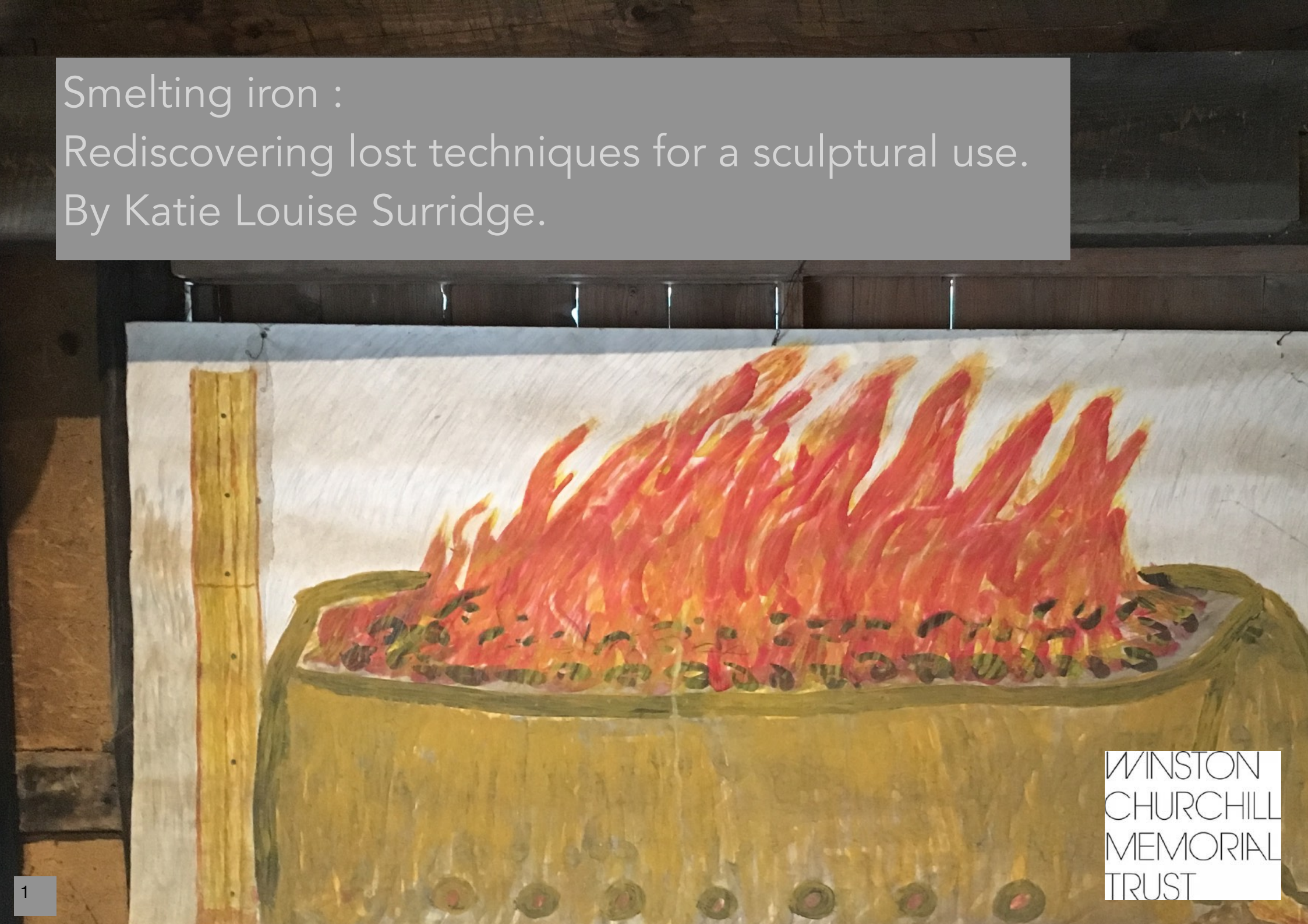
Smelting iron :
Rediscovering lost techniques for a sculptural use.

By Katie Louise Surridge.



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“Only a pure heart and a pure mind can create pure tamahagne.”
Mr Kihara. Murage at the Nittoho Tatara.

Contents page

Introduction.

Summary - What was researched.

Having completed three years training as a blacksmith I wanted to take the process back a step and research traditional methods of making steel, by smelting iron ore. Today the prevalence of mass manufactured steel has meant this technique is rarely practiced on a small scale. It's easy to forget how laborious the process was to create a bloom of iron.

I learnt the ancient technique of smelting. As a result of my WCMT research I am able to build and run my own smelting furnaces, based on the traditional designs I came into contact with whilst travelling.

The focus of my project is to use the steel I make in sculptures. Through this process I aim to gain a greater understanding of the value and history of steel. Blacksmiths today are reliant on modern industry to provide our raw material, something I want to break free of.

Key points - Aims of my research.

1) Gain an in-depth understanding of the processes and materials used in the formation of iron from ore, through hands on practical experimentation.
2) Study smelting in two different countries (Ireland and Japan) to allow for a wider, more varied growth of my own skills.
3) Learn how to build and run different types of smelting furnace safely and efficiently, to allow for technique comparison.
4) Learn how to consolidate the resulting bloom into steel, which can then be used in my forged sculptural work.
5) Work with other blacksmiths and smelters from around the world to expand my skill set, knowledge and confidence in new areas of metal working.
6) Document my learning process whilst travelling. Make this information available to others wishing to learn more about smelting processes.
7) Take these experiences back to the UK to develop and build my own furnaces. Practice these methods of smelting until I am confident with my technique.
8) Structure a workshop suitable for all ages, to pass on methods of iron production. This workshop will focus on the sculptural use of the iron created.

Glossary

- Smelting - A process of applying heat to ore in order to extract out a base metal. It is a form of extractive metallurgy.
- Iron ore - Iron ores are rocks and minerals from which metallic iron can be extracted.
- Bloomery furnace - A type of furnace once used widely for smelting iron from its oxides. The bloomery was the earliest form of smelter capable of smelting iron.
- Blast furnace - A type of metallurgical furnace used for smelting to produce industrial metals, generally pig iron.
- Bloom - A porous mass of iron and slag. Must be refined by consolidation before it is useable in forged work.
- Bloomery iron - Iron produced from the refining of a bloom.
- Steel - An alloy of iron and carbon and other elements.
- Pig iron / cast iron - Has a high carbon content, between 2.1% to 4%. It is very brittle and cant be forged.
- Wrought iron - Is an iron alloy with a very low carbon (less than 0.08%) content. The modern functional equivalent of wrought iron is mild or low carbon steel.
- Meteoric iron - Iron from meteorites which does not need any processing to use. It exists in its raw state and is extremely rare.
- Flux - It is a material used to promote the fusion of metals.
- Slip - A liquid mix of clay and sand.
- Tuyeres - A nozzle through which air is forced into a furnace, or forge.
- Direct reduction - The process by which iron oxides are reduced to metallic iron, at temperatures below the melting point of iron, by a reducing gas.

Japanese terminology.

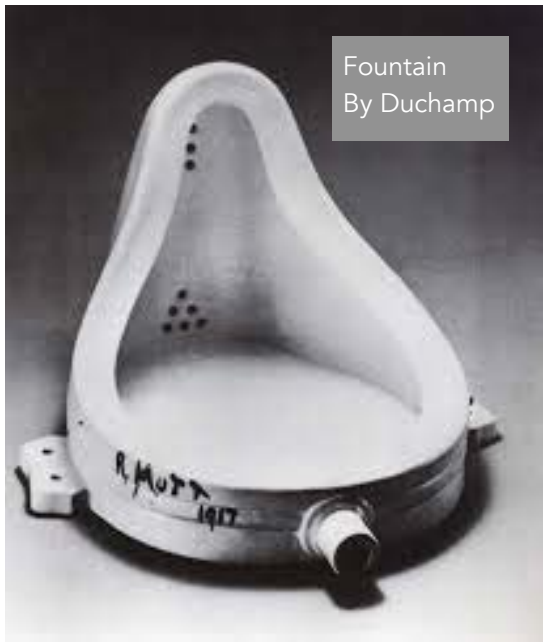
- Wakou - Japanese steel produced by the smelting of fine iron sand.
- Tamahagne - A kind of traditional Japanese steel made by tatara smelting. The name tamahagne is given only to the highest quality wakou with few impurities. It contains 1- 1.5 % carbon.
- Kera - The resulting bloom from a tatara. A mix of steel, iron and slag which will later be smashed and divided in to its components of varying carbon content and quality.
- Murage - A special job title in Japan to express the chief executive of smelting and main bearer of the tradition knowledge. They are responsible for passing this knowledge on to trainees, in tact, so it is not lost
- Tatara - The clay furnace in which iron sand is smelted. It uses clay for the walls , iron sand as the material being smelted and charcoal as the fuel. The furnace is rebuilt each operation.
- Katana - Japanese swords.
- Akome and Masa - Types of iron sand.
- Zuku - Japanese cast iron from iron sand.
- Kanna Nagashi - Instead of collecting by hand the Japanese derived this ingenious method of using water and gravity to harvest and sort the iron sand.
- Nendo - Japanese red clay.
- Satetsu - Sand in Japanese.

The lead up to the project.

In 2016 I attended a course in flint knapping. I was becoming increasingly interested in researching early mans skills, and thinking about how to use these within my art work. At the same time I was studying at the National School of Blacksmithing in Hereford. I had decided to enrol on this course as along side my interest in ancient technology, I was I was getting more and more frustrated with the craftsmanship I saw in galleries and exhibitions. I wanted to make things which would last, required technical skill in their creation, and that were not made from easily purchased or disposable items, like I saw in a lot of contemporary art.

Blacksmithing was where I was drawn. The undeniable permanence of metals and the urge to understand the mastery of fire was key to this. My aim was to learn these ancient skills and manipulate them in a way which a traditional blacksmith may not consider.

