Chemical composition of Low Moor and Walker Company cannons in the Odisha State Maritime Museum, east coast of India

Sila Tripati[1,]*, Rudra Prasad Behera[2], N. G. Rudraswami[1] and P. P. Deshpande[3]

[1]CSIR-National Institute of Oceanography, Dona Paula, Goa 403 004, India
[2]Department of Archaeology, Government of Odisha, Bhubaneswar 751 014, India
[3]Department of Metallurgy and Materials Science, College of Engineering, Pune 411 005, India

Cannons are military or civil weapons supported on carriages or fixed mounts and used in warfare as well as against rebellions. Now, most of the cannons are exhibited in museums, forts, public and private buildings, and open places. Moreover, historical documents provide information on different types of forge-welded or cast cannons, which were manufactured both in India and abroad. Like in other museums, six iron cannons are housed at the Odisha State Maritime Museum, Cuttack, Odisha, India. Among them, two Low Moor (LM) cannons are displayed at the museum's main entrance, one LM and a Walker Company (WC) cannon are exhibited adjacent to the dockyard located in the museum, and two smaller cannons are displayed in the museum gallery. Similarly, two LM and two WC cannons are displayed at Residency, Lucknow, Uttar Pradesh, which were deployed during the First War of India's independence in 1857. None of the LM and WC cannons has displayed a considerable degree of corrosion despite their exposure to the open environment for a long duration. Electron microscopy studies of the LM and WC cannons of the Odisha State Maritime Museum were carried out to ascertain corrosion and decay. This study deals with the results of chemical analysis of the LM and WC cannons, emphasizing the fact that the corrosion rate of these cannons is significantly less than other cannons of India.

Keywords: Cannons, chemical analysis, corrosion rate, decay, museums.

THE word 'cannon' represents a gun in Latin. The earliest Arabic and Chinese firearms were made of bamboo tubes known as 'Cannae' used as barrels to shoot arrows[1]. Cannon is a cylindrical device designed to fire a heavy projectile over a long distance. After the introduction of cannons, the traditional pattern of warfare changed permanently. The use of cannons amplified several fold in land and naval warfare after the arrival of the Europeans in the Indian subcontinent, because they wanted to expand their authority directly or indirectly on the Indian territory. The use of cannons in warfare contributed to a different dimension; both the army and navy used them effectively for their supremacy and cannons were an additional destructive power in the artillery. The historical records delineate the use of cannons in naval warfare and their loss along with ships in both the seas and oceans. Because of frequent naval warfare during the European rule, cargo ships also carried cannons for their safety and emergency use. The marine records suggest shipwrecks and loss of enormous cannons in several naval battles in the Indian Ocean region. The finding of cannons from the shipwrecks of Sunchi Reef, Goa; Poompuhar, Tamil Nadu, and Lakshadweep waters, India, validate the above statement. The number of cannons found in underwater explorations of India is minimal compared to that on land sites. There might be thousands of cannons spread across the country, but majority of them are housed in museums, forts, public and private buildings, and they belong to different makes, types and sizes. Among them, a large number are in good condition with minimum corrosion and crumbling. Some are corroded probably due to exposure to the harsh environment and other factors.

History of Low Moor cannon

The Low Moor (LM) Ironworks was established in 1791 CE in Low Moor village, south of Bradford in Yorkshire, England, UK. In the initial years, the company produced domestic goods and later on industrial products, including steam engines[2]. The company engaged in a contract with the British Government in 1795 to supply guns, shots and shells. Robert Wilson was appointed by the company from 1845 to 1856 to enhance productivity, and the steam hammer with the circular balanced valve was improved[3,4]. In 1851, the LM Company exhibited cannons, smaller guns and samples of pig and wrought iron in the Great Exhibition of the Crystal Palace, London[5]. The Bierley Ironworks was brought by LM in 1854 and it became the largest producer of ironworks in Yorkshire. In LM cannons, 'L' was engraved on the left trunnion and serial numbers on the right trunnion; these details are found on

*For correspondence. (e-mail: sila@nio.org)

Blomefield guns. In later periods, 'LM' was engraved on the left trunnion and serial numbers on the right trunnion until about 1858 when 'LM', serial number and date were all engraved on the left trunnion; these are found on large-calibre guns and mortars (pers. commun., Ruth Brown). During this period, LM products, namely cannons, guns, shells and shots were widely used in the Crimean war (1853–1856) and the Indian mutiny (First War of India's Independence) of 1857–1858 (refs 6, 7). Besides LM cannons, the wreck of *HMVS* (Victoria's colonial navy) *Cerberus* in 1790 suggests that its upper decks were made of LM iron. The LM iron has withstood much of the ravages of salt spray corrosion in the Half Moon Bay, in Port Phillip Bay, Victoria, Australia. Since it sank *circa* 1926, it has served as a breakwater for the local yacht club[8].

