Medieval Gunpowder Research Group

Early gunpowder, guns and gunnery

Report Number 14 – March 2016

Middelaldercentret, Nykøbing, Denmark

Introduction

The Ho Group, based at the Medieval Centre in Denmark, was formed in 2002 to investigate the history and development of early artillery and gunpowder using a combination of historical research, artefact studies and experimental archaeology. Its overall aim is to understand more fully the nature and properties of early gunpowder and the ways in which it differs from modern material. This, it is hoped, will lead to a better understanding of the development of gunpowder weapons and their effects on castles, walls, ships and men. In order to do this, the Group has conducted, over the years, a number of experiments, reconstructions and studies of various gunpowder mixtures and compositions. The Group now has a better and more nuanced understanding of the properties of blackpowder and is in a position to attempt to carry out experiments which will start to answer that fundamental question.

Following two preliminary meetings of the Ho Group, a briefing in December 2015 and a discussion group in February 2016, the Group set its sights on a large, wide-ranging programme of research into early gunpowder, guns and gunnery. The firing trials, conducted by the Vasa Museum in 2014, and the work of the Ho Group over the last few years into the properties and forms of early gunpowder, led to the proposal to attempt to make and fire two replica guns with gunpowder all made in the closest possible ways and methods that they were in the late medieval/early modern period.

The proposed two original guns from which replicas would be made were a bronze piece, made in Sweden in 1535 and now in the Maritime Museum in Stockholm, and a wrought-iron piece from the Anholt wreck site, dated to around 1525 and now in the Tojhusmuseet in Copenhagen (A1). The gunpowder would be made from sulphur ore from Iceland, charcoal made at the Medieval Centre and saltpetre made in India. Of the two cannon, the wrought iron piece would be made at the Medieval Centre by Jens Christiansen and the bronze piece in a foundry in India.

Following this proposal, a study trip to India was planned to look at the feasibility of the project and to ascertain whether any of this was, in fact, possible. A programme was devised and funding secured to allow three persons to travel to India for 2 weeks.

The timetable was:

Day 1	Arrival in India and travel to Agra
Day 2	Visit to saltpetre works in Jalesar
Day 3	Visit to saltpetre works in Jalesar
Day 4	Travel to Jaipur
Day 5	Documenting gun foundry and boring machine at Jaigarh Fort
Day 6	Documenting gun foundry and boring machine at Jaigarh Fort
Day 7	Day for discussion
Day 8	Travel to Chennai
Day 9	Investigation of Tranquebar Fort
Day 10	Visit to foundry in Swamimalai to investigate cannon casting
Day 11	Visit to foundry in Swamimalai
Day 12	Travel to Pondicherry and exploration of European remains
Day 13	Travel to Delhi
Day 14	Return

Delhi

As part of the preparation for this research visit, the Group made contact with Ganesh Explosives based in Dehradun, the capital of the state of Uttarakhand, some 240km north of New Delhi. A meeting was arranged in Delhi to meet Rishabh Jain, their Director of Business Development (see www.blackpowder.in).

We had a very productive meeting with Rish about our project and how he could help us achieve what we had set out to do. He suggested that we should seriously consider doing the entire project in India and not have components, the bronze cannon and the saltpetre, made in India and shipped back to Europe. He also of-

fered to help us with the production of the necessary blackpowder - from the ingredients we would supply - and also to assist in any way with the testing of the completed cannon. During the discussions the idea was also advanced that we should include the casting and testing of an Indian piece as well as the copies of European pieces which we originally planned.

Jalesar and saltpetre

In 2006, members of the Ho Group, had visited India to investigate whether there were any remains of the industry which had supplied Europe, and particularly Great Britain, with huge quantities of saltpetre from the 1620s to the last decades of the 19th century. This saltpetre had effectively enabled Europe to wage war on an unprecedented scale and dominate much of the world until the later 20th century. The visit was very successful and the Group found, in the town of Jalesar, north east of Agra, a small 'factory' which was still capable of producing saltpetre in the traditional way. However, the visit of the Group at that time coincided with a period when no saltpetre was being made - the process being highly seasonal. Undeterred they were shown all the stages of the process and were able to document it in some detail.

