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Characterising cast iron cannonballs from the *Mary Rose*

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In July 1545, the Tudor warship the *Mary Rose* sunk of the coast of Portsmouth, taking with her a snapshot of life during the reign of King Henry VIII. Buried beneath layers of silt, the supply of O_2 was limited, which allowed the ship and its contents to survive in seawater for over 400 years. [1] When the ship was raised in 1982, a large collection of 1,248 iron shot was excavated alongside the wreckage. Presenting some of the earliest examples of mass produced cast iron in Britain, [2] each shot was manufactured using a similar method and cast into the same spherical shape, at a range of diameters. Dating to shortly after the introduction of the blast furnace to England, [3] this set of shot provides a unique insight into an experimental phase of a technology that would go on to fuel the industrial revolution. This work aims to asses the metallurgical and chemical composition of the shot and its associated corrosion products, to determine the variation in iron composition across the sample set. In this poster, the preliminary results of the project are presented, along with a methodological framework for the ongoing investigation of the shot.

Iron Shot

1,932 shot were excavated from the *Mary Rose*, made of stone, lead, iron and composite shot, in addition to casting moulds. Of this, **1,248 cast iron shot** were recovered from the ship, with sizes ranging from 20 to 200 mm diameter. Many of these are now severely corroded.

Fig. 1 Corroded iron shot at the Mary Rose Trust. Photo credit: John Merkel

Analytical Methods

The shot and corrosion products will be studied by Scanning Electron Microscopy coupled to Energy Dispersive Spectroscopy (SEM-EDS) and powder X-ray Diffraction (XRD).

- *SEM-EDS Analysis*

Fig. 2 shows the analysis of a wrought iron archaeological bar from a marine environment. Cut samples were mounted in epoxy resin, ground flat with SiC paper (grade 200-4000), polished with diamond paste (3 and 1µm) and coated in carbon. Analyses were performed with a **Hitachi S-3400N** or **Phillips XL30 ESEM** electron microscope visualised in backscatter electron mode, at an accelerating voltage of 20 kV.

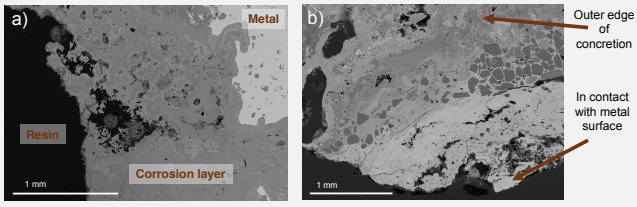


Fig. 2 Layers of corrosion observed by SEM from a marine archaeological (bloomery) iron bar a) sample cut from metal bar and b) sample from the concretion layer surrounding the artefact

- *Powder XRD Analysis*

To identify corrosion products, XRD will be performed with a **Rigaku MiniFlex 300**. Corrosion powder was taken from the iron bar and a series of XRD spectra collected between 20º and 40º. The results have been used to determine optimal parameters for iron oxide analysis with the instrument, Fig. 3.

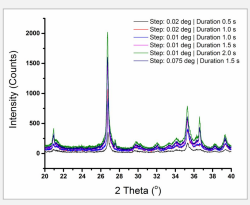


Fig. 3 Optimisation of iron bar corrosion analysis by XRD

Cast Iron Microstructure

Analysis of the microstructure of a *Mary Rose* shot shows it has an outer region of **white cast iron** and inner region of **grey cast iron**, indicating a slower cooling rate towards the centre of the casting [1,2]

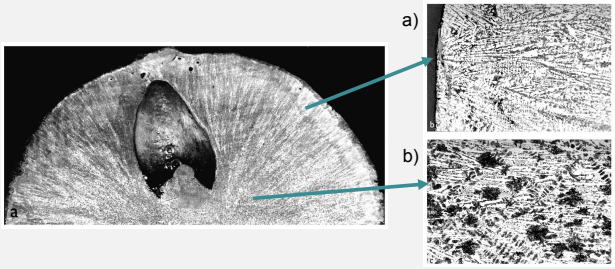


Fig. 4 SEM image of a cross-section of a cast iron shot from the *Mary Rose* a) outer and b) inner region. Reprinted from [1] with permission. Photos: Royal Armouries

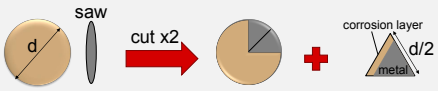
Sampling Procedure

- *Selected samples*

6 unconserved shot, stored in 3% sodium sesquicarbonate since excavation, have been selected for the investigation. All have a diameter **84-86 mm** and were found in **2 locations** on the ship.

Fig. 5 Unconserved iron shot from the *Mary Rose* stored in sodium sesquicarbonate. Photo credit: John Merkel

- *Sampling technique*



The proposed sampling method will use either a dremel power tool, or a saw with non-aqueous lubricant to cut the shot into a segment. This will allow assessment of the metallographic structure of the external/internal surfaces, corrosion products and progression of corrosion into the artefact.

Outcomes and Future Work

By characterising the composition of a selection of unconserved iron shot from the *Mary Rose,* the variation in casting methods used to produce the set will be established. Combining this with a corrosion analysis, future work will explore if there is any connection between the initial metal and corrosion products of archaeological iron.

Acknowledgments

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References

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