I appreciate the use of found objects in art and value the huge change to the art world Duchamp made when he displayed *Fountain* in April 1917. This piece was a urinal chosen by Duchamp and submitted for an exhibition of the 'Society of Independent Artists', staged at The Grand Central Palace in New York.



Fountain
By Duchamp

Fountain , is what now is known as a 'readymade', an ordinary manufactured object re-labelled by the artist as a work of art. There is no doubt in my mind that this was an important moment in art history. It is something I employ in my practice, but somehow excessive use of this technique seemed less valid to me in the context of my own work, once I started forging.

If we look back in history people had to physically work to make a 'work of art' . Early painters had to crush rocks to make their own pigments, potters dig for clay to throw. I wanted to challenge myself when making art, and use forging techniques to create unique objects at the opposite end of the spectrum to the ready made.

My favourite exhibition was 'The tomb of the unknown crafts man' by the British artist Grayson Perry. It show cased Perry's response to items in the British museum's collection. The exhibition pays homage to generations of people, unknown people, who created and made incredible, fascinating, confusing, mystical things. It valued the work of the skilled maker, whose name may have been forgotten, yet their objects still grasp and hold our attention.


Old iron work I like in the V and A made using smelted steel.

I am drawn to well made works of art and hold them in high regard. There is something indescribably ‘of worth’ about these objects and I don't mean this in a monetary way . Beautifully hand crafted things, both modern and old, sit on a pedestal for me. I believe they take on the personality of the maker during their creation, they almost gain a soul, and this is what we are attracted to. I knew I wanted to forge things which had this ability to demand attention or a second though, but was unsure as how to go about this using modern materials.

Blacksmithing is a craft which uses many of the same tools today as when it first started, in this sense there is a strong connection between metal workers of the past and present. When I look at early iron work I am first filled with wonder at the lack of modern technology that would have been available to make the steel used in these beautiful items.

I value the hands on approach of the ancient blacksmith who would first have had to have the knowledge of smelting, to make the material with which he works. Today we come from a world where stock can easily be bought. I realised the modern steel I use in my work was the disconnection to the past I was feeling, and by understanding the process of making my own I would be able to create sculptural works with another layer of meaning to them.

Thanks to my formal training at the National School of Blacksmithing I now had a skill set from which to draw from and it seemed obvious that I should next learn how to make the raw material I use in the forge.

Old iron work I like in the V and A made using smelted steel.

Smelting in the UK - Project relevance and impact.

Through the research conducted for my WCMT application I discovered that not only was smelting hardly practiced anywhere in the world on a notable scale, the community of people smelting around the world for research, or creative purposes, is also much smaller than I had imagined.

This initially posed problems as it jeopardised my whole proposal. If there was no one or nowhere willing to teach me or to make contact with abroad, then there was no place to travel to on my WCMT Fellowship. This really highlighted to me the need to relearn this ancient skill and reintroduced it in to the UK, in a manner that inspires new interest in the topic. Using hand smelted iron in sculpture seemed the obvious way to demonstrate the beauty of the hand made, and inspire others to learn.

In the UK there are a few people who are perhaps more experiential and less experimental in their approach to smelting. Much of their research is specifically for archeological purposes. They are more interested in the slag produced (its composition tells them more about what went on inside the furnace), or rebuilding furnaces based on archeological remains. It seemed that no one was interested in making steel and then using it in a sculptural way or really in any way at all, aside from a very small handful of blade smiths.

In the UK we are lucky to have a long history of iron work and many early examples are still intact or preserved. I realised how important it is to the history of British iron work to continue this tradition of a blacksmith being able to source raw materials, smelt them and forge the resultant steel or wrought iron into a final piece.

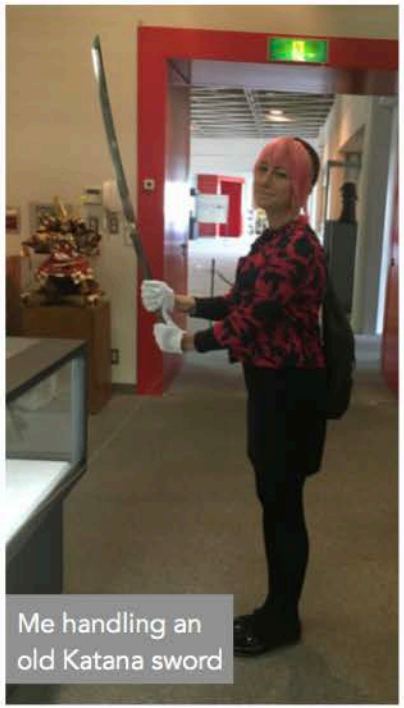
By eschewing material knowledge we cease to understand the world around us. The funding has given me the chance to relearn and eventually re-share these ancient skills with in the UK and use them in a contemporary and exciting way, which I hope will promote new interest in British ironwork.

Me and my furnace design in Ireland.

Background - Why I chose Japan and Ireland.

As smelting is such a hands on activity I felt as if it was something which I needed to be physically taught to understand. I began researching where It was still practiced and I was immediately struck with numerous walls.

It seemed that much of this ancient knowledge ceased to still be practiced on a day to day basis. Universally smelting is a dying craft, with the prevalence of mass manufactured and scrap steel, hardy anywhere in the world still practices production on a small scale. This is mainly because of economic reasons. The time and effort spent sourcing ore and clay and high cost / lack of availability of charcoal means that most places which once smelted now rely on modern products, or recycled steel.



Me handling an old Katana sword

Japan is the only country in the world where masters still practice the craft of smelting in a way which is economically viable. The world famous tamahagne, is Japanese high quality steel smelted from iron sand. It is used in swords, or Katana, which are still highly valuable and collected items. Sword smiths must train as an apprentice for a minimum of five years and then apply for a government licence to be allowed to practice and make katana.

In 1977 the production of Tamahagne was chosen as one of the 'Selected conservation techniques' safeguarded by the Japanese Law for the Protection of Cultural Property. Their aim is to preserve historically important cultural techniques, skills, tools and practices so that they are handed down to the next generation in 'good condition'.

At the same time 'The Society for the preservation of Japanese art swords' was recognised as the conservation body which promotes this conservation. Two chief engineers or 'Murages' were also designated as cultural properties. I met and spent time with Mr Kihara, one of the murages trained by the last surviving holder of this ancient knowledge, so the rich history and tradition was preserved.

Me and Mr Kihara

The Nittoho tatara was built in 1977, on the site of the last functioning tatara in Japan , the former Yasukuno tatara. This was supported by Hitachi metals. Smelting, which had ceased production from after WW2 (due to a law making it illegal to make steel or for the Japanese people to own swords, from the General headquarters of the supreme commander for the allied powers) was reinstated here. This ancient technique which was almost lost is now practiced 2-3 times a year in this special facility.

This situation is unique to the world. There is a continuation of the traditional methods. The skills, tooling and secrets of smelting worked out over generations, have been preserved. This 'cultural property' of Japan stands alone as an important place to visit, it is the only place in the world smelting on any recognisable scale.

The Nittoho Tatara

Because of the government protected status of Tamahagne, and the dedicated Nithotto tatara facility, the production and use of this steel is held in high regard and many people are interested or involved with its use across the county and world-wide.

Ireland was my other choice of places to visit, not because of a dedicated centre for preserving traditional techniques, but due to the fact the 'Furnace festival' was being held there. This was the 3rd Furnace Festival organised by the Sliabh Aughty Furnace Project, which focused on producing iron from locally sourced ore.

The Furnace festival site in Woodford.

Lee Sauder and his furnace design.

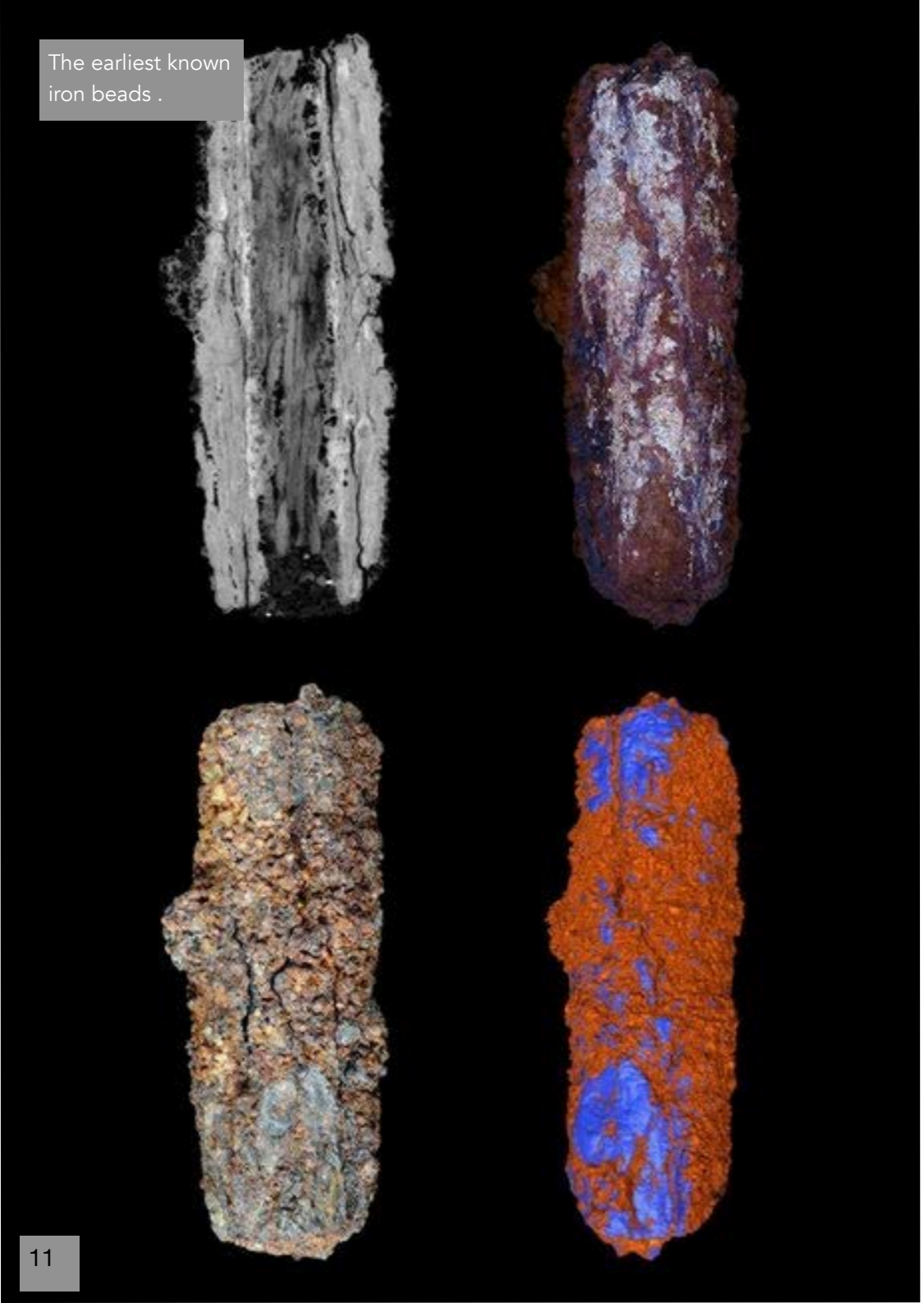
The Furnace festival site in Woodford.