The purpose of our visit in 2016 was to re-visit the site and discuss with the owners whether we could acquire a significant quantity of saltpetre to make the necessary blackpowder for the testing of the cannon we wanted to make. So, from Delhi, the Group travelled to Agra where we were based for 3 days. Here we were also joined by Dr Alok Kanungo, Assistant Research Professor of Archaeology at IIT Gandhinagar.

In Jalesar the Group met up with the Mittal family to discuss our requirements. We had a very fruitful discussion with them, especially with Aditya Mittal, but the situation there was not as simple as it appeared. Aditya took us to the site of the factory that we had seen in 2006 where we were disappointed to find that it had been significantly changed. The huge shallow purifying bowl had been removed (and subsequently cut up), and the remaining plant had been changed to producing saltpetre in a more modern way. Similarly the area where the extraction had been carried out had been destroyed as had the wooden settling tanks, though some wooden planks from these were still lying around. This made us realise just how important our record of the site from 2006 was.

The saltpetre refiner as seen in 2006 - the iron pan containing the dissolved saltpetre

The same area - the square iron pans are used to make saltpetre in a modern method

The wooden side of one of the settling tanks we had seen in 2006

However, it turned out that there is still a store of perhaps some 2000 kg of raw saltpetre surviving from the last time the plant had operated and we were able to negotiate a price for this to be purified by the traditional process. Aditya also agreed that he would be able to re-assemble the whole process for us, and produce some 200 kg of raw saltpetre, enabling us to document the whole process and fully record it one last time.

Jaigarh Fort as seen from the approach road

Jaipur and Jaigarh Fort

From Agra, the Group travelled to Jaipur to visit Jaigarh Fort and the cannon foundry and boring machine which survives within the Fort. We were very lucky to be able to meet with Mr Yunus Khimani, Director of the Mararaja Sawai Man Singh II Museum, the City Palace, Jaipur who has responsibility for the Fort. He was very enthusiastic about our project and gave us permission to go behind the scenes and document both the boring machine and the foundry in considerable detail. This proved to be very exciting as they are probably the best surviving examples in the world. Fred Hocker

The foundry

and Kay Smith hope to prepare a preliminary report of these important facilities late in 2016 but a brief description is given here.

The foundry

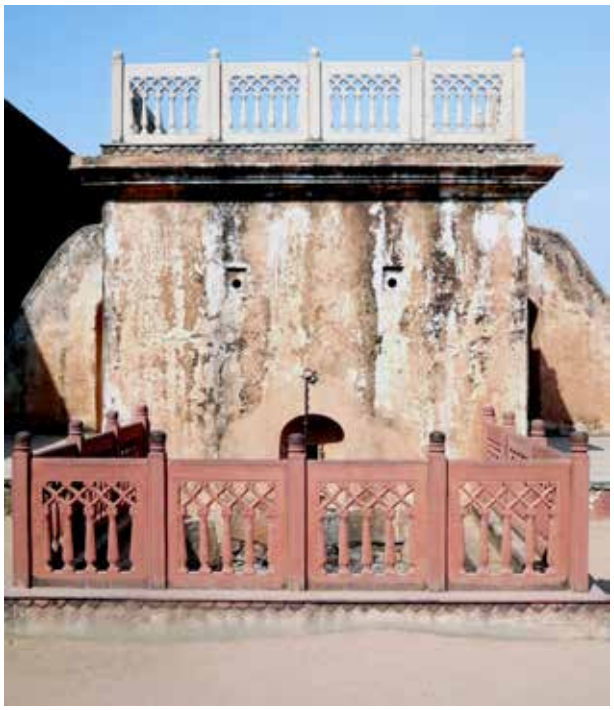
The foundry is a free standing structure some 3 metres tall, excluding the modern railing at the top. It consists of essentially four parts. The main section of the standing building, the furnace itself, contains the fire box and the melting chamber. The second section, at the rear, is an open structure enclosing the rear of the fire box and provides a cover over and around it. Below the furnace, the third part, is a 'tunnel-like' structure running beneath the main building which acted as an air channel to provide a forced draft for the fire, greatly increasing its potential heat-generating capabilities. This air channel continues under the firebox to an opening into the bottom of the casting pit. The final section is the casting pit at the front of the building. There are three chimneys in the roof - one over the fire box and two over the melting chamber. On either side of the melting chamber are small openings closed by sliding iron doors which are opened by levers set in the roof of the building. Two sets of stairs, one on each side, provide access to the roof.