The technical difficulties of LM started from 1880 onwards, and the demand for its products dropped. Then the company manufactured railway tyres, steam-engine boilers, water pipes and heavy iron components for industrial purposes. Robert Heath and Sons of Staffordshire took over the LM Company and renamed it 'Robert Heath and LM Ltd'. Efforts to reduce the cost affected the quality of production significantly[2]. The demand for LM products further reduced because of the decline in heavy industries in the 1920s. In order to overcome these problems, the company attempted to diversify its operations but failed; it was declared bankrupt in 1928. Consequently, Thos. W. Ward bought the assets of the LM Company, and some mines and plants were either closed or dismantled. Many LM Company buildings were either sold or leased to other companies. The production of wrought iron finally terminated in 1957, and in 1971, some new owners produced about 350 tonnes of alloy steel per week[2].

History of Walker Company cannon

The Walker & Co (WC) was the outcome of the early foundry experiments initiated at Grenoside near Sheffield, UK, in 1741 by Samuel, Jonathan and Aaron Walker and their cousin, John Crawshaw. The WC foundry, established in 1746 at Masborough, Rotherham, UK, manufactured special castings and exported them to different places by both land and sea. In 1774, the company produced cast iron guns at Holmes. Consequently, the demand for quality guns and gun power steadily increased from 1781 onwards. Rotherham was the production centre of cannons until 1820, after which it shifted to Gospel Oak, Tipton, Staffordshire, UK.

Walker cannons were made of cast iron with single pour mould, which used to take several days for cooling, and then the holes, calibre and touch were drilled. Despite skilled work, proper care and rigorous inspection, there were many rejects. The company at Rotherham produced from 2 to 32 pounder cannons. Cannons manufactured in Rotherham are easily distinguished because a special mark 'WC^{o}' is inscribed on the casting on the end face of the left trunnion for WC and a serial numbers on the right trunnion (pers. commun., Ruth Brown).

The royal cypher of George III died in 1820, afterwards the same was found on the barrel at the second reinforcement of the cannon. The Rotherham production shut down in 1820 and now there are no WC remains there. The WC cannons with George IV cypher were produced at the Gospel Oaks Works, Tipton, Staffordshire. Other symbols found on the end face of the right trunnion are the casting number, the cannon's weight in hundred weights, quarters and stones (the old imperial measures) on the lower part of the breech end (cascabel) and broad government arrow stamp on the barrel.

Among the many cast-iron ordnance suppliers, WC was the most established supplier[9]. The WC cannons have been reported around the world, including the old British Empire. Some of the earliest surviving Walker guns from the 1770 to 80s are now in the Royal Armouries at Fort Nelson, Portsmouth, UK. James L. Fern while working at the Yorkshire Unit had made a list of places, where WC cannons have been found. The WCs of Rotherham were onboard from Nelson's Flagship *HMS Victory*, which was engaged in the famous Battle of Trafalgar[10–13]. About 80 WC^{o} guns of Rotherham with WC^{o} marks on the left trunnion were used on-board *HMS Victory*[14]. Among other places, the WC cannons recovered from the *HMS Victory* are now on permanent display in the Portsmouth Dockyard[15–17]. *HMS Weazle* wrecked off the North Devon coast in 1799, was carrying WC cannons[18], which salvaged and restored, are now displayed at the Library and Arts Centre in Rotherham. Further, WC cannons have been reported from different parts of the British Isles and Australia, Canada, USA, West Indies, and places where the British had ruled. Moreover, eight WC cannons are reported from South Africa (pers. commun., Malcolm Turner); the 'WC^{o}' mark can be seen distinctly on two trunnions, whereas on one trunnion is marked with WC^{o}, 230 and 1858. Several WC cannons have been displayed around the fortifications of Rio de Janeiro. As a part of the third order of Portugal of 1799, WC cannons of 12, 9, 6 and 4 pounders of Rio de Janeiro were brought to Portugal in 1800 (ref. 19).