This concept was important to me as learning how to use and collect all the materials is something key to my research. The furnaces people built here are on a smaller scale still to the Nittoho Tatara operation, and therefore a more feasible and cost-effective way for me to develop the use of smelted iron in my own sculptures.

As the smelting community is very small this annual gathering of around 40 people all involved with smelting was a great way for me to be introduced to a number of different furnace designs. The festival would be a chance for me to learn with some of the most experienced people in this unique field, and also make contacts from around the world.

The week before the Festival, six local people were also to be trained in the skills of bloomery iron making by Lee Sauder from the USA. He is of particular interest to me because of his unique take on smelting. I think he is one of the few blacksmiths in the world using hand made steel for a sculptural purpose.

The two places are obviously very different. From the start I was presented with big language issues when contacting or talking to people in Japan about smelting. However the context in which I experienced smelting once there was infused with tradition and culture and very inspiring to the creation of sculpture. What I experienced in Ireland could all be discussed and explained easily with no language barriers. However, it was not a direct passing on of traditional knowledge, but results of much trial and error of modern smelters. Both places play an important part in my accumulation of knowledge and therefore presented equally beneficial reasons to visit.



The earliest known iron beads .

A brief history of ancient iron.

The earliest known iron artefacts are nine small beads dated to circa 3200 BC, from two burials in Gerzeh, northern Egypt. They were made from meteoritic iron. Before the start of iron smelting, meteoric iron was the only source of iron metal, apart from minor amounts of telluric iron. Telluric iron originates on Earth, and is found in a metallic form rather than as an ore. Both are extremely rare, they are useable in their found state, there is no smelting required to extract the iron. Meteoritic and telluric iron were both already in use before the beginning of the iron age to make cultural objects, tools and weapons.

The precise date and time when the smelting of iron from ores began is not known (there are many different ideas which I do not want to lay claim to with in this report), but by the end of the 2nd millennium BC iron was being produced from iron ores from Sub-Saharan Africa to China. The Iron Age is defined by the widespread replacement of bronze weapons and tools with those of iron and steel. This transition happened at different times in different places, as the technology spread.

Iron smelting is the extraction of usable metal from oxidized iron ores. It is more difficult than tin and copper smelting because it requires much higher temperatures only reached in specially designed furnaces, hence why the bronze age preceded the iron age. Copper and its alloys can be cold-worked or melted in relatively simple furnaces such similar to the kilns used for pottery.

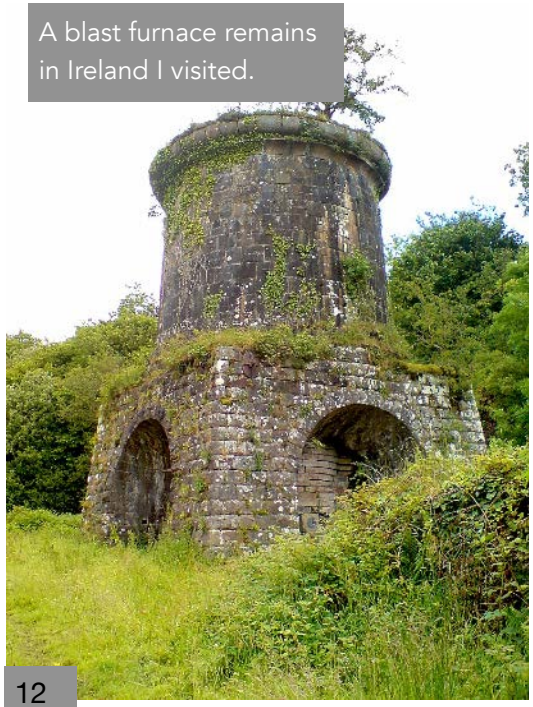
Many people I discussed the origins of smelting with during the trip suggest that it started with potters whom already had the experience of making clay furnaces and an understanding of fire management to reach the temperatures they required. Smelted iron requires hot-working and can be melted only in specially designed furnaces which means its discovery was never an accident, ancient people made a considered decision to build these.

The process - An introduction.

The technique I am studying is known as the bloomery process. A bloomery is a type of ancient furnace, once the only known way for smelting iron from its oxides. The main components are charcoal as fuel, iron ore, an air source and a furnace made of clay.

I am not a chemist and will explain what I have come to understand happens in simple terms. Lee Sauder especially highlighted to me the importance of having a basic idea of what is happening chemically. Knowing this can give you clues to as what is occurring inside your furnace and how you can adjust its running. He also is a strong believer in the value of practical experience 'don't blindly trust what anyone tells you. Trust your eyes and your experience and your instinct' .

Iron ore varies in its chemical composition, aside from the other compounds it contains a high level of iron oxide is key (over 70% was recommended to me for a successful smelt). Iron oxides are made up of combinations of different numbers of iron and oxygen molecules. The bloomery process reduces iron ore to iron via direct reduction. Direct reduction is the process by which iron oxides are reduced to metallic iron, at temperatures below the melting point of iron (1,538 °C), by a reducing gas.



A blast furnace remains in Ireland I visited.

Bloomery furnaces were the earliest means of obtaining iron from ores, before the development of blast furnaces. Blast furnaces produced pig iron or cast iron, which was a higher carbon content. Cast iron occurs when the iron melts and absorbs 2% to 4% carbon. This must be further refined to make steel. This additional refining of cast iron is still considered more cost effective today than bloomery production due to the huge scale possible of the blast furnace operation, and the amount it can continuously produce.

The use of bloomery furnaces is a much smaller scale operation compared to the blast furnaces, and is where my research will be focused. They also operate at relatively lower temperatures (around 1300°C). The disadvantage, relative to a blast furnace, is that only very small quantities of iron can be made at a time.

Molten slag exiting a furnace.

The bloomery process does not produce liquid cast iron like the blast furnace. What we see running out is the slag, the waste material created during the process. With the bloomery process a bloom is left inside the furnace. A bloom is a spongy and porous mass of malleable iron and other waste materials in the form of slag. This mix of slag and iron is also know as sponge iron and must be consolidated by repeatedly heating and hitting it, removing impurities as it is forged. Only through this is it fully processed into a material useful to the blacksmith.

This being said with experience a smelter may be able to control the temperature and adjust the furnace and material input so that cast iron can be made on purpose, like I witnessed at the Niimi City Tatara festival. Cast iron cannot be forged it is too brittle,

but as the name suggests is a very interesting material for casting. Although I did witness the production of cast iron (Zuku) my focus is currently to make forgeable iron. However it is an interesting future for my work once I develop my smelting skills.

Zuku being made at Niimi Tatara festival. The white sparkling nature what is running out indicates cast iron not slag.

A bloomery furnace in Ireland.

A bloomery consists of a pit or chimney like structure with walls made of a mix of clay, sand and sometimes natural fibres such as straw. They vary in shape, size, and design. Near the bottom, one or more pipes enter through the side walls. These pipes, called tuyeres, and allow air to enter the furnace. In the past this air is forced in from hand operated bellows, in more recent times electric blowers are used. The air flow is essential as it allows the charcoal to burn at higher temperatures and the reactions to occur.

The first step taken before the bloomery furnace can operate is the preparation of the charcoal and the iron ore. The charcoal is the only fuel suitable to smelt with. It is made by the slow burning of wood in the absence of oxygen, producing the nearly pure carbon fuel needed for the reductive smelting process. The ore is broken into small pieces and usually pre roasted in a fire to remove any moisture and being the reductive process.

Iron is the most abundant element on earth, but iron oxide is the most common the form in which we find it. Iron and oxygen love to combine, we see this in how quickly untreated steel will rust! However at temperatures over 900°C the oxygen wants to break away and prefers to combine with carbon. Put simply inside the furnace the iron ore is reduced by carbon produced from burning of charcoal. This reduces the iron oxides in the ore to metallic iron, without melting the ore. The carbon joins with the oxygen contained in the iron oxide, to create carbon dioxide or monoxide. This exits from the top of the furnace and leaves behind iron.

These tiny iron particles from the iron oxide sink to the bottom of the furnace and fall into a pool of slag which is forming here. Slag is a waste material in the process , (made from other elements contained in the ore and the clay walls) but is also essential for the formation of iron. Luckily it has a lower melting temperature than iron and so the slag pool can form. This is important as it protects the tiny iron particles with in it from burning.

The iron particles gather in the slag and eventually join to form a bloom. The slag must be liquid to allow this to happen. Slag has a high iron content and also contains silicon a very common impurity of iron ore, and oxygen, and with the iron they combine to form fayalite

The desired product of a bloomery is steel or wrought iron which is easily forgeable, it requires a low carbon content. An opening at the bottom of the bloomery may be used to remove the bloom, or the bloomery can be tipped over and the bloom removed from the top.