The rear of the foundry - an open structure which surrounds the opening to the firebox

The opening to the firebox at the rear of the foundry - the iron hooks would hold a locking bar to hold a door in position

This part of the foudry contains the melting chamber and has walls of around 1 metre thick. The small arched access hole is closed off with an iron plate operated by a lever set in the roof. The railing on top is a modern addition

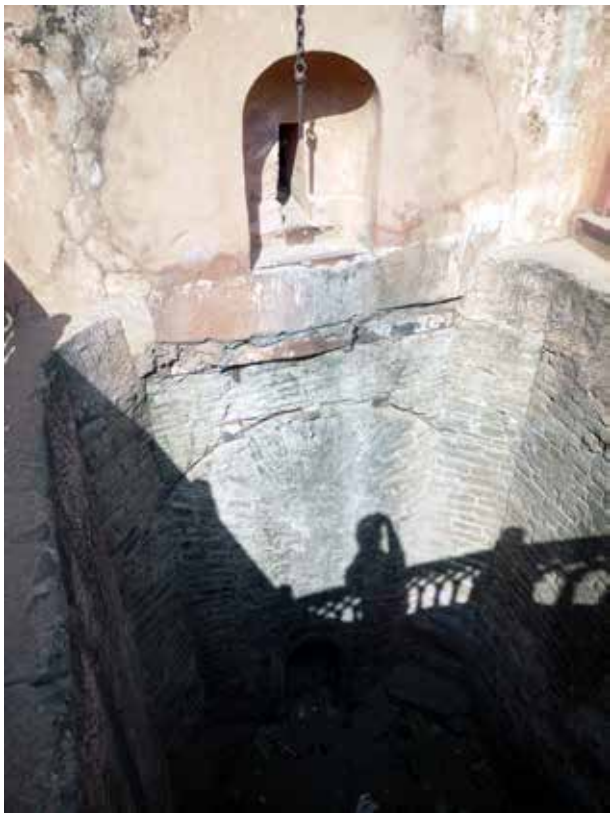
The air passage under the foundry which provides an air draft for the fire



The front of the furnace with the 'tapping' arch and the casting pit behind the modern railing

Looking down into the casting pit. Although it is now roughly octagonal, it appears that it was originally circular

The charging hole in the side of the furnace. The metal door is operated by a lever set into the top of the furnace



The casting pit below the tapping arch of the furnace. A number of features are also visible in the back wall though their function is unclear. The chain hanging down probably operated the mechanism to open the tapping hole

The chimneys - the two on the left are above the melting chamber, that at the rear is above the firebox

The boring machine

The boring machine is contained in a separate building, divided into two chambers. The outer, rectangular chamber contains the boring head and the ways on which guns were mounted, and the octagonal inner chamber holds the drive mechanism on two levels, above and below a wooden floor. Power was provided by four animals, probably oxen, yoked to a whim (a type of capstan). This turned a large wooden gear below the floor. The motion of this gear was transmitted to a gear on the boring spindle by a train of gears on a layshaft mounted below the floor, so that the boring tool turned at 10.5 times the speed of the whim. The gears and shafts are primarily made of wood, with iron reinforcing and pivots, sitting in bronze bearings. The gears themselves are of three different types. The large gear mounted on the whim is a crownwheel, with cylindrical wooden teeth, turning a squirrel cage gear on the end of the layshaft. The other end of the layshaft carries a pinion with wooden teeth, which meshes with a second squirrel cage gear on the boring spindle.