LM and WC cannons at the Odisha State Maritime Museum

The Government of Odisha converted the Jobra workshop, Cuttack, which was non-operational and abandoned in 1950 into the Odisha State Maritime Museum, on 1 April 2013 with 11 galleries. The British Government had built the Jobra workshop after the great famine of Odisha (1866 CE) to fabricate essential items for boat-building, sluice gate, irrigation canals, surface transport and anicut on River Mahanadi to cater to the needs of the whole of

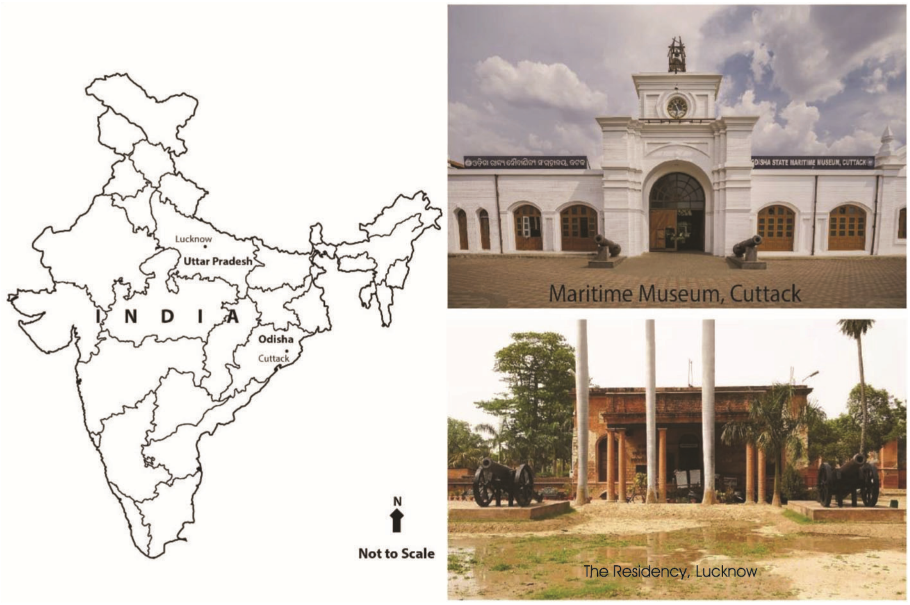

Figure 1. Low moor (LM) and Walker Company (WC) cannons displayed at the main entrance of the Odisha State Maritime Museum, Cuttack, Odisha and The Residency, Lucknow, Uttar Pradesh, India.

Figure 2 *a*, *b*. WC and LM cannons exhibited near the dockyard of Odisha State Maritime Museum.

the Bengal province. George Faulkner built a mighty stonewall anicut about 1.5 km long on the banks of River Mahanadi and made provision for connecting the river with the Jobra workshop by a canal[20]. Overall facilities were made available at the workshop, including repairing and building big boats for the Government departments. Drills, lathe, cutters and machinery required for the workshop were brought from England. Sometimes the British administration sent old, usable items to the workshop, including cannons, for reuse after repairing, smelting or breaking them[21]. It appears that the old and unusable LM and WC cannons were brought to the Jobra workshop to make hinges for lock gates of the dockyard[20]. The dockyard had wooden gates connected with River Mahanadi, and the canal, moreover a sawmill was built near the boat jetty[22]. If these cannons were brought for reuse, why were they not smelted for the purpose is unknown. However, the workshop has a long history of achievements.

Description of the cannons of Odisha State Maritime Museum

In all, six cannons are housed in the Odisha State Maritime Museum; among them, two LM cannons are placed at the main entrance of the museum (Figure 1), one WC (Figure 2 *a*) and another LM (Figure 2 *b*) cannon are displayed near the dockyard, whereas other two small cannons exhibited inside the museum. All the LM and WC cannons look identical; each cannon measures 306 cm long having three reinforce rings and tapering from base to mouth. Table 1 provides the details of the LM and WC

Table 1. Detailed measurements of Low moor (LM) and Walker Company (WC) cannons at the Odisha State Maritime Museum, Cuttack and the Residency, Lucknow

Cannon company	Engraving on the surface	Trunnion (left)	Trunnion (right)
Odisha State Maritime Museum			
WC (near dockyard)	1858, 94-3-0, ↑ 1967	WC° 239 1858	Blank
LM (near dockyard)	1856, 95-3-1, ↑ +	Blank	LM
LM (main gate, left)	1856, 96-0-0, ↑ +	7210	LM
LM (main gate, right)	1856, 96-0-0, ↑ +	Numbers unseen	LM
The Residency, Lucknow			
LM (front side of the museum building)	1854, 65, 2, 16, ↑, 8	5844	LM
LM (backside of the museum building)	1854, 65, 0, 20, ↑, 19	5885	LM
WC (front side of the museum building)	1854, 228, 64, 2, 0, ↑, H	WC	722
WC (backside of the museum building)	1854, 64, 3, 0, ↑, 25	WC	728

