Medieval Gunpowder Research Group

Sulphur from Iceland

A Galathea 3 Project

Report Number 5 – September 2006

Middelaldercentret, Nykøbing, Denmark

Introduction

Over the past 4 years the Ho Group has investigated a number of aspects of the properties of medieval black powder and has conducted experimental work to try to understand this important, and little understood, material. These have concentrated primarily on the composition of gunpowder mixtures and on the physical aspects of gunpowder and how these affect the burning rate and energy available – for example in test firings and measurement of muzzle velocities. In 2006 however the focus of the work of the Group returned to one of the least researched ingredient of black powder – sulphur, following up on the expedition of 2005 when the Group travelled to Iceland to develop contacts and links between archaeologists, historians and museum professionals.

Due to the kind contributions of the Danish Research Council, the Group, represented by Bob Smith, managed to write the results together for the previous years and get an excellent platform for future work. On the basis of this material the group applied for participation in the Galathea 3 Expedition, which resulted in funding for two more projects - sulphur from Iceland and saltpetre from Bengal in India.

In 2006 the first of these projects were carried out and we travelled to Iceland with the purpose of collecting samples of sulphur from as many sites as possible around the island. These can then be analysed with the aim to provide more detailed information about the form and purity of the sulphur produced for use in the making of black powder. The intention is to use this as a basis for a database of specimens from sulphur sources around the world, which, throughout time, have been used for gunpowder production

Sulphur in gunpowder

Gunpowder is made from three materials – saltpetre, charcoal and sulphur. In the last few years saltpetre has been the focus for research and investigation and a number of studies have appeared which are helping us to understand more fully just how it was made and processed in the medieval period. Charcoal has been the subject to a number of studies in the past – especially the effect of using different types of wood and the extent of charring. Sulphur however has never been looked at nor studied in detail and in 2006 it was decided that this ingredient of black powder would be the focus of our work. An extensive survey was made of the sulphur deposits on Iceland – known to have supplied northern Europe in particular in the medieval and early modern periods – with the intention of building up some knowledge of this particular ingredient of gunpowder.

Sulphur collection in Iceland

The aim of the first part of this research was to collect samples of sulphur from a range of known sites in Iceland which could then be analysed to gather information about its purity as well as the range of contaminants present. Information from the Geological Department of the University in Reykjavik listed possible sites where sulphur occurs on the island – some of which are known to be sites where sulphur was mined in the past. Samples of sulphur from each area as well as samples of water from each were collected for future analysis. The sites included:

Reykjanes - plenty
Krisuvik – plenty, mined
Geysir – small quantities
Hveravellir - plenty
Kerlingarfjöll - plenty

Kverkfjöll - plenty
Askja - plenty
Námafjall – plenty, mined
Krafla - plenty
Þeistareykir – plenty, mined

Monday 24 July 2006

The area of Lake Myvatn, most especially at the nearby site of Námafjall, is well known as an area of sulphur mining and this area was the first to be visited. Unfortunately the very wet weather of the preceding week meant that it was not possible to obtain a sample of the sulphur from this area but, as we had managed to acquire a sample here in 2005, this was not a problem. A sample of the water was taken from the southern shore of Lake Myvatn where the water was very clear, the lake bottom was pebbly and dark brown.

From there we drove some 30km north of Reykjahilð to the site of Þeistareykir – an extensive area of considerable activity with many pools, areas of white/yellow colouration and steam and vapour rising all around. However though the whole area seemed to be rich in sulphur there was, at first sight, little evidence of large deposits but just a very thin surface layer. However after climbing about 50 metres above the road to an area of hot activity, a more substantial sulphur deposit was found and a sample taken. The material collected was very bright yellow with a crystalline appearance and was very hot to the touch.

From there we retraced our journey and headed west from Reykjahilð to the Krafla area just to the north east of the Lake – a well-known volcanic region. The area examined was about 250 metres west of the road – called Leirhnjúkur. Here again large pools of water, vapour and obvious superficial signs of sulphur were noted but again much seemed just a superficial surface layer. On climbing higher however, richer deposits were found and two samples of sulphur collected – both bright yellow, crystalline and very hot to the touch though both with visible impurities.

On returning to the Lake Myvatn area, a sample of the water was taken from the kiesulguhr (commonly known as diatomite) workings just to the north of the road outside Reykjahilð.

