very economical when processing





Tables 1-2. The speed of chloride extraction versus time in days recorded for Victory's *two recovered cannon.*

Fig. 2. Odyssey's chief conservator Fred van de Walle recording levels of chloride ion extraction within sodium sesquicarbonate solution using a Fisher Scientific Accumet XL50 meter.

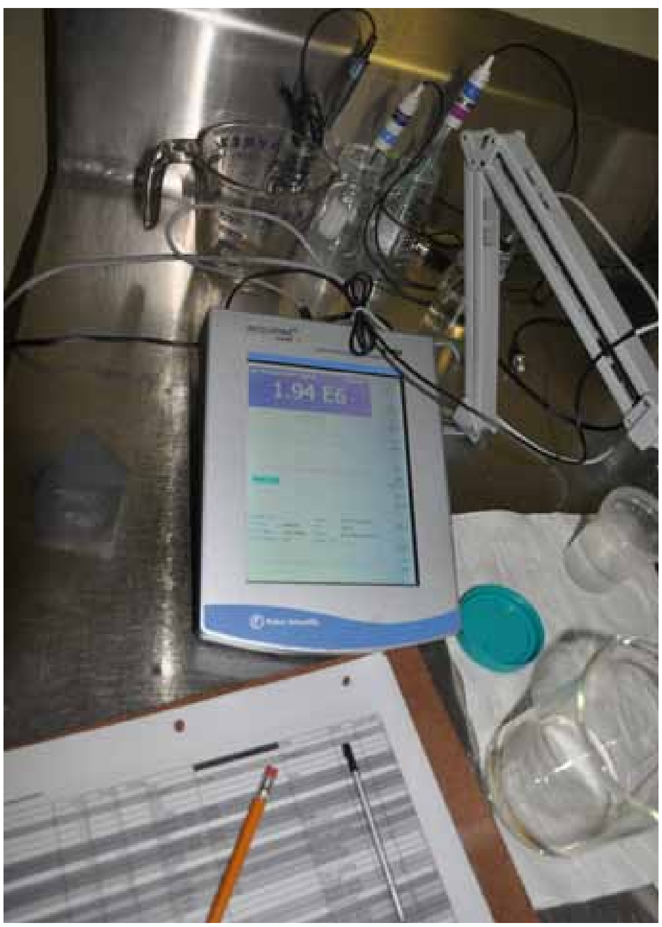


Fig. 3. Detail of the Fisher Scientific Accumet XL50 meter used to record levels of chloride ion extraction within the sodium sesquicarbonate solution covering the cannon from Balchin's Victory *undergoing conservation.*

objects that require months (or perhaps years) of treatment, such as the two cannon recovered from HMS *Victory*.

Immediately upon recovery from the wreck, both of the *Victory*'s cannon were stored in stainless steel tanks holding tap water (Fig. 1). After arrival at the secure storage facility in the Royal Naval Base in Portsmouth, the cannon were submerged in a 5% solution of sodium sesquicarbonate in tap water. The amount of chlorides extracted from the solution has been measured approximately every 10 weeks by analyzing solution samples (Figs. 2-3, Tables 1-2).

4. Analysis

Salt levels in desalination baths need to be measured to assess the progression of the desalination process and to determine the end point. The removal of the chloride ions from the *Victory*'s cannon can be said to be the principle goal of the stabilization treatment. Chloride ion extraction from the sodium sesquicarbonate solution was monitored using a Fisher Scientific Accumet XL50 meter with an ion specific electrode, which is able to measure amounts of chloride in a sample by electrolytical means, and its accuracy is trusted to be ±5ppm within the range of 10-400ppm (Figs. 2-3).

Tables 1-2 show the speed of chloride (Cl^-) extraction versus time (in days) recorded so far for the *Victory*'s recovered cannon. These measurements demonstrate that chlorides are being extracted as rapidly as would be expected using this treatment. After one year of treatment in sodium sesquicarbonate, the chloride levels had dropped from the initial measurements of 41.2 ppm to 20.2 ppm and 142 ppm to 21.6 ppm. When no more chlorides are being extracted by the chemical treatment, the desalination process will be complete. At the current rate from when Odyssey Marine Exploration began the conservation of *Victory*'s cannon, the likely completion date for the desalinization process would be within a total period of 24 months from the very start of the treatment.