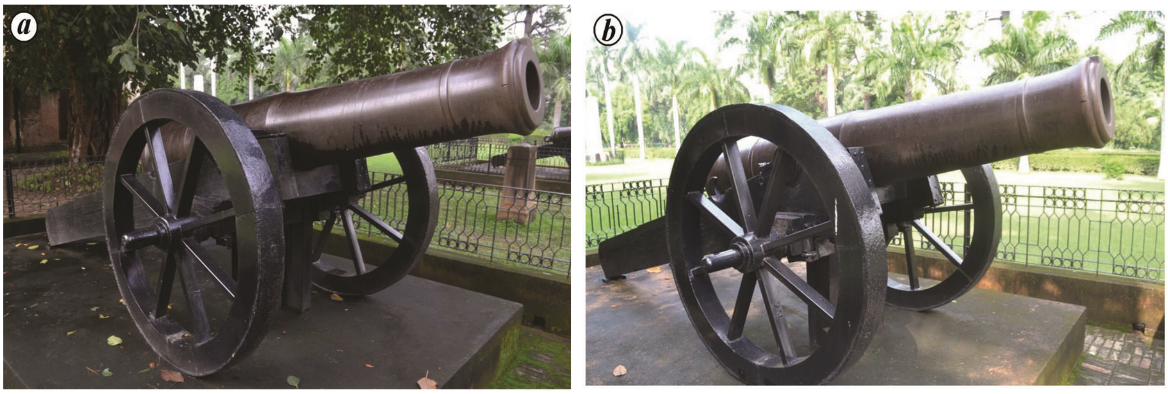

Figure 3 ***a***, ***b***. LM and WC cannons displayed at The Residency, Lucknow (photograph: Archaeological Survey of India).

cannons. The two small cannons measure 99 and 82 cm respectively. One cannon has a flag-type symbol along with 2-3-22 inscribed, whereas the other cannon has no signs and symbols but is mounted on a stand, and two vent holes are present. Samples of the WC and LM cannons displayed near the dockyard were obtained for analysis and the results are detailed.

LM and WC cannons at The Residency, Lucknow

Two LM and WC cannons are displayed at The Residency, Lucknow (Figure 3 *a* and *b*). The Residency was constructed between 1774 and 1800 CE by Nawab Shuja-ud- Daula and Nawab Saadat Ali Khan for the British. During the First War of India's Independence in 1857, Lucknow became the central point for revolutionists under Begum Hazrat Mahal's leadership. The native Indian forces seized The Residency for 87 days. On 30 June 1857, the British had deputed the Royal Indian Artillery equipped with 80 pounder LM and WC cannons of smoothbore muzzle loading and other various-sized guns to combat the Indian troops at Lucknow. The First War of India's Independence caused enormous damage to The Residency because of heavy shelling. In the recent past, the Archaeological Survey of India (ASI, New Delhi) while preserving the ruins of The Residency, carried out excavations and brought to light buried structures, water management system, cannonballs and cannons[23]. The Residency has been recently converted into the '1875 Memorial Museum', and paintings, coins, lithographs, cannons and other materials of the First War of India's Independence have been displayed there[24]. One LM and WC cannon are mounted on the northern side of The Residency, whereas two other LM and WC cannons are displayed behind it (Table 1).

History of cannons in India

Early evidence of India's breakthrough in iron production and technology goes back to the middle of the second millennium BCE, evidenced from numerous early Iron Age sites spread across the country, including Raj Nal-ka-Tila. However, by the 12th–13th century BCE, iron was well known in the Indian subcontinent and was used extensively in remote parts of the country for various purposes, starting from weaponry, agriculture, carpentry to household products[25]. Naikund, a megalithic site, 42 km northeast east of Nagpur in the Vidarbha region of Maharashtra, has yielded valuable evidence of iron-smelting furnace with complete tuyere[26].

Similarly, excavations of Mahurjhari also in the Vidarbha region of Maharashtra have yielded a steel chisel.