A bloom of iron cut in half on a log

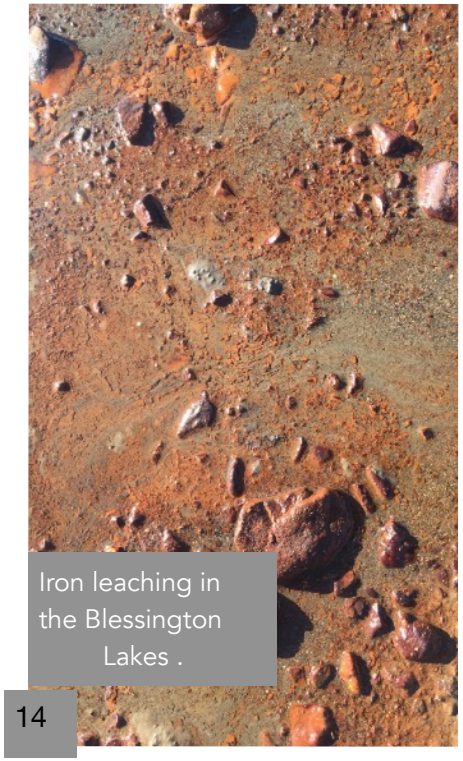
Findings

Part one - The all important Iron ore

Collecting ore in Ireland

From my travels I have discovered that there is no text book correct way to smelt. The process varies dramatically from place to place, person to person. At the furnace festival 13 different furnaces were built by different teams. They all used different techniques and styles. One of the key concerns from the smelters was the ore quality. A key factor to the whole process is a reliable source of iron ore. Without a good quality ore with a high iron oxide content the creation of steel is not possible in a bloomery furnace.

Collecting iron ore was my first job in Ireland. I wanted to experience sourcing ore alone to fully understand the process from start to finish. I was recommended three different locations possibly containing iron ore. What I discovered was ore collection isn't as easy as first expected and presented the first challenge of the whole process.



Iron leaching in the Blessington Lakes .

Abandoned iron ore mine in Blessington.

Location one was a lake bed where there was apparently some bog ore, but all I found was iron leaching into the water. The next location was an abandoned iron ore mine which was essentially a rocky outcrop that had been mined in the past. I collected some samples by sledge hammering boulders left on the floor.

Several lessons can be learnt here. The locations were remote and not always accessible by vehicle. It was often a long walk up and heavy work collecting ore but this should not be off putting. It is a majorly important part of the process for me and so the hard work was expected. The collection of ore should be factored in to the process.

As I had no previous experience what I collected from the second site did not have a high enough iron oxide content and was too quartzy. This was obviously a good source at one point as Paul Rondalez had access to archeological documentation saying it was once a ore mine, however I had selected pieces from the ground. These had obviously already been discarded by people removing the ore in the past. I learnt that it is really important to think about your actions when sourcing ore. Either work with a geologist or a renown source of ore in the first place to avoid the disappointment of hauling large amounts of rock across country by hand.

Other ideas shared with me were to use old maps that mark iron works or mines. This was the case of the third location in Arigna. This location was a river bed which had been marked on an old map of the area as an iron ore mine. Whats more there was good information available online about a rich mining history in the area. A local mountain was named 'Sliabh an Larainn' this translates literally as the "Mountain of the Iron'. It originates from an appreciation of the Iron ore that is present in high quantities within it. Clues like this can also help when sourcing ore. From the riverbed I collected a dense dark stone, which was later chemically analysed in a laboratory for me by a scientist and identified as Siderite.

I had luckily collected enough of this siderite ore from the river to be able to do a smelt at the furnace festival. This site was documented and I returned here after the festival and collected a large amount of this to bring back to the UK and practice my smelting with.

The other ore we collected during the furnace festival was a bog ore. This was what everyone else used at the festival. For me the whole purpose and importance of smelting is to be able to understand and take charge of the full process of creating

steel, from ore collecting to finished sculpture so I also helped collect this, and smelted once using it.

Bog ore is a form of impure iron deposit that develops in bogs or swamps by the chemical or biochemical oxidation of iron carried in solution. Iron-bearing groundwater typically emerges as a spring. It used to be a very important source of ore before better alternatives like banded iron formations were discovered. Bog iron may in many cases be quite rich in iron. The main problem is that it forms only a thin layer of rust-colored and porous layer at the bottom of bogs. Bog iron is associated with bogs because bog water contains very little oxygen and can therefore hold iron.

Some of the smelting teams trainees had already visited this site in early 2018. Due to the hot dry summer, what had been freezing swamp like conditions in March, was now a lot drier, meaning that we could drive a jeep over the bog to the site of the ore. Before the team had to walk over 200 m with heavy bags on their backs through the bogs! The land was still rough and damp with long reed like grasses but we had a 4x4. Tooling and support when collecting ore on any scale is important to bear in mind.

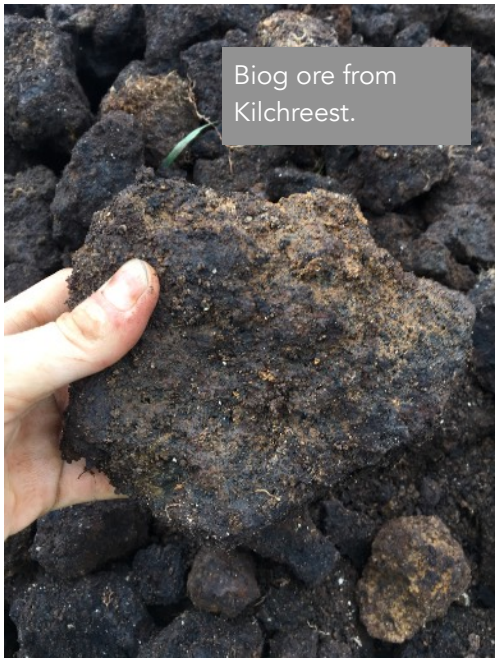
Paul took us to one of the small mounds they had worked near before. Without this experience or his prior research work it would have been hard to notice ore was present as nothing was visible from the surface with out digging.

This ore had been found because a local historical group had thought they had found a ring fort up at Kilchreest. An archaeologist had been called in who did some of his own digging at thought what lay beneath the surface was burnt material. Finally Paul was called in who instantly recognised it as bog ore, this is just sitting with in the mounds just below the sods.

The sods were removed and then there was 10-30cm of a manganese's rich layer, below which lay the ore. The manganese was black and easily crumbled in the hand, although some is ok and helps slag formation we did not collect this as later layers had it mixed in. Below this the ore then started to form and was found in varying states and colours. Towards the surface it was a lot softer. As we dug down it became denser, harder and darker in colour.

On testing with a magnet none of the ores previously mentioned were magnetic prior to roasting, so this is not an option to help collect them.

Quartzy ore from the Blessington mine.

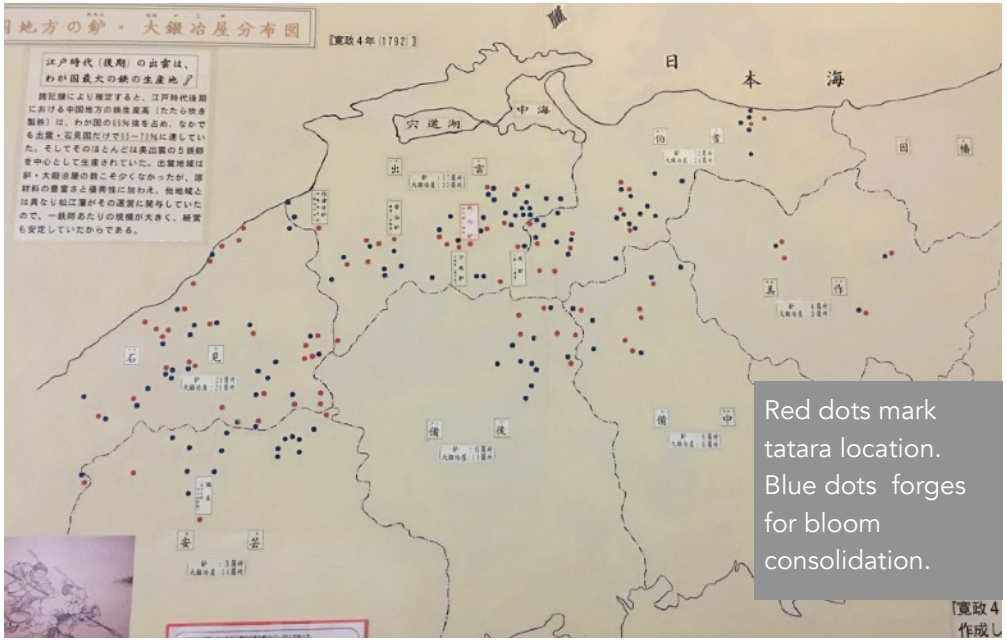


Biog ore from Kilchreest.

Siderite from the river bed in Arigna

Collecting ore in Japan

In Japan I travelled to the Shimane province, one of the early centres of iron production. Here was once a concentration of smelting experts unique to the world. Historical records show the high number of tataras operating in the area.



Red dots mark tatara location. Blue dots forges for bloom consolidation.