The capstan of the boring machine

The ways extend for nearly 10 meters in front of the chuck on the boring spindle, but it is not clear yet how tools and guns were mounted. The size of the ways suggests that guns were mounted on a sliding carriage and driven towards a rotating tool mounted in the chuck. A number of iron tool steadies, for mounting on the ways, were in place.

Part of the gearing of the boring machine - the floor to the capstan is above and this drives the main gear wheel below

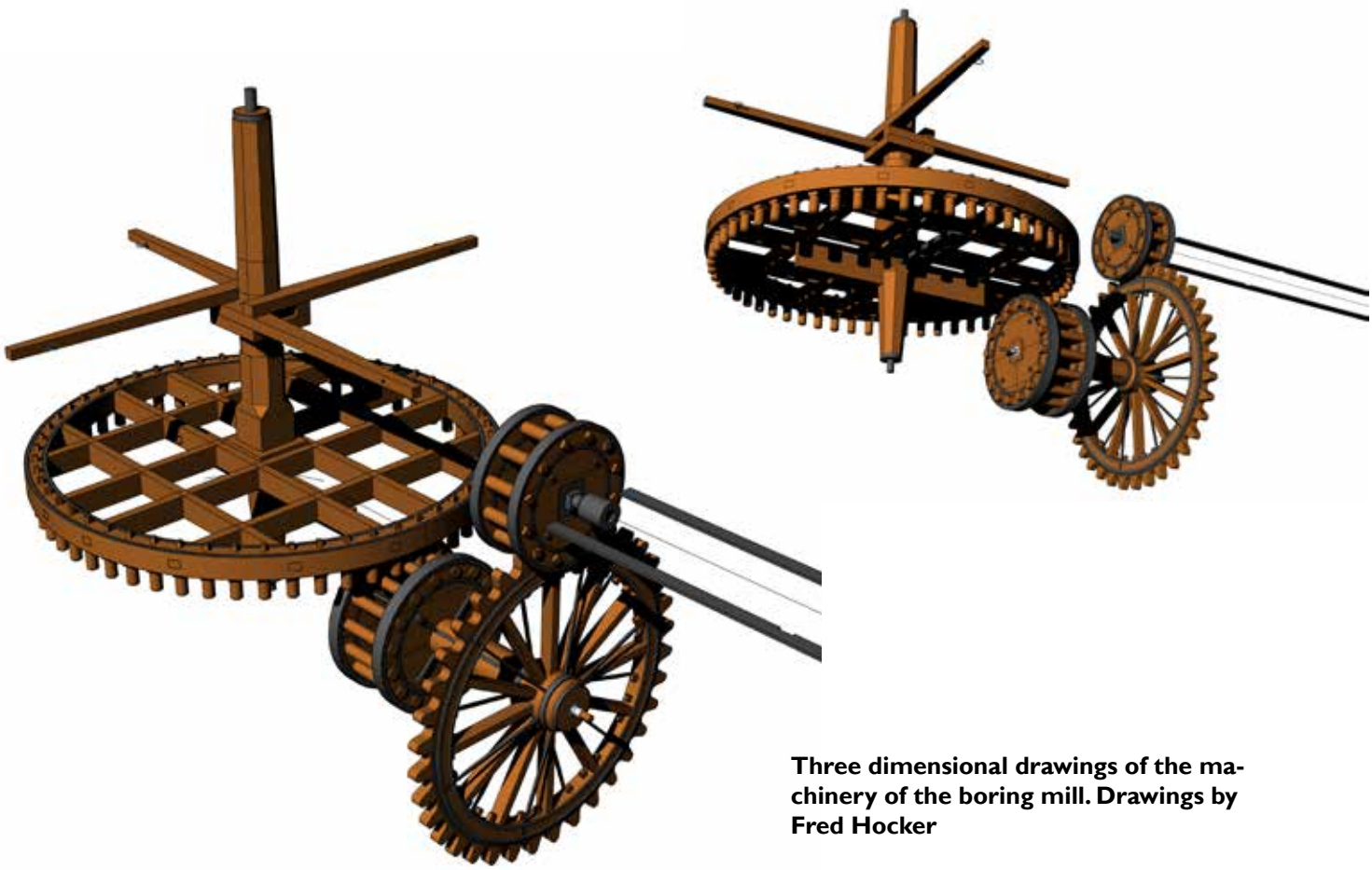
The underside of the main gear wheel showing its teeth and the second 'squirrel cage' gear wheel