The metallographic studies of the chisel show advancement in hardening and quenching, followed by tempering treatment known as early as 900 BCE (ref. 27). Wootz steel has a special quality of high toughness. It inherits both high ductility and high strength and is one of the most modern materials discovered by ancient people. Studies on Wootz steel in the 19th century Europe led to the foundation of modern metallurgy[28]. Wootz steel is an ultra-high carbon steel exhibiting properties such as superplasticity and high impact hardness and it is based on the idea that the processing of an advanced material leads to a structure, which has a definite combination of properties[29]. Significant progress in the iron technology of India is known from the historical period onwards, which is evident from the iron pillars of Delhi constructed by Chandragupta II (375–415 CE); Dhar of Madhya Pradesh in the 11th century CE and the use of iron beams at the Sun Temple of Konark, Odisha in the 13th century CE. Jai Singh II (1686–1743) established an iron foundry at Jaigarh[30]; Mir Qasim (1760–63) and Tipu Sultan (1782–99) set up foundries in the later periods[31,32]. Tipu Sultan had artillery manufacturing establishments at Seringapatam (Srirangapatna), Bengaluru, Chitaldurg (Chitradurga) and Nagar. During the medieval period, the demand for weapons and ironware increased manyfold. In the absence of casting technology, the Indian artisans made remarkable developments in forging techniques; probably, this technology was developed in India. Nevertheless, the manufacturing of bronze casting cannon was adopted from the Ottoman Turks[33]. The Ottoman cannon technology probably reached India through both land and maritime routes, and the Chinese cannon technology was transferred by maritime contacts with Kerala[34]. Although cannons have played a vital role in territorial and naval warfare in India and abroad, inadequate information is available on the technical development of forge-welded cannon technology of India. In the earlier decades of the 20th century, Neogi[35] worked on the forge-welded cannons of India. Joshi[36] studied the cannon technology of the medieval period from 1200 to 1800 CE. Forge-welded iron cannons have been reported from Bishnupur, Bijapur, Gulbarga and Thanjavur in India and Nurwar Mushirabad, Dacca Bangladesh, which represent the skill of medieval Indian blacksmith who were capable of engineering and construction of large, forge-welded iron products. The *Ain-i Akbari* describes forge-welded cannons which were made with thick discs of perforated barrel types and iron rings provided at the joints to reinforce the cannons[31]. In the recent past, Balasubramaniam[37] catalogued and made a thorough survey of cannon technology, and published a comprehensive work on the forge welding technique in India. Deshpande *et al.*[38] studied the forge welded iron cannons of western Maharashtra. Subsequently, Ambekar[39] and Ambekar *et al.*[40,41] have compiled information on the cannons of the west coast of India, including Diu and Goa. However, a limited number of cannons of India have been studied from a mineralogical point of view to understand the quality of the iron used in manufacturing the cannon(s) and the factors responsible for their decay. In the present study, the LM and WC cannons displayed near the dockyard of the Odisha State Maritime Museum have been analysed to determine the chemical composition and low rate of corrosion. Besides, the history of LM and WC cannons has been briefly discussed.

Electron microscopic analysis of cannon samples

Samples for electron microscopy analysis (EMA) were collected from the lower side of trunnions of LM and WC cannons (Figure 2 *a* and *b*). The small pieces (~1 inch) of LM and WC cannon samples were initially mounted on epoxy and finely polished. These samples were further coated with carbon. The backscattered electron (BSE) images were obtained using a scanning electron microscope (SEM, JEOL JSM 5800LV) along with the OXFORD-INCA energy dispersive spectrometer detector (EDS, ISIS-300) for characterization of the cannon samples and their phases were closely examined. Further, the samples were analysed using electron microprobe to determine their chemical composition. Major and minor elements were obtained using the electron probe micro-analyzer (EPMA, Cameca SX5 fitted with four spectrometers). The analyses were conducted using ~15 kV accelerating voltage, ~12 nA beam current and ~1–2 μm beam spot. Several analyses (~30–50) were conducted on each prepared section to understand the consistency of the chemical composition. The data obtained in the electron microprobe were corrected using the PAP correction program to the elemental composition[42]. The calibration and quantification were performed with electron microprobe using natural mineral standards (e.g. albite, corundum, apatite, orthoclase, rutile and chromite).

Results

EMA of LM and WC cannon samples was carried out. Figure 4 shows BSE images of the cannon samples. Cracks apparent in sections of the samples at regular intervals suggest that they are not homogenous. The cracks indicate a corrosive environment that the cannon has survived, and that deterioration might have started. Nevertheless, the relatively slight degree of corrosion indicates the excellent condition of the cannons. The chemical composition in the clean area of both samples was dominated by Fe, which ranged from 92.1% to 95.5% (Figure 5). However, a small amount of Si with less than 1 wt% was also detected in the sample, probably due to contamination, along with an insignificant amount of Mn. There was no evidence of large-scale corrosion containing an oxide form of iron during the analysis. Table 2 provides detailed chemical composition of the samples. The low total of chemical