5. Odyssey's Conservation Strategy

Under Odyssey's management the two cannon were documented, measured and desalinated in sodium sesquicarbonate in tap water. The following steps were also recommended for the cannon's continued conservation and preservation after they were turned over to the MOD and placed in their care. These phases are also applicable to any future recovery and conservation of *Victory*'s extensive cannon collection.

Fig. 4. Detail of the relatively non-encrusted royal arms Of King George I on 42-pounder cannon C33.

Fig. 5. Detail of the crown on the royal arms of King George I on 42-pounder cannon C33.

Fig. 6. Detail of the concreted crown on the royal arms of King George II on 12-pounder cannon C28.

Figs. 7-8. Detail of the fleur de lis, lions and harp within the quadrants on the royal arms of King George II on 12-pounder cannon C28. Note the extensive concretion.

Encrustations, corrosion products and debris should be removed mechanically from the cannon to reveal the preserved surface of the metal and the inside of the bore. A cleavage line between the original metallic surface and the encrustation was formed on the seabed, which makes identification of the Georgian surfaces and the removal of post-depositional concretion fairly easy.

In modern conservation practice, superficial encrustation is often deliberately left adhering to the surface of the artifact due to its fragility or to avoid damaging its surface. Careful mechanical cleaning and rinsing in water may be all that is required to remove this remaining superficial encrustation. Encrustation can also be removed by soaking the object in 5-10% citric acid with 1-4% thiourea added

Figs. 9-10. Dolphin handles from 12-pounder cannon C28 (top) and 42-pounder C33 (bottom). Note the far greater concretion on the former gun.

as an inhibitor to prevent metal etching (North, 1987: 233; Pearson, 1974: 301; Plenderleith and Torraca, 1968: 246). If applied, citric acid should be used cautiously because it can dissolve cupric and cuprous compounds within the artifact. In this process cannon are completely submerged in the solution of citric acid until the encrustation is removed. If this acid treatment is considered to be too severe, the cannon can be soaked in a 5-15% solution of sodium hexametaphosphate (Plenderleith and Werner, 1971: 255) to convert the insoluble calcium and magnesium salts in the encrustation to soluble salts, which subsequently can be washed away.

Tap water should be used until the chloride level in the solution approximates the chloride level of standard tap water. De-ionized water should then substituted. The same procedure with a solution of 5% sodium sesquicarbonate is repeated until the chloride levels are sufficiently low.

When desalination is complete, the cannon should be put through a series of hot rinses in de-ionized water until the pH of the last rinse bath is neutral. Because copper tarnishes in water (Pearson, 1974: 302), Odyssey planned to wash the cannon in several baths of denatured ethanol. If a water rinse is used, any tarnish could be removed with 5% formic acid or by polishing the area with a wet paste of sodium bicarbonate.

A benzotriazole (BTA) treatment should follow the chemical treatment to create a barrier between the remaining cuprous chloride and moisture in the atmosphere. The benzotriazole forms an insoluble, complex compound with cupric ions (Madsen, 1967; Plenderleith and Werner, 1971: 254). The precipitation of this insoluble complex over the cuprous chloride forms a barrier against any moisture that could activate the cuprous chloride and cause bronze disease. A solution of 1-3% BTA dissolved in ethanol or water is recommended. After the cannon are removed from the solution, they should be wiped off with a rag saturated in ethanol to remove excess BTA. If any fresh

Fig. 11. Detail of the tail of one of the dolphin handles from 42-pounder C33.

Fig. 12. Detail of the button of 42-pounder C33.

Figs. 13-14. Detail of the muzzles of 12-pounder cannon C28 (left) and 42-pounder C33 (right). Note the eroded upper surface of C28 and the dense concretion on the interior of its lower mouth.

