■ **Fig. 1** (left) Employees from the Medieval Centre re-enact medieval sulphur mining in Iceland ■ **Fig. 2** (right) Excavating animal dung from a pit at the Medieval Centre. The dong is used for producing saltpetre - unfortunately with little luck so far!

Early guns and gunpowder – experiments and ethnoarchaeological research

Experiments testing early gun powder recipes has grown into a complex study researching the gaining and processing of raw materials needed for gun powder production and the casting of bronze medieval guns.

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Introduction

Nobody knows for sure where gunpowder was invented, but the Chinese already knew about it around 1000 AD when it was used for fireworks and in primitive fireweapons. Gunpowder is made of three simple ingredients, which by themselves are relatively harmless, but put together act extremely violently and dangerously. These ingredients are sulphur, saltpetre and charcoal. The saltpetre provides oxygen for the pyrotechnical mixture, and the charcoal and sulphur deliver the fuel. The charcoal can be acquired easily, but it is much more difficult to get hold of the other two ingredients. Therefore, a reason for placing the invention of gunpowder in China is probably because saltpetre exists in a natural form there, as well as in the Bengal area in India. The third ingredient – sulphur – is found in volcanic areas.

It took around 200 years for gunpowder to reach Europe. Here the English monk and philosopher Roger Bacon speaks about it in a cryptogram dated to 1267, which presents the first gunpowder recipe: *"but from saltpetre and sulphur you make lightening, if you know the art!"*

It can hardly be questioned that the invention of gunpowder was brought to Europe by the Arabs, and that in the first couple of hundred years after its invention it came to the West via the old caravan roads from India. When the Turks took Constantinople in 1453 these old trade routes were cut off and it became necessary to find the seaway to India to get the valuable and precious saltpetre – and of course spices!

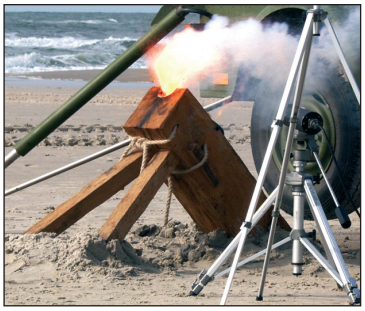
Sulphur is found in areas with volcanic activity, and to understand how sulphur was mined and processed one has to go to Iceland to the big thermal areas in the northern part of the country. At the locality Gásir local archaeologists from the Museum of Akureyri have excavated the first known sulphur trade stations. They are dated to the 14th century, and it was not only the raw sulphur that was traded at these stations, it was also cleaned and processed by heat-treatment into a form which was useful for gunpowder production. Sulphur was excavated from the huge deposits in northern Iceland and brought to the coast and from the trade stations onwards to Europe.

From the beginning of the 11th century sulphur was being exported from Iceland. It was used in the wine production in the south where barrels were cleaned with sulphur before being filled with wine. However, it is not until after 1300 AD that Europeans really begin to demand huge amounts of sulphur for gunpowder production.

Sulphur was sold in different qualities:

- 1 barrel raw sulphur
  = 1 barrel flour or 30 fish
- 1 barrel washed sulphur
  = 2 barrels flour or 60 fish
- 1 barrel heat-treated sulphur
  = 3 barrels flour or 90 fish

So much for the Icelandic peasant, but when the sulphur reached Europe its value increased 30 times!



■ **Fig. 3** The Loshult gun is fired with a lead ball and 20 grams of gunpowder. The ball reaches 1050 meters. Everything is documented by Military radar

The Europeans

There is no doubt that Europeans developed their first truly effective gunpowder recipes for use in guns and canons at the beginning of the 13th century. These recipes took hold with such a speed that by the 1350s the armouries in Europe already contained vast stores of guns and gunpowder. In 1350 the monk Francesco Petrach writes about the first canons on the battlefields of Europe:

These instruments, which fire metal balls with enormous bangs followed by lightening, were very rare a few years ago and were looked upon with great admiration and astonishment. Now they are as common as any other weapon. How fast and ingenious the human brain learns even the most difficult of arts!

Scholars have always considered early guns highly ineffective and difficult to properly aim. It is indeed true that great English battles in the "Hundred Year War" against the French were most likely won by the tactical use of the longbow rather than by gunpowder weapons. However, modern experiments at the Medieval Centre in Denmark with early guns and contemporary gunpowder recipes shows that these first canons and gunpowder mixes were extremely efficient on the battlefield. Today it is commonly recognized that the Europeans quickly learned how to use the gunpowder effectively, and we can see that these early gunpowder recipes are on the same level as modern ones. The primary reason as to why these early gunpowder weapons did not at once dominate the battlefields is not because Europeans did not understand how to use these new weapons, but because it was initially very hard to establish steady and reliable deliveries of the raw materials necessary for gunpowder production, namely saltpetre and sulphur.