Table 2. Chemical composition (wt%) of the LM and WC cannons, suggests domination by Fe with some silicon, probably due to diffusion during its residence time

	Na	Mg	Al	Si	Ca	Ti	Cr	Mn	Fe	Co	Ni	Sum
LM-1	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.4	95.3	0.0	0.0	96.8
LM-2	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.3	95.0	0.0	0.0	96.5
LM-3	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.3	94.7	0.0	0.0	96.2
WC-1	0.0	0.0	0.1	1.1	0.0	0.0	0.0	0.5	95.5	0.0	0.0	97.2
WC-2	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.5	94.6	0.0	0.0	96.4
WC-3	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.5	92.1	0.0	0.0	94.1

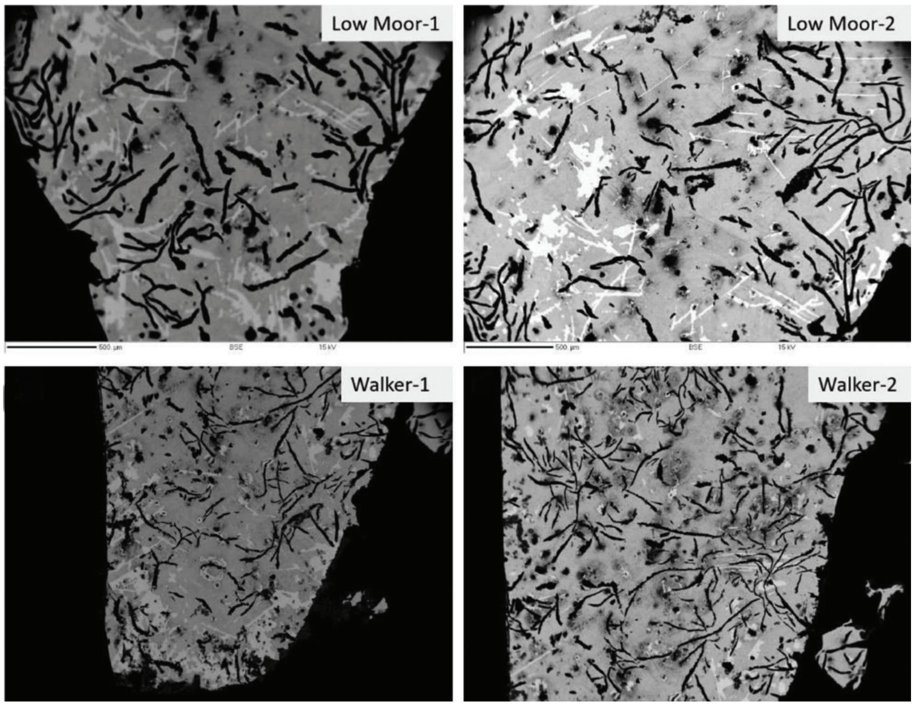

Figure 4. Backscatted electron images of the section of the LM and WC cannons at the Odisha State Maritime Museum.

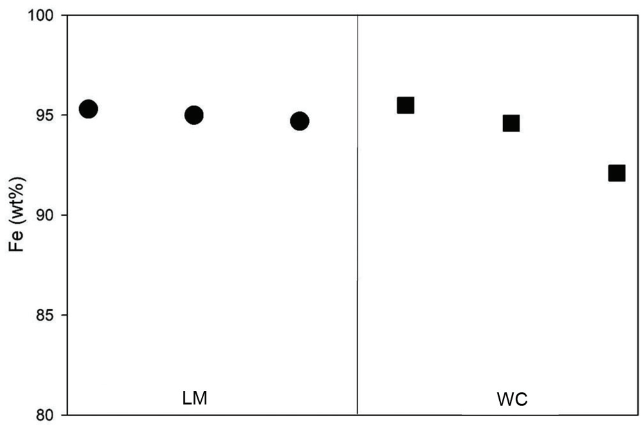

Figure 5. Plot showing Fe (wt%) of both cannons (circle and rectangle represent for LM and WC respectively).

composition in the sample indicates a small quantity of oxidized iron, which could not be confirmed unambiguously in this study.