Fig. 15. Early Georgian-era damage to the mouth of 42-pounder C33.

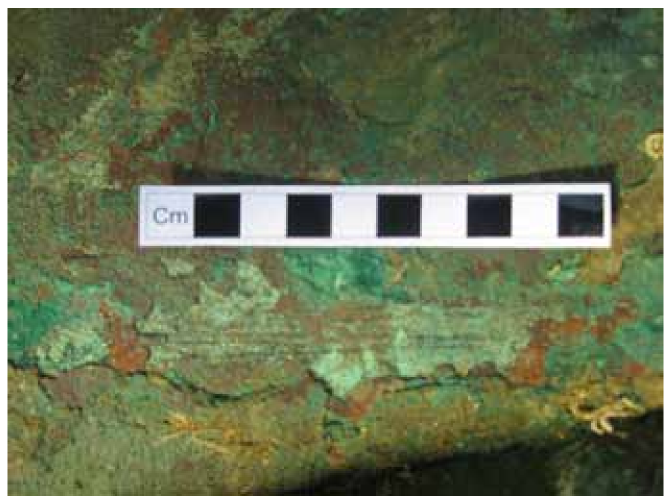


Fig. 16. Delaminated bronze on the surface of 42-pounder C33.

corrosion appears, the process would need to be repeated until no adverse reaction occurs (Green, 1975; Hamilton, 1976; Merk, 1981; Sease, 1978; Walker, 1979). Following BTA treatment, the cannon can be polished to any degree desired and then should be dehydrated in acetone or a water-miscible alcohol and coated with clear acrylic lacquer or microcrystalline wax.

Assuming that the two cannon from HMS *Victory* are destined for exhibition, an optimum storage area would need to include controls for temperature, relative humidity, pollutants, pests and other degradative factors. In particular, rapid and extreme changes in humidity and temperature will cause cycles of shrinkage and expansion of the cannon and remaining salts. These can cause significant damage and encourage degradation. It is therefore important that the storage system be able to maintain stable temperature and relative humidity levels, and that when fluctuations do occur they are slow and gradual.

Silica gel is the most commonly used desiccant in storage and display cases because it is efficient and relatively inexpensive. This is an amorphous silica crystal capable of absorbing and holding large quantities of atmospheric moisture when properly prepared and used. It can maintain a very low relative humidity (ie. less than 20% RH), as long as the gel is used in the correct proportions, monitored and regenerated periodically. There are two forms of silica gel: non-indicating gel, which is clear, and indicating gel, which is colored and experiences a color change as it becomes saturated. The indicating silica gel can be used to quickly and easily monitor the relative humidity in the storage environment, as the color change is clearly visible. Indicating gel is usually significantly more expensive than non-indicating gel, so a cost-effective approach is to mix one part indicating gel with three parts non-indicating gel.

6. Conclusion

The extremely long time required for washing finds in sodium carbonate and sodium sesquicarbonate treatments often discourages their use, but the process provides very satisfactory results and does not prevent other treatments, like electrolysis, from being carried out in the future. The sodium sesquicarbonate treatment is also used because, unlike other cleaning treatments, it does not remove the green patina on the surface of cupreous objects. This means that the end result should be cannon retaining their original surface color, as opposed to over-polished surfaces, which are common in many ordnance collections. Regardless of preliminary treatments, an application of BTA should be an inherent step in the conservation of all cupreous metal artifacts.

Following 12 months of conservation, the *Victory*'s cannon were formally handed over to the UK Ministry of Defence and were relocated to the Mary Rose Trust for ongoing treatment. This article details Odyssey Marine Exploration's conservation strategy – completed and planned, and in no way anticipates the preferences adopted by the Mary Rose Trust. The above practice and theory is intended to be applicable to any future recovery of bronze cannon from the wreck of Balchin's *Victory*.

Figs. 17-18. Some of the cannon on the wreck of Balchin's Victory *are almost completely devoid of concretion (top), whilst others are densely concreted.*

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