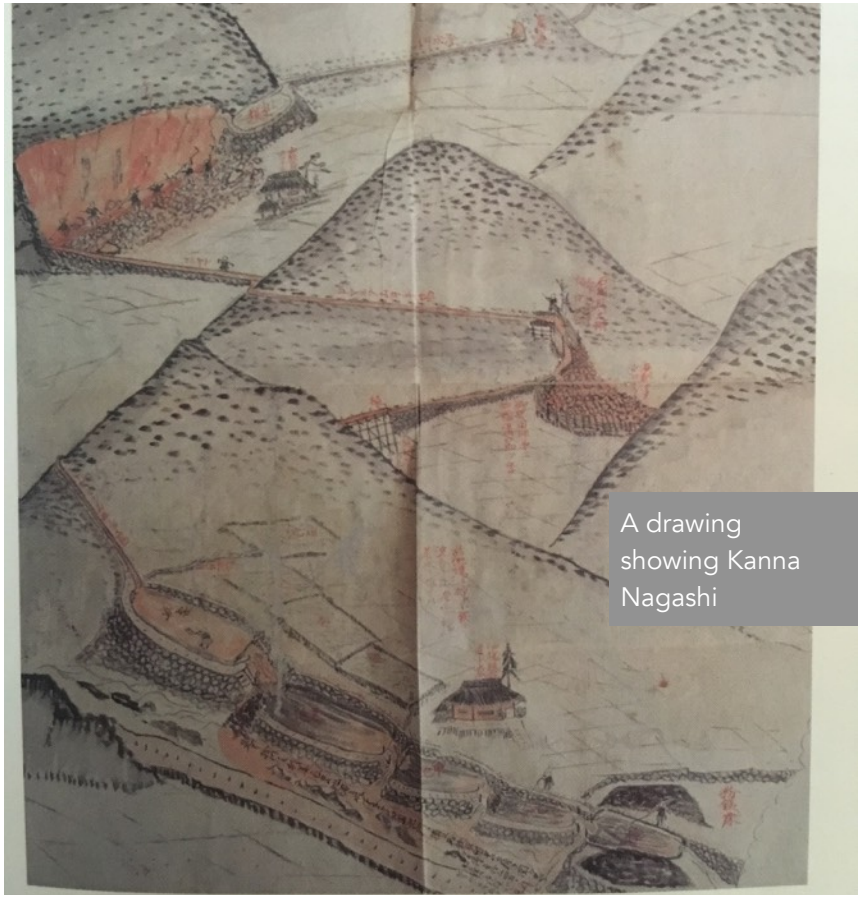
Yasugi is still heavily involved in modern steel production, it is known also as "steel town". It is set on a natural harbour and is also near the Chūgoku mountains where there are rich deposits of high quality iron sand.

Iron sand or Magnetite is the ore used for the Tatara process. There are two types of iron sand 'Akome' and 'Masa'. Masa iron sand is typically found in the mountain regions I visited, and is used for Kera production in the tatara process. It is formed from weathered granite rock. Akome sand has a lower melting point and so is used in the production of 'Zuku' or cast iron.

According to 'Tetsu - zan Hisho', 'Secrets of the iron mountain', written by Shigenaka Shimohara in the Edo period 'In order to produce high quality iron, the quality of the iron sand is the first priority and this is a basic concept of tatara operation'. Once the high quality iron sand had been discovered here a wealth of industry was set up involved in the formation of iron, which made the clans very rich in the 16th Century.

The iron sand is classified into three categories. 'Kawa satetsu" is iron sand made from erosion of river beds, and Hama satetsu is collected at river mouths. Yama satetsu (mountain iron sand) is the best quality sand used in the tatara, which is produced by Kanna Nagashi.

Instead of collecting ore by hand the Japanese derived and ingenious method of using water and gravity to harvest and sort the iron sand, called Kanna Nagashi. First areas were stripped of forest by burning. The person harvesting the sand chooses a point in the mountain where the iron sand is contained in very soft granite, with a high iron content. This is mined out and then placed in a pond with a water source in and out of it. The iron sand is very heavy and using the power of gravity the water flows down stream through several ponds. The lighter non iron material flows down stream and is removed in side channels. The heavy iron sand sinks to the bottom and so sorted from the waste materials. The process is very efficient and a 80-90% purity can be achieved this way.



A drawing showing Kanna Nagashi

It is important to note the scale of these operations. Around 1000 cubic meters of mountain was removed to produce about 4m cubed of iron sand. Whole stretches of mountains were physically dug away, leaving the 'Tanada' rice terraces we see today. The production of tatara steel in the 1600's was landscape altering. This highly efficient system is unique in the world and allowed the mass collection of iron ore with relatively low technology and effort.

Between 1600 - 1630 the Lord of Matsue actually banned smelting because it was silting up rivers and the acidic nature of the water meant crops were failing. He eventually allowed it to go on in the winter months when the crops were not effected, due to the huge loss of wealth banning it caused. The climate is also less moist in winter and cooler for tatara workers, better operating conditions which are still adhered to today in the Nithotto tatara.

For my needs collecting the iron sand is also possible on a much smaller scale as the magnetite is magnetic in its natural state, even with out roasting. This meant that I was able to pass a strong magnet over the river bed and collect it. Once collected it was purified by passing the magnet over it several more times so that any waste material was left behind.

Collecting iron sand with a strong magnet.

The iron sand is contained in very soft granite rock which crumbles in your hand.

Collecting iron sand with a strong magnet.

Preparing the ore.

Roasting.

Once a reliable source of ore has been identified it must usually be roasted. The aim of roasting is to drive out moisture, and some of the other compounds to leave behind an oxide . It also helps break it down in to smaller pieces that are better to smelt with .

Of the ore I had collected my self the only promising stuff was from the river bed in Arigna. Due to the dense rock like nature of this ore Lee advised it was best to contain it when roasting, as at high temperatures it was likely to explode. To do this an oil drum was used and I made air holes up the side to allow the draw needed. The ore was broken down in to smaller pieces (about golf ball size) and alternate layers of wood and then added to a fire in the drum.This was then left overnight to burn down and properly roast. The temperature should not me too high or the ore will start to melt. A orange colour is ideal.

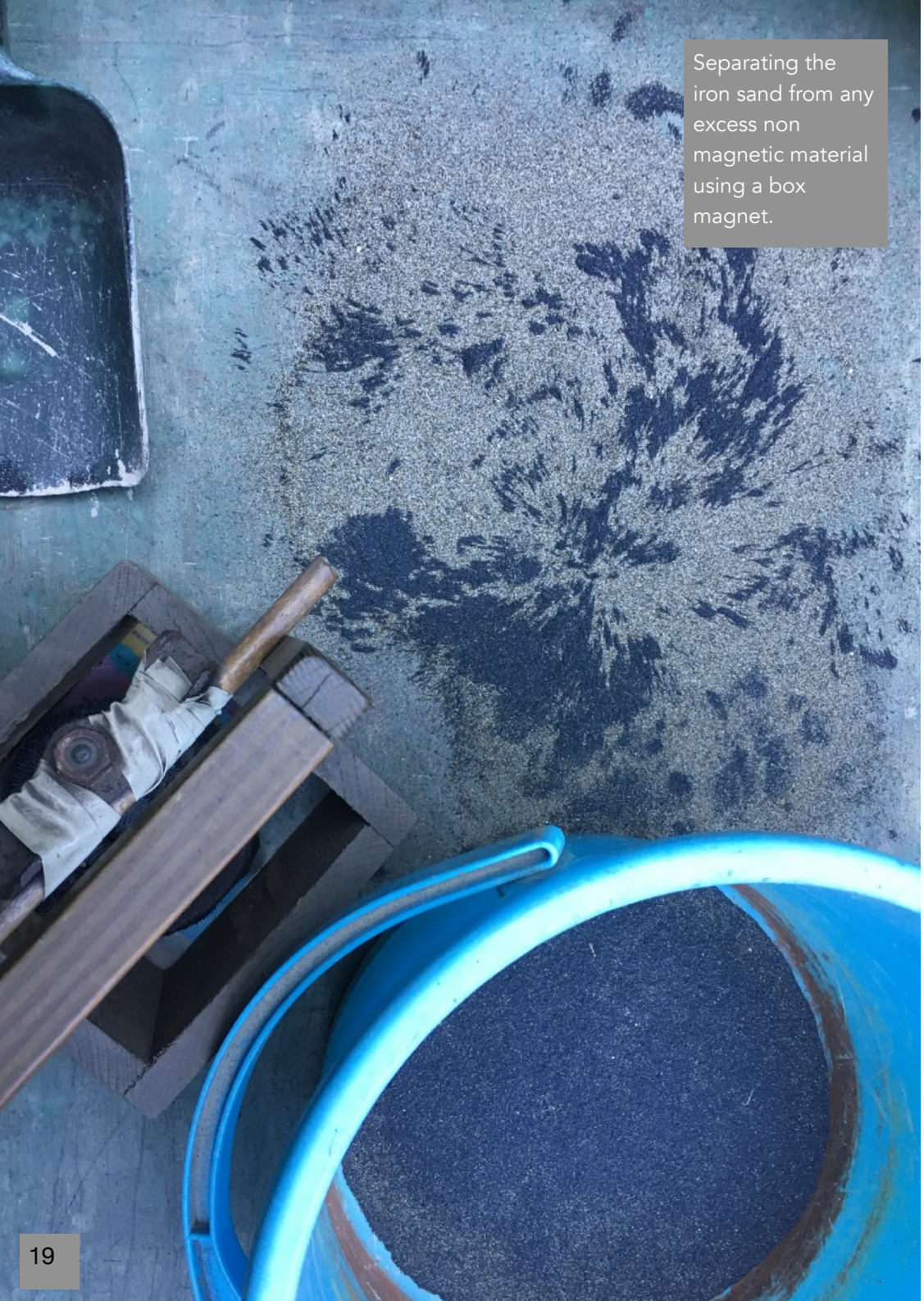
By the morning the wood was all gone and all that was left was the ore and some ash. At this point it can be tested with a magnet. It had changed colour from a dark grey to a red and was magnetic. These are all promising signs to look out for when indicating a ore will smelt well.

The bog ore was also roasted in a open wood fire. This was less likely to explode due to its porous structure. It was important not to make the fire too hot as it is a much less robust ore. It was very difficult to not to get it too hot. Although there were some larger chunks left, a lot of it broke up in to tiny pieces in the roasting process, almost as fine as dust. This was able to be collected with a magnet, but people were worried it was too fine. In Japan I learnt that they mix the fine iron sand with water, clay powder and ash to stop it from burning when added. This could be an interesting point to raise at the next furnace festival.

I prepared 18 kg of ore for each smelt which is added to the furnace at a 1:1 ration with charcoal, 1kg of each at a time, roughly every 15 minutes.