SEM images showed several minor cracks, probably indicating the damage due to frequent firing of the cannons. The thermal damage of the cannons is directly dependent on the number of firings, as the temperature attained during firing results in partial melting and the heat impact can give pathways to cracks. The extensive firing from cannons and stress and explosion pressure would have produced cracks on them. Mahdavinejad[43] studied the number and size of cracks in the cannon using ANSYS software. More firing will induce crack growth on them, thereby reducing the strength of the cannons. Following weathering over the period, and the age of the cannons also have the advantage to develop cracks on them. Cast iron is an alloy of iron and carbon with carbon content of more than 2.14 wt% and some impurities. In practice, however, most of the cast iron contains between 3 wt% and 4.5 wt% carbon besides other alloying elements, thereby reducing its overall strength. The most common cast iron types are grey, white, nodular, malleable and compacted graphite. Photomicrographs of both cannon samples reveal graphite flakes embedded in the ferrite matrix (Figure 6 *a* and *b*). This confirms that grey cast iron was used for making WC and LM cannons. Graphite formation is promoted by the presence of silicon at concentration greater

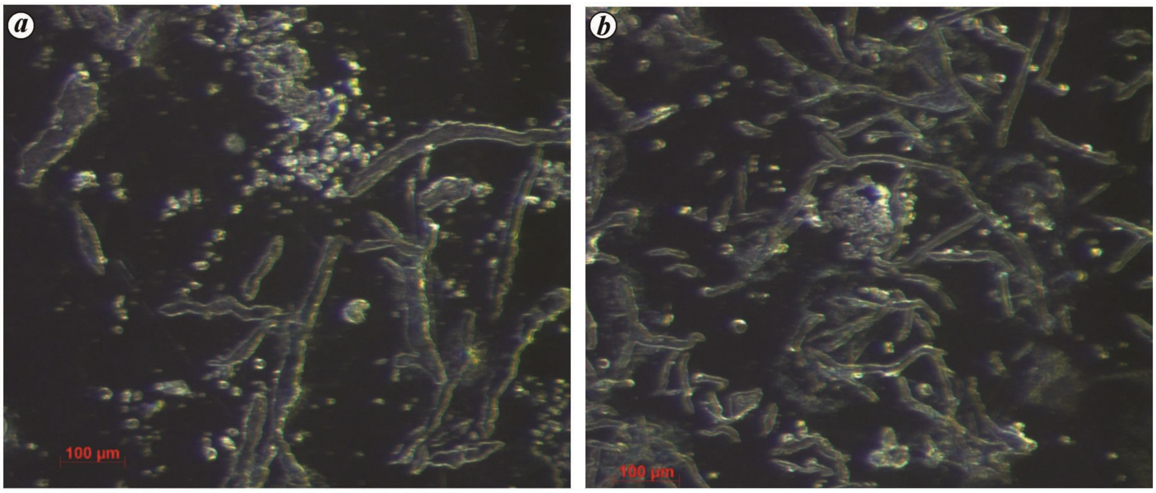

Figure 6 ***a***, ***b***. Photomicrograph of LM and WC cannons.

than about 1 wt% and slower cooling rates during solidification favour graphitization. Mechanically, grey cast iron is weak and brittle in tension because of this microstructure; the tips of the graphite flakes are sharp and pointed, and may serve as points of stress concentration when an external tensile load is applied. However, grey cast iron has desirable properties such as high compression strength, resistance to oxidation, low melting point and excellent damping capacity to absorb vibrations, and hence is used extensively. In the molten state, it has high fluidity at the casting temperature, which permits ease of casting and reduces shrinkage[44].

Discussion and conclusion

The introduction of iron cannons in the Indian Ocean region goes back to the 16th century. The European ships that sailed to India carried cannons on-board for their self-defence because of frequent naval battles fought between the European powers and pirates, and for resisting the local rulers. During the return voyage, these cannons were sold locally, or mounted at the respective forts and European establishments such as buildings and factories in India. Regarding cannons, Colonel H. Munro has specified that ‘there is hardly a ship that comes to India that does not sell them (the Indian rulers) cannons and small arm’[45]. European cannons and cannonballs were greatly sought after in the 18th century owing to their accuracy and as efficient artillery in several gruesome battles, namely Anglo-Mysore wars (1767–99), Anglo-Maratha wars (1775–1819), Anglo-Sikh wars (1845–49)[46,47] and the First War of India’s Independence in 1857 fought against the British by the Indian rulers.

Iron cannons were manufactured either by casting (pouring of molten metal in moulds) or by forge welding (joining solid pieces of iron by hammering them together while hot). Most of the India’s cannons were forge-welded, and some are similar to the cannons of other parts of the world. Both bronze and iron cannons have been recorded in India. Some are significant in many ways; for instance, the bronze cannon of the *Malik-i-Maidan* of Bijapur[37], Karnataka. Cannons can be distinguished from their features such as engravings, emblem, shape of the trunnion and cascabel. It is challenging to date the cannons, unless it is stamped on them. Among the discoveries of cannons in India, more have been reported on the west coast than the east coast, and the largest number was recorded from the forts of the west coast, including both European and Indian make. Some of the Indian-made cannons have either corroded, are broken or damaged, probably because of the quality of iron; and a minimal number of Indian cannons have seals, symbols and other details on their surface.