Tuesday 25 July 2006

The next site investigated was in the Askja region, some 150km from Reykjahilð in the south east of the island, yet another well-known volcanic area. Though there was some evidence of sulphur in the area as a whole there did not appear to be appreciable quantities though there was considerable evidence of its presence in the crater of Viti. However, on closer inspection, this was found to be quite superficial and no significant deposits were found. A sample was taken though it contained a great deal of sediment and contaminants. A sample of water was also taken from the lake in the crater.

Wednesday 26 July 2006

The intention was to investigate the sulphur deposits in the area of Kverkfjöll on the northern edge of the Vatnajökull glacier. The deposits here are situated on the glacier and it required a day's journey to investigate. It was also clear that this area had not been explored nor investigated till the 19th century making it unlikely that sulphur was collected from here in the medieval period. With little time to investigate in detail it was decided, after discussion with the rangers, that it was not worth collecting sulphur here.

Figures 1 and 2. Left, the small 'crater' Viti, in the Askja region. On the right the sulphur deposits we found on the edges of the lake in the crater were not at all extensive

Thursday 27 July 2006

From Kverkfjöll we drove back westwards. Two areas were then explored. The first was Hveravellir on the northern edge of the Langjökull glacier. This small area of high geothermal energy showed considerable signs of sulphur. On closer inspection however this was found to be just a light surface layer and no substantial deposits were discovered and only a very small sample was taken.

From Hveravellir we drove some 40km east to Kerlingarfjöll just to the south of Hofsjökull. Here, at a considerable altitude we discovered a landscape very similar to that at Námafjall to the east of Lake Myvatn, with huge areas of what appeared to be sulphur. However it was impossible to get close to the larger deposits as there was a large river running through the area. A sample was collected though it appeared to be heavily contaminated with a sandy material. We stayed that night close to Geysir and a small sample was taken from the area though it is clear that here too the sulphur was just a superficial layer and not present in quantity.

Figure 3. Hveravellir with the Langjökull glacier in the background

Figure 4 and 5 One of the cones at Hveravellir with, on the right, a detail showing the sulphurous 'nozzle' from which the steam is gushing out

Figures 6 and 7. The area where sulphur was collected at Hveravellir with, on the left, a detail showing the paucity of the deposits

From here we went to Reykjanes where there is now a substantial thermal energy plant serving Reykjavik. However a site where there was evidence of sulphur was found and this was explored. At first there appeared to be only very impure sulphur deposits but on further examination more pure deposits were found and sampled.

Figure 8. View of Kerlingarfjöll

Figure 9. View of the sulphur at Geysir

Friday 28 July 2006

From Geysir we travelled to the far south western tip of the island. The area of Krysuvik was explored first. Here we found an area of very high geothermal energy with substantial evidence of sulphur and a sample was taken.

Figure 10. General view of the area of sulphur at Krysuvik

Figures 11 and 12. Collecting sulphur at Krysuvik

Figure 13. General view of the site at Reykjanes

Figures 14 and 15. Collecting sulphur at Reykjanes

Historical sites
Lars Barfod spend the time in Iceland visiting sites and investigating the possible routes of sulphur trade and history. Husavik, some 50km to the north of the Myvatn area, was important as a harbour. Though the terrain is rough, transport was not such a problem as it is largely downhill and, during the winter months, sledges could be used. In the south the important harbour was Hafnarfjodur.

Further information was also obtained from Kristian Jonasson of the Icelandic Institute of Natural History who also provided us with a sample of purified sulphur found in 1958 in a peat hut in the Námafyall area.

Preliminary observations and results
The expedition to Iceland was just the first stage in our investigation of sulphur and back powder. It is clear that some areas, especially, Námafjall, Krysuvik and Reykjanes have extensive sulphur deposits and these have been exploited in the past. At some sites, Kerlingarfjöll in particular, although sulphur is present in large quantities it was probably not exploited in the medieval period as they were just too far from trade routes and habitation. At some places, Hveravellir for example, there is just not enough sulphur to make collection feasible. Finally Askja and Kverkfjöll were just not explored till the 19th and even 20th centuries and could not have been exploited for sulphur in the medieval and early modern periods.
All the work undertaken was fully documented and a DVD of the expedition produced.