Roasting the Arigna ore in an oil drum and the colour change this process caused.

Roasting the bog ore in a fire and the resultant material became magnetic.



Separating the iron sand from any excess non magnetic material using a box magnet.

Crushing and sizing.

Obviously the Japanese ore did not need crushing or sizing as it was already very fine sand. The siderite ore from Arigna was crushed into pea size pieces. The sizing is important when smelting. If the pieces are smaller they have a larger surface area. This means that more of it is exposed to the reductive gasses in the furnace, and the time taken for them to heat up is quicker. Obviously this is a fine balance and too small in powder form they will burn when added. This crushing is an important and time consuming process. PPE should be worn as the pieces can be sharp of fly off when hit with a hammer. Crushing took place on a large hard rock used like an anvil. This sat on a tarpaulin so the pieces could easily be collected.

The bog ore could be crumbled by hand into small pieces. The finer powder was used towards the start of the smelt when the temperatures were lower so it wouldn't burn away on adding.

Sorting.

Kanna Nagashi (translated literally as iron flow hole) or the refining of iron sand using water power and gravity has been discussed previously and is the notable method used when sorting high quality iron sand from other waste materials. As expected this method is not totally efficient and some escaped. This set up whole secondary industries of people collecting where it was deposited, for example the inside curve of a river bed or lower down in the estuary.

On a much smaller scale the sorting of the iron sand I collected myself was done with a magnet Kurogane Forge. By passing the magnet lightly over over the top of the sand only the iron sand attached to it, all the non magnetic waste material is left behind. This was done two times till the purity was improved. A box release magnet is very helpful for this process.

Dumpling test.

Lee Sauder taught me an important technique to test ore quality rather than just using it in a smelt, and hoping for the best. Testing an ore using the method described is important for several reasons. If a small but varied sample is collected when out ore hunting, it saves the hard work of hauling a huge amount of ore back to the workshop and it being no good! The process of building a furnace is time consuming and expensive, as is the charcoal used to smelt. This test helps eliminate the disappointment of proceeding with a smelt and producing no iron due to bad ore. It is still not 100 percent that you will produce iron, even if the test reveals a good amount of iron present, because there are so many other factors that effect the smelt.

The process is known as the dumpling test. It saves time and money in the long run as it gives an indication to if your ore is a viable source of iron. By using exact measurements we are able to get an indication of the quantity and quality of the iron present, and ore it came from. This is achieved by first grinding up some of the roasted ore and some charcoal in to a fine powder in a pestle and mortar.

25g of powered ore and 8g of charcoal are measured out and mixed together. Lee had made up a sample batch of clay mix which may be used for the building of furnace walls. The dumpling test is also a good way to see how this mix reacts to the high temperatures of the smelt.

We took a good handful of this clay mix and made a pinch pot so that the walls were around 1 inch thick. The inside of this was coated in charcoal powder to act as a release agent and stop the precisely measured mix of charcoal and ore from sticking or fusing to the edge of the clay dumpling when brought up to temperature.

The mixture (25g +8g) was next poured in to the small well in the centre of the dumpling. Lee then proceeded to close up the dumpling leaving a small hole the diameter of a pen at the top. He also shaped the dumpling into a pear shape. This is important as it stops the dumpling tipping over so easily. The distinct shape also allows us to locate the top with the hole in more easily whilst in the fire. The clay dumpling was then left to start to air dry till the clay hardens.

Once dry the dumpling can be heated in the forge. The aim is to bring it up to an even temperature and reach a white colour all over including the hole in. This indicates and even heat throughout the dumpling, and must be maintained for 15 minutes. It is a good idea to prepare several dumplings so that several results can be compared, or to allow for problems if one breaks or tips over.

The dumpling is left to cool in the fire and then removed and cracked open. The aim is to get a good bead of iron. This can be weighed and this will give and indication of how much iron 25g or ore will produce. Scaling up figures we can get an indication of how much iron to expect from 1kg of ore.

Crushing the roasted ore and charcoal and the formation of the clay dumpling.

Part 2 - Other components used to a smelt.

Charcoal

The process of making charcoal is ancient, with archaeological evidence of charcoal production going back about 30,000 years. It is made by burning wood in the absence of air, the resulting charcoal is almost pure carbon. It not only produces heat, the carbon it contains is needed to reduce the iron oxide. Water and other components are not present in charcoal so it burns hotter, cleaner, and more evenly than wood, important factors for smelting. It is the only material suitable as fuel to smelt with and burns at temperatures exceeding 1100°C. Lump-wood charcoal must be used, not man made briquettes.

The charcoal is made in a retort. Plans to build one of these can be found or bought online. I want to eventually be able to make my own charcoal as it is another step closer to totally controlling the whole process. Like with collecting the ore by hand, I believe hard work helps create a stronger connection with the final sculpture.

Charcoal can also be bought from suppliers. In Ireland we used a hard wood charcoal, where as in Japan we used a pine (soft wood) charcoal. Hard woods are slow growing (80-100 yrs to maturity) and therefore provide a dense timber. In contrast softwood grows much faster maturing in 25-30 yrs and the timber is less dense.

In all the smelting operations I witnessed only one type of charcoal was used, however in 'Testy - zan hisho' there is reference to the importance of charcoal, and how different woods were used to make charcoals for different stages of the Tatara operation.

The charcoal must be sized before being used. Too small and it burns too quickly and too big and it will lower the temperature of the furnace when added. A sieving table can be made to separate the fines and the different sized pieces but this seemed a bit over the top to me. Alternatively in Japan I used a small axe and roughly chopped it to size which in most cases was to around 40- 50 mm cubed. The fines should be saved as they are useful in creating a carbon bed in the furnace.

Cutting charcoal to size with a special axe in Japan.

The sieving table design used in Ireland.

When making charcoal the amount made is about 25% of the original weight of wood, after burning. This obviously impacts the high price, one of the main expenses when smelting. In all examples I witnessed the furnace is preheated or dried with wood not charcoal as it is cheaper. We also used peat to do this in Ireland.

It is interesting to note the scale of the tatara process. One cycle consumes nearly 12 tonnes of charcoal over 3 days, In comparison to my furnace in Ireland which used around 30 kg. To produce 12 tonnes of charcoal about 1 hectare of woodland was used. Each tatara operated around 60 times per year which meant 60 hectares cleared per year for one tatara! In the Shimane province the moist warm climate allows a tree to mature in around 30 years. SO 60 hectares x 30 years means around 1800 hectares of land was needed per tatara to allow it to run as a business and not self destroy due to lack of charcoal! This explains the even spread of tataras seen on ancient maps.

Records from a furnace in 1875 show that the people needed to operate one included 5 managers, 20 general managers, 393 involved in sand or clay extraction and furnace building, 530 in charcoal and 262 in transport. Charcoal and its production is a very important part of the process.

Mixing the clay mix for my furnace walls .

The mix was
2 parts chopped straw
2 parts sand
2 parts china clay (bought)
1 part found local clay
3/4 part water.

This varies from furnace to furnace and what is locally available. The mix must be firm and not too wet.

Clay

Clay plays a major part smelting as it makes up the furnace walls, along with sand and sometimes natural fibres. Clay is an incredible material as it can withstand the high temperatures required to reduce the iron ore inside the furnace. It is important to note that each clay is different and varies as to how it behaves under the stress of heat. Some slump or burn away too fast, others hold up strong and help in the production of a good quality slag. It is important to test your clay source and know how it reacts. Once you find one that works for you stick to it.

There is no hard and fast rule to the ratio of the mix, or type of clay used in the walls, it is different depending on the person building the furnace and what is available. The huge variation in materials and other variables in smelting make it quite hard to quantify things and this is something which frustrated me at times. The more I spoke to people I realised it is something which you feel and judge, and must work out through trial and error.

The purpose of the clay wall is to contain the reaction going on inside the furnace. This is both physically in terms of holding all the iron ore and charcoal together, and also in terms of insulating it and keeping in the heat.

The clay in the furnace wall also breaks down in the process and helps form the slag. This is an especially important part of the tatara process as the iron sand has few impurities in it to make slag. At the Niimi city tatara festival the furnace walls were purposefully made almost twice as thick (40cm) at the bottom of the tatara to allow for this degrading.

In Karagone forge I also added powdered clay to the iron sand (2kg for 26 kg of iron sand) to help the slag formation. The clay and some added water clings to the iron sand mix preventing it from rising out the furnace with the thermal currents when added. Extra clay was also placed above the air source entrance points on this

The lower section of the Niimi furnace was made wider before the side walls were built up to around 1.2m high.

The lumps of excess clay added above each of the air holes on the furnace I ran at Karogane forge.

furnace as this is the hottest point and so the quickest to degrade.

A test mix of clay should be made up in a small batch and left to dry naturally before building a furnace. This way we can see how it behaves and if it cracks easily or falls apart. The dumpling test can also give an indication of how your clay will hold up to high temperatures.

The clay mix for the Nithotto tatara is a heavily guarded secret and this indicates how important sourcing the correct clay is. At the Niimi city tatara festival (as is true of the Nithotto tatara) different mixes of clay and clay types were used in different areas of the furnace and all have different special names (motogama - base clay, nakagama middle clay, uwagama - top section clay) and qualities. In Karegone forge interestingly he bought a premixed clay used for starting off rice seedlings, probably not available in England but it worked well for him.

The notable thing about all the clay wall in both Ireland and Japan was the firm texture they were made into. The balls were stiff and held together. This is hard to explain in words but something the hands come to recognise. It was either worked by hand or foot and then made in to balls which are easier to handle when building begins.

In Ireland 13 different furnaces were built and they all used their own ratios and mixes of clay, sand, fibres and water. Some clay had been dug up locally but the majority of what we used was bought china clay powder. This is fairly cheap to buy and comes in powdered form. I think for learning purposes I may do the same at first but ideally I would like to be able to source my own clay to build my furnaces with as it adds to the project and the importance of following ancient techniques. It also helps cut the costs involved.