The squirrel cage second gear wheel

The final and fourth gear wheel - it is driven by a third gear beneath the floor which was impossible to photograph. The wall has been cut back to accommodate the wheel leading us to think that there has been some adaption or change to the original configuration. The 'chuck' to hold the boring bar is mounted directly in front. The gear, like the second and third gears, runs on copper alloy bearings, one of which can be seen here between the gear and the 'chuck'

The trough in front of the 'chuck' showing the iron rails on either side and the removable cross pieces that can be used as 'steadies'

Detail of the 'chuck' with a boring bar in place

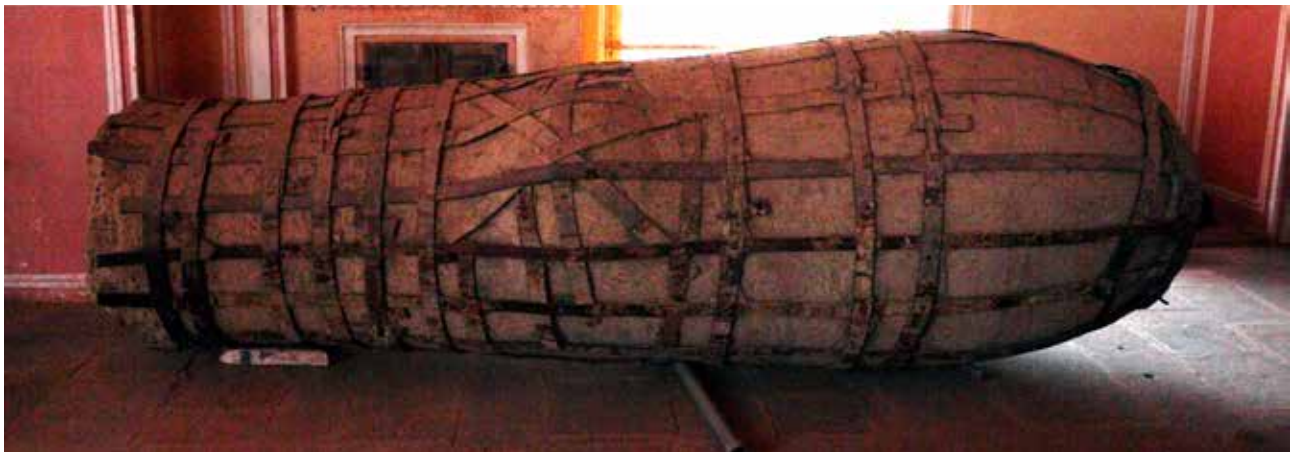


Three dimensional drawings of the machinery of the boring mill. Drawings by Fred Hocker

Cannon moulds

In addition there are the remains of at least five cannon moulds - three located with the boring machine itself and two, more fragmentary ones, located with the tools collection. Intriguingly these moulds were made in a different way to those in Europe which were made in one piece. These were produced by making an initial two-part mould of the pattern. Each half mould was then built up to a thickness of about 100mm before the two halves were put together and the mould then built up in layers to a thickness of some 250mm. The layers differ in composition, the inner ones are made from a fine clay while the outer ones are composed of coarser clay with added materials, straw, small stones and animal dung. Finally the whole is bound with a cage of wrought-iron straps and the breech reinforced with a large circular iron plate.