Future work
Now that we have samples of the sulphur from the various areas of Iceland we intend to have them analysed both for their sulphur content as well to discover what impurities are present. We aim to try to answer the question of just why sulphur from Iceland was not exploited further and why, in the later period, the powder makers in Scandinavia positively discriminated against it – preferring sulphur from other areas, notably Sicily.

Finally it is the aim of the gunpowder groups aim to build up a world-wide database of sulphur deposits exploited for making gunpowder throughout history.

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Samples collected in Iceland – 24-28 July 2006

Sample number	Material	Weight g	Place where sample taken	Coordinates	Notes
G3IS/1	Water	-	Lake Myvatn	65º 34. 204 N 016º 57. 203 W	Taken from the south shore of the lake. Water very clear, the bottom brown and speckled black.
G3IS/2	Sulphur	206	Þeistareykir	65º 52. 264 N 016º 58. 122 W	Sample taken from about 50 metres above the road. After scraping away the surface layer, the sulphur very clear and yellow with a crystalline appearance. Lumps broke up very easily. Hot to the touch
G3IS/3	Sulphur	219	Leirhnjúkur, Krafla	65º 43. 171 N 016º 47. 473 W	Sample taken from deposits on west side of road. Very hot to the touch. The sulphur mixed with quite a lot of visible impurities
G3IS/4	Water	-	Námafyall	65º 38 378 N 016º 51 860 W	Water taken from a pool just to the north of the road at Námafyall at the old working. Clear with fine silt bottom. About 25o C
G3IS/5	Sulphur	67	Viti - Askja	65º 02 772 N 016º 43 622 W At 1026 metres	Taken from inside the 'crater' at Viti. The sulphur just a light layer on the surface and very poor. Very hot to the touch
G3IS/6	Water	-	Viti – Askja	65º 02 772 N 016º 43 622 W At 1026 metres	Taken from water in the 'crater' – cool to the touch
G3IS/7	Sulphur	-	Hreravellir	64º 51 720 N 019º 33 257 W	Tiny sample scraped from the ground – the sulphur more a layer than a deposit. Could not find any real deposits
G3IS/8	Water	-	Hreravellir	64º 51 720 N 019º 33 257 W	Taken from main site – cool. Water running over hard deposit of sulphur
G3IS/9	Sulphur	115	Kerlingarfjöll	64º 38 687 N 019º 17 258 W	Taken from down near the river. Although I could see huge deposits of sulphurous material I could not get to them. Sample taken from huge yellow pile of sand/sulphur?
G3IS/10	Water	-	Geysir	64º 18 825 N 020º 18 103 W	About 30oC. Running over sulphur streaked rocks
G3IS/11	Sulphur	207	Krysuvik	63º 53 721 N 022º 03 440 W	
G3IS/12	Water	-	Krysuvik	63º 53 721 N 022º 03 440 W	
G3IS/13	Sulphur	77	Rejkjanes	63º 49 141 N 022º 41 136 W	Sample was very mixed with clay and appeared not to be very clean
G3IS/14	Sulphur	163	Rejkjanes	63º 49 141 N 022º 41 136 W	Much cleaner and purer sample of sulphur from very near the last sample (G3IS/13)
G3IS/15	Water	-	Rejkjanes	63º 49 141 N 022º 41 136 W	Very dirty grey colour
G3IS/16	Sulphur	17	Geysir	64º 18 825 N 020º 18 103 W	Sample was very mixed with clay and not very clean at all. Not much actual sulphur noted
G3IS/17	Water	-	The Blue Lagoon		From Blue Lagoon bathing area
G3IS/18	Water	-	Lake Myvatn		Sample taken from the lake near Reykjahlið
G3IS/19	Sulphur	274	The pass of Námaskard Myvatnssveit.		Cleaned sulphur. From a turf hut south of the road in the western part of the pass Námaskard, Myvatnssveit, Iceland. From the private collection of Svennir Björnsson, found in 1958 and donated to the Institute for Natural History, Rejkyavik, in 1984. Given to Lars Barfod by the Institute in 2006
G3IS/20	Sulphur	150	Leirhnjúkur, Krafla	65º 43 171 N 016º 47 473 W	Second sample from deposits of this site taken by Peter Vemming – see (G3IS/3)
G3IS/21	Sulphur		Námafjall		Collected in 2005