Brown[48] has made a detailed study of the 18th century British iron guns, mainly identifying the guns exclusively on trunnion marks. Later, he studied European cannons dating between 1550 and 1820 CE based on the size of the muzzle, weight, founder marks, trunnion marks and dates[49]. Cannons were even identified based on whether they were cast in the British Isles or Sweden.

The LM cannons of India were Yorkshire’s products, whereas WC cannons were manufactured in Gospel Oak, Staffordshire. WC cannons are limited in India and have been reported only from Odisha State Maritime Museum, The Residency, Lucknow, and Jodhpur Fort (Figure 7). A thorough exploration alone can provide information on whether there are more LM and WC cannons in India. The LM and WC cannons are dominated by Fe, indicating that not much corrosion has taken place during their residence time. However, the presence of small microscopic fissures at regular intervals seen in the SEM image indicates damage at a prolonged rate. The contamination of the cannons can be observed in their chemical composition of silicon (~1%) and Mn (0.5%), indicating metal alloy

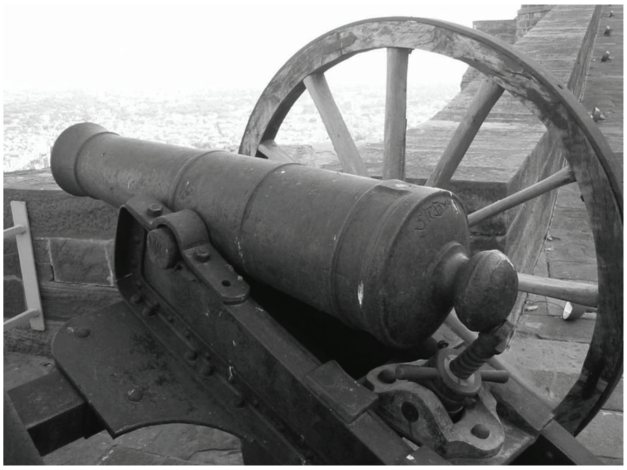

Figure 7. WC ecannon at Jodhpur Fort (photograph: Ruth Brown).

casting during that period. The chemical composition of the cannons analysed in this study does not very much, indicating uniformity in making them. The chemical composition does not support the complete absence of corrosion, and high-resolution microscopic images have shown that some void pores could affect the strength of the material. However, the density of such porosity was small. In general, the smaller amount of corrosion in the cannons demonstrates that they were exceptional, and best technique were adopted in making them.

Among several cannons of Jangira Fort, Maharashtra, two belong to WC. In one of them, WC is stamped on the barrel but not on the trunnion, while on the other W is considered on the base ring. The Bailey, Pegg & Company acquired WC in 1860 along with its old stock and had stamped WC and W on the barrel and base ring of the cannons instead of the trunnion[40,50,51]. The LM and WC cannons do not have loop handles, or a coat of arms or other royal insignias on them, because these were private companies not patronized by any dynasties. Similarly, one 68 pounder LM cannon used for the defence of Hobson's Bay around 1893 was later moved to Portland and used for training purposes. Later, it was moved to a park in front of the old courthouse in 1919 and Battery Hill in 1922, and eventually placed in its current position in 1984 (ref. 52). One more 32 pounder cannon of Dundas designed and cast by LM in 1859 is displayed in the National Maritime Museum, London[53]. The British army used 68 pounder LM cannons for coastal defence purposes. These were made of wrought iron and manufactured at LM Iron Works at Bradford. LM cannons were used until 1921 thereafter, they were abandoned. Several European companies manufactured cannons, shots, etc. between 1811 and 1815. The East India Company had purchased iron guns and shots from Carron and Wiggin, Graham & Son and John Roebuck[9]. However, except LM and WC cannons, none from the above-mentioned companies has been found in India. Cannons manufactured both by Indian and European companies should be studied thoroughly to comprehend the technology, the number of fireballs used to fire and explosion pressure which would have produced cracks on them, because knowledge on the history of these cannons is limited. More importantly, cannon samples should be reanalysed extensively on a wider range to understand the chemical composition during those times, the manufacturing process and causes of corrosion, for proper conservation measures.

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