Making clay bricks at Niimi tatara festival was on a much larger scale than i witnessed elsewhere due to the size of the furnace being built.

Mixing the clay was done by foot in the Karogane forge.

Sand

Sand contains silica and is added to the clay wall mix to give it structure and also to help in the formation of slag. Different furnaces have different amounts of sand added to the wall mix depending on the clay quality in the first place. Some clay is naturally very sandy and requires less. This is very much something learnt by trial and error depending on the source of materials available to you. When I collected sand from a sand mine in Ireland with Lee and Jake they selected something which wasn't too fine. It was quite corse but did not contain any stones which could heat up and explode out, damaging the furnace walls.

In all the furnaces I saw operate they had a slip of clay with a high sand content on hand in a bucket. This was to paint over any cracks which formed thus keep the heat and gasses in place.

Straw

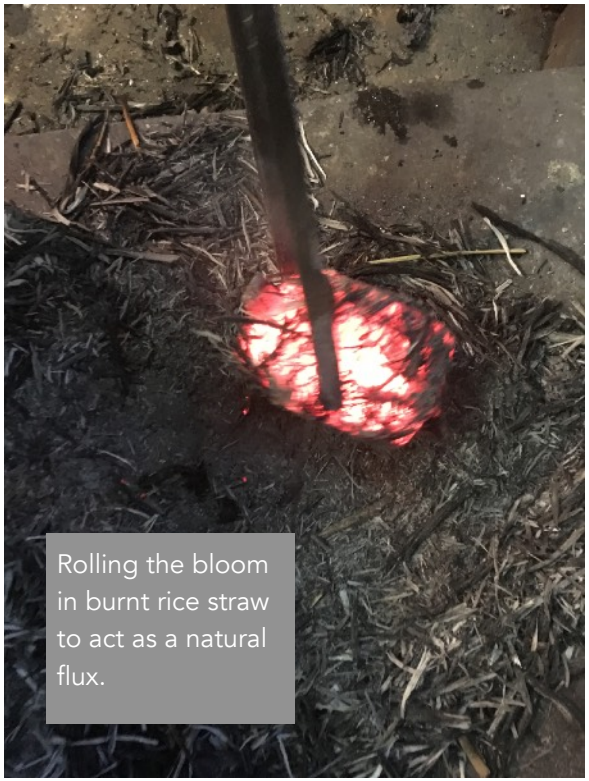
Straw and/or other natural fibres (such as horse or cow dung) can be used in the wall of the furnace to help it breath and give it strength. In Ireland this was a component of the furnace I was taught to make by Jake. It was chopped in to 1 inch pieces and used in the clay and sand outer wall mix. However Lee did not use straw in his furnace building, just used clay and sand, similar to all the Japanese examples I witnessed. Like many things it seems to be up to the specific smelter and his furnace design. I personally liked the inclusion of straw, both visually and for the strength it seemed to give it.

In Japan I was taught two other useful techniques with straw which I will adapt into my own smelting practice. They used hand made straw brushes which were dipped in water and used to cool hot metal handles when forging, or used as brushes to paint the clay / sand slip over cracks in the furnace walls.

Burnt straw was also used when pattern welding, a technique I really liked. The billet was rolled in this and then a clay slip poured over the surface. The straw ash acts as a natural flux and also helps the clay stick to the steel which protect the outside areas from decarburising in the fire.

Collecting sand with Jake keen from a sand mine in Ireland

Photo demonstrating the use of chopped straw in my furnace in Ireland.



Rolling the bloom in burnt rice straw to act as a natural flux.

Air source

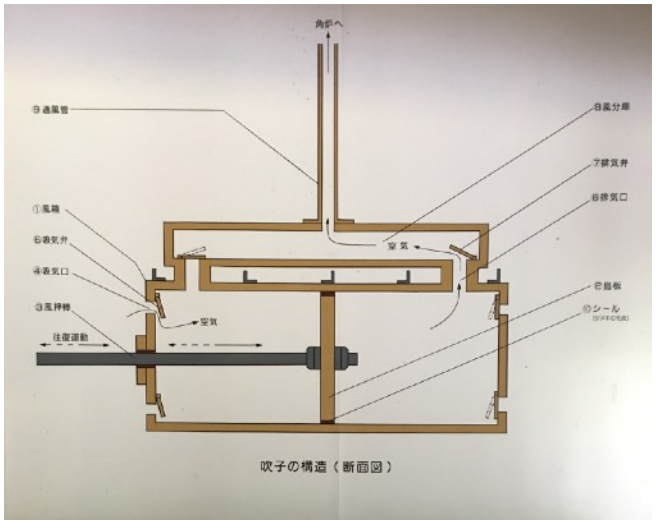
In the past the air source came from man powered bellows. There are a huge variety of bellow designs available which I came into contact with on my travels. In Japan I got to experience box bellows which were used to run the furnace at the Niimi city tatara festival. For the first three hours, four of the six air feeds in, were run on these. We worked in teams doing shift work to preheat the furnace. After this it was switched over to electric blowers, but it helped me get an understanding of the heavy work involved in the past.

The most important technological revolution to the tatara process was the invention of the *tenbin*, or balanced bellows in 1692, which I tested at the Wakuo museum.

Top left- Box bellows at Niimi.

Top right- Tenbin balance bellows.

Right- Box bellow internal workings.

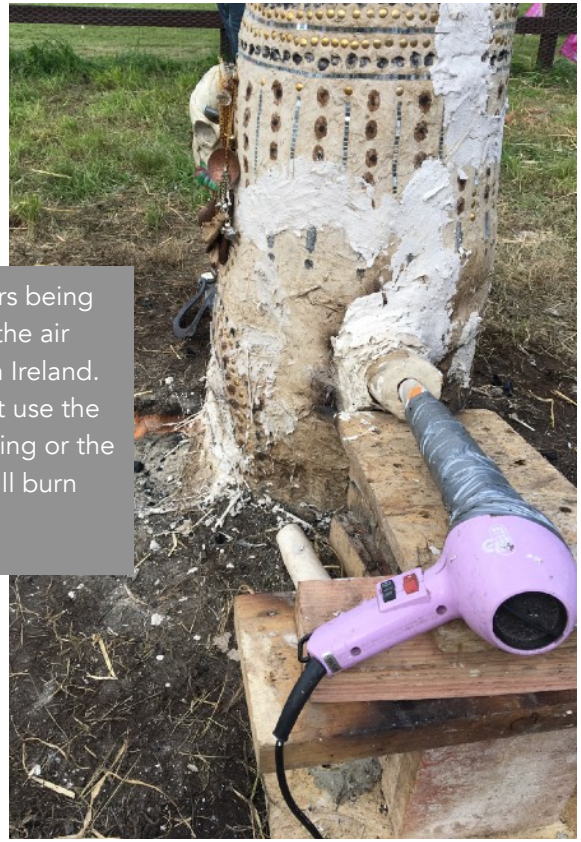


In Ireland I saw many variations of hand operated bag bellows, as well as operated a huge set of hand cranked forge bellows.

Large hand cranked bellows in Ireland.

The design and use of man powered bellows (ie not reliant on electricity) needs a whole research trip inits self. They do have a huge advantage in that they are the traditional option and look more appealing. They also allow you to smelt where you want with out being reliant on electricity, and don't cost anything to run. Although I love their design and would like to make some, for the initial purpose ease of my learning I will begin with using an electric blower.

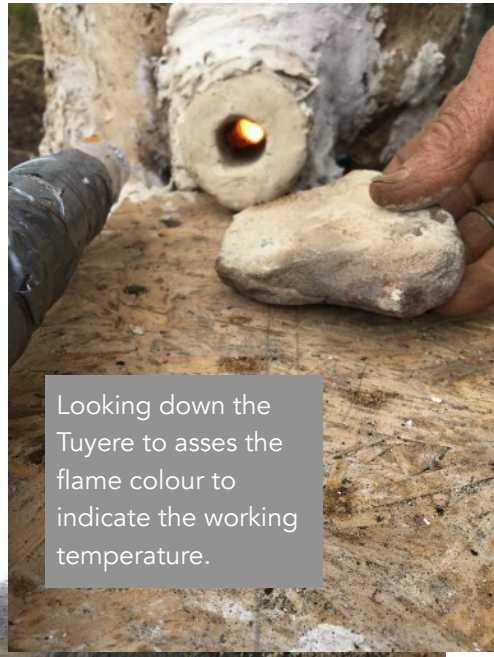
At the furnace festival Jake wanted to experiment with the idea of using a hairdryer as the blower and all three of us had successful smelts. The idea was to reduce the stack height as much as possible and use a lower and slower air source to slow down the reaction. The size and style of the furnace impacts the number of tuyeres and air requirements. All the furnaces I came across had different ways to adjust the air flow power from the electric blowers .



Hairdryers being used as the air source in Ireland. You must use the cold setting or the motor will burn out.

The Nithotto tatara (the largest operation) has 20 tuyeres each side, and Niimi 10 set at an angle of around 15- 20 degrees to the wall. Above each of these was a peep hole the murage could look in to if needed to see what was happening inside (colour gives an indication of temperature). The murage controls the angle and it impacts wether steel or zuku is produced. This angle naturally must also be considered on smaller European stack furnaces, and something to be aware of in furnace design. In comparison my furnace in Ireland had only one tuyere you looked down to asses the colour in side, and the Kurogane furnace had 3 lower air sources with moveable metal flaps to look inside, and one higher air source.

The furnace design at Karogane forge with three lower and one upper air source.



Looking down the Tuyere to asses the flame colour to indicate the working temperature.

Ten tuyeres at Niimi, all wrapped in Japanese paper and clay to prevent burning.

They Japanese tuyeres were made from bamboo wrapped in clay soaked paper with a iron tip that protruded in to the clay wall, but not into the fire or it would melt. They fanned out towards the end walls. In Ireland we made a clay tuyere, using a stick as a former for the internal hollow. This tuyere projected in to the furnace body about 2-3 inches, it melted in the process and was disposable. The end of this was about level with the top of the tapping arch. A hole was cut in the furnace wall and then the clay tuyere shaved down to size and sealed in place with more clay. It is a good idea to make two in case one breaks as they are fragile.