■ **Fig. 4** Sulphur from Iceland – It needs to be cleaned purified before it can be used for gunpowder

For the past seven years an international group of scholars has been working at the Medieval Centre with gunpowder and canons in conjunction with the Danish Army. In an extensive process the early guns and gunpowder recipes were tested at the army's firing grounds. Slowly the group has opened up a small window into understanding early gunpowder production and the use of gunpowder weapons. There has also been a growing understanding of how people developed trade routes in order to get the valuable raw materials for gunpowder production, as well as how the invention of gunpowder – as important as the invention of the modern microchip – was the instrument in the rapid globalisation and development of the world we live in today.

The First Experiments

When the Medieval Centre undertook the first experiments in 2001 with a replica of the small Loshult gun – perhaps the oldest surviving gun in the world, found in Sweden – we used different medieval gunpowder recipes with very interesting results. However we quickly realised that even though the old gunpowder recipes were used, in order to get the highest possibility statement in our experiments we needed to use original, not modern, raw materials in the experimental work. The charcoal we were able to make ourselves with no problem. However, we had to go to Iceland to get sulphur from the same sources used in medieval times. At the same time we started the work of making saltpetre from old animal dung, a work that has not been successful as yet. Therefore, we sourced our sulphur from Iceland from original sources, acquired homemade charcoal as well as saltpetre from Chile, which was the saltpetre we believed came closest to the medieval saltpetre. The first experiments were repeated with the new materials, and we designed new experiments for refining the sulphur with old methods.

The Galathea 3 Expedition

A couple of years later these experiments were still going on, and the Ho Group was formed. At that time the Danish government started the third Galathea Expedition and called for projects. Every 50 years or so, a refurnished Danish battleship sails around the world packed with Danish scientist, collecting data for further research. Now the government had decided it was time for a third Galathea expedition. The Ho Group suggested a project on early guns and gunpowder, and got on board the ship for the Artic areas and the Bengal Bay of India. Unfortunately, prior to the ship leaving Denmark for the trip round the world, Denmark ran into the so-called 'Mohammad Crisis' and the expedition ship changed its route away from 'troubled waters.' This meant that the Ho Group suddenly became a land-based project, and the group was not able to use the research labs on board the ship.

The aim of the project was to document all the places in Iceland where sulphur deposits had been exploited in historical times and take samples from them all for further analysis. The first samples from Iceland, collected a few years ago, indicated that the Icelandic sulphur contained quite a bit of silicon and therefore water, as silicon is a hydrophilic (it attracts water). This meant that the cleansing process would be more effective because 'wet' sulphur is not the best for gunpowder production. The cleansing process of Icelandic sulphur thus

became a part of the project and the process was reconstructed from historical sources in cooperation with Akureyri Museum.

As part of the project we also planned to go to Sicily to locate sulphur sources on that island. On Sicily the sulphur is embedded in the rock and is mined in deep shafts. To extract the sulphur they burned it in a pit, in more or less the same way as charcoal is produced. This method is wasteful, but gives a very clean end product. The quality of the Sicilian sulphur could very well be the reason why this island rapidly took over the sulphur production for the world market from Iceland. Later on a big find of sulphur in Utah, USA was able to be sold and processed so cheaply that it took over the world market, and the economy of Sicily collapsed, because the landowners had risked everything in the sulphur production. The island experienced very tough times with huge social problems!

Another vital part of gunpowder is – as mentioned above – saltpetre. Saltpetre is found naturally along the Ganges River, where for centuries farmers have scraped the topsoil off the fields and extracted the valuable white powder every spring. This production was extremely intense, and for centuries Bengal was the saltpetre centre of the world until more effective explosives took over in modern times. From old English accounts the Ho Group has coordinates of a number of old production sites in the Bihar province, but the places are not easily accessible, and most likely impossible to find without local help. This we got from professor Balasubramaniam from the Indian University of Technology, Kanpur. With his students as guides and a modern GPS, we tried to locate the areas in question, but had to give up as it was too dangerous to drive around the different areas.

Instead, another approach was chosen. In the areas around the town of Agra numerous illegal firework factories produce primitive fireworks for Indian festivals like *Diwali*. If we could get in contact with one of these factories we could potentially follow the saltpetre backwards to the producer. This approach did not work out, as the farmers were extremely suspicious of us, but we managed to get an address of a modern saltpetre factory. This place produced saltpetre from modern chemicals, but being a family business they had been in the trade for generations, and after a while they showed the group the old facilities where, until recently, they had produced saltpetre from the top soil of the fields close to river Ganges using the traditional methods. The Ho group hired the factory, and the old people reconstructed the plant and actually produced saltpetre using traditional methods, which had probably been used since medieval times in that area. Due to this ethnological approach we were able, for the first time, to document the process and take samples for further analysis.

Afterwards, we followed the trade routes for saltpetre along the Ganges River to Calcutta (or Kolkata). Here the English had established themselves at Fort Wilson, and from this stronghold they claimed a monopoly on the saltpetre trade. The Danish colony Serampore, a little further up the river, was not strong enough to fight the English so it was sold for a little over one million rigsdaler. The Ho Group visited this old Danish colony, and knowing that the first Danish Galathea ship and expedition had been here 150 years earlier to hand over the colony to the English made the visit a bit emotional!