Although the moulds are now broken, to a greater or less extent, it appears that the cannon were cast without a casting head as was normal practice in Europe.



The most complete of the 5 moulds in Jaigarh

The rear of the mould showing the large iron plate to which the longitudinal reinforcing straps are secured. We were puzzled by the small square hole in the centre of the end, the purpose of which is still unclear

Detail of the iron reinforcing straps showing the way they were tightened around the moould using wedges to draw the ends together

The front of the mould - the circumferential layers of the mould are clear as are the join lines at top and bottom where the two half moulds were put together. These are only visible for about 100mm showing that the mould halves were reinforced that far before being put together and the final 150mm added over the whole mould

The other 2 moulds in the boring machine area - both are broken and have lost their iron reinforcing straps

A view down the larger of the two moulds above. The join line can clearly be seen running down the length of the mould as can the trunnions at roughly 4 and 10 o'clock. The void at the top is probably decoration though this is not at all clear

The boring machine is inside this building - the right hand door leads into the octagonal room housing the capstan. The door to its left (hidden behind the tree) is the actual boring area. The door on the far left is a corridor at the end of the boring area.
We have speculated that the area in front (with the trees in the middle) was where the patterns and moulds were made - there is evidence of foundations all round the rough gravel area - indicating the presence of a substantial building that would be needed to house all the necessary tools and equipment

Tools

In a separate courtyard are a number of small rooms containing a wide range of tools and equipment associated with the boring machine and the foundry. Unfortunately we were unable to study these in detail on this visit but they included boring bars and drills, boring heads, taps and dies, a gin as well as blacksmith and furnace tools.

Tools for use in the furnace

A series of boring reamers of various sizes

Taps, for cutting threads, of a wide range of sizes

Two more fragmentary cannon moulds

Finally, following discussion with Mr Khimani, we were able to visit a part of the Fort, normally closed to the public, where we were shown stores of armour, guns and artillery and rocket casings.

Mail and plate armour

Gun barrels

Gunpowder and sulphur store

Rocket casings

Rockets on display in the museum

Small cannon in store

Tranquebar

From Jaipur the Group travelled to the south of India, to Tamil Nadu, to discuss the possibilities of casting cannon. Our first stop, however, was the former Danish colony of Tranquebar, now called Tharangambadi. The settlement was established by the Danish Admiral Ove Gjedde in 1620 and a fortress, known as Dansborg, built there.

The town and the fort had been badly damaged in the tsunami of December 2004 and there has been a huge rebuilding programme of renovation and restoration - see http://www.tranquebar.in

The main building in Dansborg

The only surviving part of the walls that originally surrounded the settlement at Tranquebar

The Danish church at Tranquebar

Swamimalai

The state of Tamil Nadu in southern India was ruled from the 9th to the 13th centuries by the Chola dynasty, who were noted, among other achievements, for their skills in bronze casting - skills which are still in evidence today and it was here that we were hoping to find craftsmen who could cast cannon for us. The Group stayed in Swamimalai, some 25 km north east of Thanjavur and visited the noted bronze casters at Sri Jayam Industries, S Devasenapathy Sthapathy and Sons. This company, run by three brothers, is justly famous for the ability to cast high-quality bronze statues and works of art.

Sri Jayam Industries, S Devasenapathy Sthapathy and Sons in Swamimalai

Making a model out of wax

Here we discussed the possibility that they could cast cannon using traditional methods - essentially casting a gun in one piece using the lost wax process. After showing them the methods used in the past of how the model and mould were made, we came to an agreement that they would cast two cannon for us some time in 2017. As part of our visit, we were shown the casting of a small bronze piece. The Group was also able to visit Thanjavur, the ancient capital of the Chola Empire, and visit the museum there and see some of the famous Chola statuary for ourselves.

Once the wax model is complete a one-piece mould is made. They are then left to dry for at least a week and often longer

The mould is then baked to harden it - the wax melts and runs away

Once the mould is baked and hot and the wax has run out it is carried to the casting floor where a small depression has been made for it

The mould is still red hot from the baking process

A small crucible of bronze is being heated up - air is pumped into the fire by the small electric fan in the foreground

Pouring the bronze into the mould. The man kneeling down is holding a stick with a piece of sacking wrapped round the end and is holding back any dross on the top of the molten metal

Pondicherry

From Swamimalai the Group stayed briefly at Pondicherry, formerly a French colony south of Chennai. Here we were able to visit a traditional paper making company, Sri Aurabindo Handmade Paper (www.sriaurobindopaper.com). A brief discussion confirmed that they were able to make traditional cartridge paper from which we could make up the cartridges of powder necessary for the cannon trials.

The Group then returned home.

Summary

Following our conversation on the first day, with Rishabh Jain, the idea was discussed in detail among the Group and it was agreed that we would investigate the possibilities of carrying out the majority of the project in India. Most of the raw ingredients as well as the skills and experience are there and there seems no real reason not to carry out the work there rather than ship everything back to Europe. In addition, the very positive responses we had had from all our contacts more and more convinced us that this was a real possibility. In summary:

The saltpetre we need would be made and purified in Jalesar under the direction of Mr Mittal. We would also have the opportunity to fully document and record the process of saltpetre production.

The saltpetre would be supplied to Ganesh Explosives for the production of the necessary gunpowder, made using traditional methods to our specifications.

The very positive reaction from Mr Khimani in Jaipur also added to our hopes that we can do all the work in India - possibly basing the project at Jaigarh Fort.

Our visit to Swamimalai convinced us that the foundry under the Devasenapathy brothers can make bronze cannon cast in the traditional way.

Cartridge paper for the test firings could be acquired from Sri Aurabindo Handmade Paper in Pondicherry

The final large piece of the jigsaw, a suitable range on which we could carry out the test firings, could also be supplied by Rishabh Jain of Ganesh Explosives who said that he could help and find us a suitable site.

Our meeting and discussion with Dr Alok Kanungo would, we hope, lead to a cooperation between ourselves and his university, IIT Gandhinagar.

Members of the Group at Jaigarh Fort - Peter is second from left, Fred is third from thr right, Mr Khimani, second from right and Torben on the right

The additional materials we would need would be the sulphur for the gunpowder which we would still acquire in Iceland. The question of the charcoal needed would also need to be addressed and this might need to be made in Denmark and, together with the sulphur, shipped to India. We would also need suitable mounts and carriages which would be relatively easy to have made for us in India. Similarly the ammunition, cast-iron shot and stone balls, could easily be acquired in India.

The Ho Group - 2016

Peter Vemming Hansen – Director mag. art.
Middelaldercentret, Ved Hamborgskoven 2, DK 4800 Nykøbing F, Denmark
Telephone +45 54 86 19 34
peter@middelaldercentret.dk

Fred Hocker - Research Director
Vasa Museum, Swedish National Maritime Museums, P.O. Box 27131 | SE-102 52 Stockholm
Telephone +46 (0)8 519 548 06
fred.hocker@maritima.se

Kay Smith – Independent scholar
Hawthorne Cottage, Moorfield Road, Leeds, LS12 3SE, UK
Telephone +44 (0)113 263 7547
smithbrown@basiliscoe.fsnet.co.uk

Acknowledgments

We would like to extend our warmest thanks to Torben Sode who was our guide for our first week in India and put his extensive knowledge of India at our disposal - without him we would not have been as successful as we were.

We would also like to thank:

Mr Yunus Khimani, Director, Mararaja Sawai Man Singh II Museum, the City Palace, Jaipur
Aditya Mittal and his brothers, Mittal Group, Jalesar
S Devasenapathy Sthapathy Sons, Swamimalai
Rishabh Jain, Ganesh Explosives Pvt. Ltd, Dehradun
Dr Alok Kanungo, IIT Gandhinagar, Ahmedabad
Sri Aurobindo Handmade Papers, Pondicherry

Financial support
The Ho Group would like to thank the Middelaldercentret and the Friends of the Vasa for their generous support.