The Canon

Returning to the experiments that started it all, (the test shootings with the Loshult gun) we actually had a touch of bad conscience on this matter. The replica gun was made at a local foundry, but they had not mastered the old techniques, and the barrel had been bored out. This did not have any influence on the experimental results, but there was a wish to see and document bigger bronze corpus pieces being made with *cire perdue* or lost wax technique.

In the last couple of years the University of Moesgaard in Denmark has been experimenting with bell founding on the basis of early medieval accounts. They had succeeded in making a couple of bells, and they agreed to try and make

■ **Fig. 5a** Along the banks of the river Ganges the farmers every spring scrapes of the top soil in very thin layers to produce saltpetre

■ **Fig. 5b** The soil is put into a pit and water is poured over so that the saltpetre is extracted from the earth

■ **Fig. 5c** In huge evaporating tanks the water that contains saltpetre is boiled down

■ **Fig. 5d** Impurities such as common salt are removed

■ **Fig. 5e** After crystallizing it goes through a number of cleansing processes before it can be used in gunpowder production

the Loshult gun using the lost wax technique. They made a couple of guns but were not that satisfied with the finish on the surface – they simply lacked hundreds of years of experience. At this point we contacted the University of Kanpur again and were directed to a university in southern India in Bangalore – The Institute of Advanced Studies – and Dr. Sharada Srinivasan. Through her we contacted a highly reputed factory in the village of Swamimalai near Tanjavur and later went there to document the lost wax technique and to visit a nearby bell-foundry workshop.

In India many of the old crafts are preserved and alive today, even though they are rapidly disappearing. Much work is being done to preserve the crafts, but the work is enormous and the funds are few. In the workshop of Swamilai we found an unbroken line of 350 years of master bronze casters – the Sthapathys (which means 'master'). Mr. Devansenapathy, the present Master of the Workshop, is unmarried and devotes his entire life to this old craft. The workshop produces religious images in the old tradition using lost wax technique. A total of 20% of the earning of the workshop goes to the poor people in the village, another part goes to building houses for the workers and yet another part for running a school to educate new bronze casters in the old technique. This model of preserving crafts is in use in several places in India, but in many cases one also sees highly qualified craftsmen selling their work for the lowest price on the streets. Programmes that seeks to unite these crafts in communities, set up distribution systems for the finished products and make it worthwhile so that being a craftsman in modern India is highly prised – not just in India but anywhere where old crafts are in the danger of disappearing as victims of our modern world! The visit in the Tanjavur district and to the different workshops gave the bell- and canon founders of Aarhus University a gargantuan jump forward in knowledge and skill and they are now producing very good quality bronzes applying the Indian experience to local tradition.

■ **Fig. 6** The reconstructions department from Aarhus University is making an oven to cast a replica of the Loshult gun in lost wax technique

■ **Fig. 7** In Swamimalai in southern India, the ancient art of bell founding is demonstrated to the Danish museum representatives

The Future

The work with early guns and gunpowder has brought the Medieval Centre and the Ho Group quite a long way, but there is still quite a lot of field work and a lot of experiments to be done. However, slowly, year by year, the group has uncovers more and more knowledge of this fascinating subject. A wonderful story tells about times when the blast from a gun was considered a work of the devil. To prove this, a bishop took two canons and loaded them. In one of them he sprayed holy water and, as it would not fire, he had proven that it was the devil's making! Today we know a bit more about gunpowder, but studying early gunpowder is not a simple task and there remains much work to be done!

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Summary

Armes à feu et poudre à cannon - expériences et recherches ethnoarchéologiques

Les européens ont développé les premières recettes de poudre à canon utilisable dans des armes à feu au début du XIIIe siècle. Les expériences modernes ont démontré leur efficacité. La raison pour laquelle elles n'étaient pas utilisées plus fréquemment est probablement la difficulté de se procurer les matières premières. Lancées en 2001, les expérimentations au "Medieval Center" sont passées de l'utilisation de matériaux modernes au recours aux matériaux originaux cités dans les sources médiévales et à la production même de ces matières premières. Les recherches ont été ensuite approfondies avec la réalisation d'une arme reconstituée selon la technique originale de fonte à cire perdue.

Frühe Schusswaffen und Schießpulver – Experimente und ethnoarchäologische Forschung

Die Europäer entwickelten die ersten Anleitungen zur Herstellung von Schießpulver für Schusswaffen zu Beginn des 13. Jahrhunderts. Moderne Experimente zeigen, dass die frühen Waffen und das Schießpulver effektiv gewesen sind. Der Grund, weshalb sie nicht häufiger zum Einsatz kamen, mag darin liegen, dass es schwierig war, zuverlässige Lieferungen der notwendigen Rohstoffe zu gewährleisten. Die Experimente im Mittelalter-Zentrum wurden 2001 begonnen und entwickelten sich von der Nutzung moderner Materialien über die Herstellung originalgetreuer Zusammensetzungen bis zum Erwerb von Materialien aus den selben Rohstoffquellen wie im Mittelalter; dabei wurde dann auch die Verarbeitung und die Gewinnung des Rohmaterials genau beachtet. Weiter widmeten sich die Untersuchungen der Herstellung einer für die Versuche geeigneten Schusswaffe mit Hilfe des Gusses in verlorener Form.

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