Below. Using a cerated bade to fit the tuyere to the hole.

Above - To make the tuyere make a thick sausage of clay wall mix . Use a thin stick to poke a hole and slowly increase its diameter around 3-4cm.

I like this method as it seems more traditional. I even found one similar to the one I made as an exhibit in the Osaka national history museum. Lee's website gives instruction on how to forge a metal reusable one.

Ancient clay tuyere I found in a museum in Osaka which resembled the one i made in Ireland.

The point inside the furnace where the charcoal burns at the end of the air source is the hottest area of the furnace, and where most of the reactions take place. It is important to keep the air source in clear and unblocked or the temperatures will drop.

There are so many factors to control and consider when smelting and it can seem a bit overwhelming at times especially when running a furnace alone. I think that it is important to not loose sight of the main goal which is the creation of iron for a sculptural use using traditional methods, but some times modern interventions are ok for the purpose of learning , such as a electric blower. A lot of my experimentation on return will be done alone, and so it is impossible to do man powered bellows and feed the furnace at the same time. In a team operation it is easier to do things totally traditionally, but not alone.

Part 3 - Notable specialist items to aid smelting.

I have always had an interest in tooling and how people adapt their own for specific jobs. Some of the most ingenious smelting tools I came across are discussed below and are all things I will combine in to my own practice.

Reed bundle

This is an excellent way to form the shape of the furnace round and follows with the idea of using ancient materials. Allowing the clay to air harden around them over night allows it to become strong enough to not slump. Clay contracts as it dries but the loose reeds can easily be pulled out gently from the centre bit by bit so the hollow shape remains. They can be reused many times but can be tricky to source (try a roof thatcher).

Using a bundle of reeds as the furnace former.

Wooden slatted former

This is another method to form a furnace shape. Two disks the same size are joined by numerous slats of wood to form a tube shape, the size of the required internal furnace diameter. The clay wall is built up around this and then its is burnt out. This also helps dry the inside of the furnace but is not reusable.

Using wooden slats and disks as the furnace former

Using a wicker bin as the furnace former.

Natural wicker woven bin former

One furnace I saw being built was round a wicker basket. Obviously this must be burnt out not pulled out but was an ingenious method to create a furnace shape.

Pocket saw

This tool is essential for cutting the tapping arch and tuyere hole. It means that you don't have to worry about building an arch which creates a weak point and may cause the clay to slump. Instead the furnace can air harden and then have it cut out when it has more rigidity.

Tapping bar and support bar

These two tools are very helpful when tapping the slag. The support bar acts as a leverage point so the tapping bar can probe up inside the furnace. The tapping bar is a long bar with a pointed curved end to break through the slag.

Metal pots to add fuel and ore

A set of steel buckets and measuring jugs are very helpful to add ore and charcoal into the furnace. When running it is very hot and other materials will degrade. It is also good to get several of each, this way you can measure up multiple charges at once and so you are always one step ahead should the furnace require something

quickly. Using a sharpie pen to mark the height of one measured charge on the inside of your pans is a good way to then be able to quickly measure roughly the same amount again and again.

Wok welded on to a steel bar

This is a nice home made tool to be able to add ore to the furnace from a distance which is useful as the work is very hot.

Using the wok welded on a steel bar to add iron sand.

Takadono

I was particularly impressed with the idea of the takadono, a special building designed to house the smelt and equipment. I witnessed this at the Nithotto tatara, Niimi and also at Sugaya Tatara Sannai where the original Sugaya Takadono still exists. This is an original building complex especially for the Tatara to be housed in. It was built in 1751 and used for 170 years. The roof is Made up of thousands of pieces of chestnut split in to 3mm thick strips. Between these was copper and Japanese paper to help combat mould, a very ingenious design. There are some hinged sections at the top which could be opened to allow ventilation. People would sit up here and also put water in the roof to prevent it from burning when the Tatara was fired.There was an east facing window where the first rays of light would shine in the morning. This could have acted as a clock of sorts over the three day process.

The other Takadonos I visited were more modern and built of steel but they all had dedicated areas for the storage of iron sand and charcoal. A Kanayago shrine always sat above the iron sand. The sand store was also on a slope. This allowed any excess moisture to drain out of it using gravity.

Excavation shows that there are also large foundations below the Sugaya Takadono Tatara to help with the humidity and moisture. This underground moisture management is a key feature to the Takadono design and comprised of among other things alot of compressed charcoal. Similarly this carbon bed was very important in the furnace design I made in Ireland. It helps bloom removal, controls moisture and helps the reductive processes.

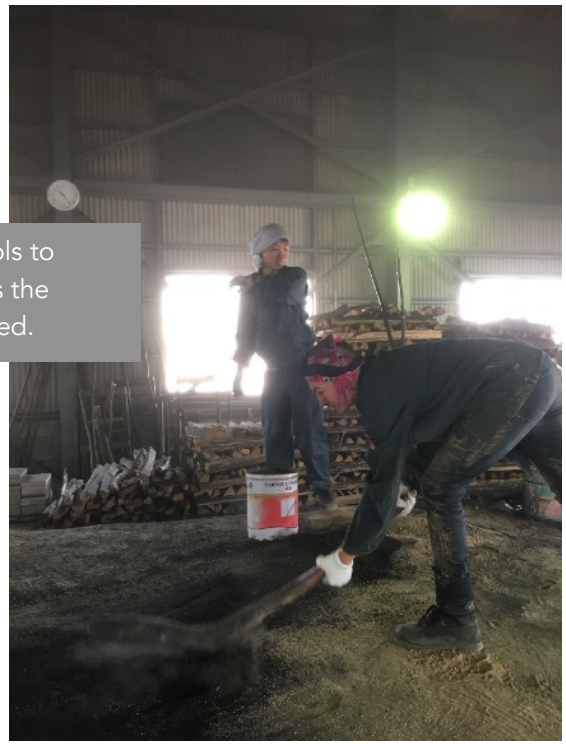
Left - the complex underground system used in Takadonos. Above- on a much smaller scale a carbon bed was also made in my furnace in Ireland.

Katsura tree

In Japan there is always a Katsura tree planted next to the Takedono. This is because it is the tree that the bird Kannayago (the female god of tatara and metal workers) rides landed in. These trees also consume a lot of water. This means that they are useful in drying out the ground and helping manage moisture, important to the furnace functioning.

Tools for compressing the charcoal bed

The idea of a compressed charcoal bed is very important in a furnace for moisture management. After a fire has burnt leaving only charcoal, special sticks (shinae) were used to beat the floor by by two groups of three workers, opposite each other. This breaks it down in to a fine and compacted powder. A L shaped club stick or toko - jime is used to further pound and compares the bed.



Using tools to compress the carbon bed.

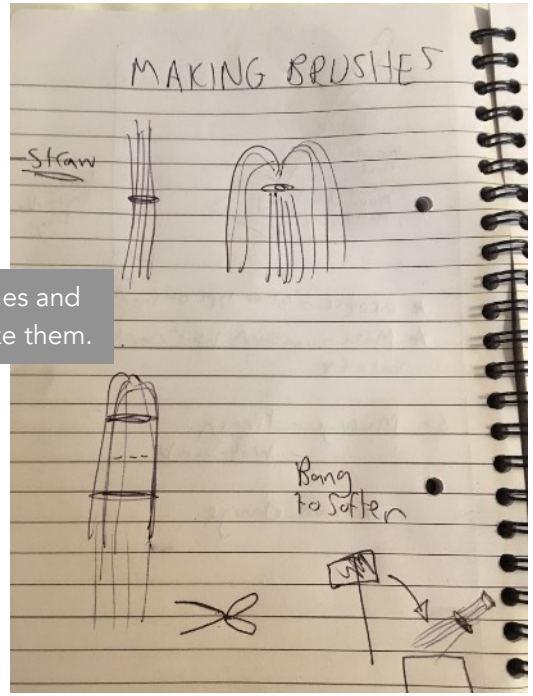
Photos showing the Oroshigane two part furnace used to join small pieces of bloom.

Oroshigane

This is a technique which requires a small secondary two part furnace. It is clay lined, has a charcoal bed and one air source in. The idea of this furnace is to join all the small pieces of steel made in the smelt together as they are not forgeable when they are so small. It runs on charcoal and operates much like a smelting furnace apart from we are adding iron pieces not ore. 200g of iron pieces and charcoal were added every 3 minutes until 2.4 kg had been added. When the furnace is split open it gives us a small bloom which is now forgeable. A very useful technique to save precious smelted iron and make it workable.

Straw brush

These simply made straw brushes are useful to paint on clay slip if cracks appear in the furnace.



Straw brushes and how to make them.

Wooden tools

Interestingly the hand tools used in the tatara operation I witnessed at Niimi and also the tools I saw in the Nithotto tatara are all made of wood despite the fact the heat could damage them. This is because of the duration of the process, using heavy iron tools would be a waste of energy. It is an interesting thing to bear in mind if the smelt is challenging or long.

Japanese paper soaked in clay

The tuyeres were made up of a steel tip mounted on a bamboo shaft. The bamboo was wrapped in layers of Japanese paper dipped in clay. The heat given off from the tatara is immense yet this simple technique makes the bamboo fire proof and not able to burn. In my own furnace development It would be a way of making sculptural paper mache elements heat resistant, an interesting concept as I believe the furnace should be sculptural as well as functional.

Charcoal chopping axe

This tool was gifted to me on leaving the Kurogane forge. It is a tool that is unique to the Kochi area and is originally for clearing bamboo. It has been cut down in length from the original blade length. The blade angle is very comfortable tool to chop charcoal with.

Special axe for chopping charcoal.

Clay paddle

This specially shaped tool was something I used in Ireland and Japan. It was a nice item to manipulate and shape the clay firmly with and to reach tricky places. It also helps you get a nice smooth surface when finishing .

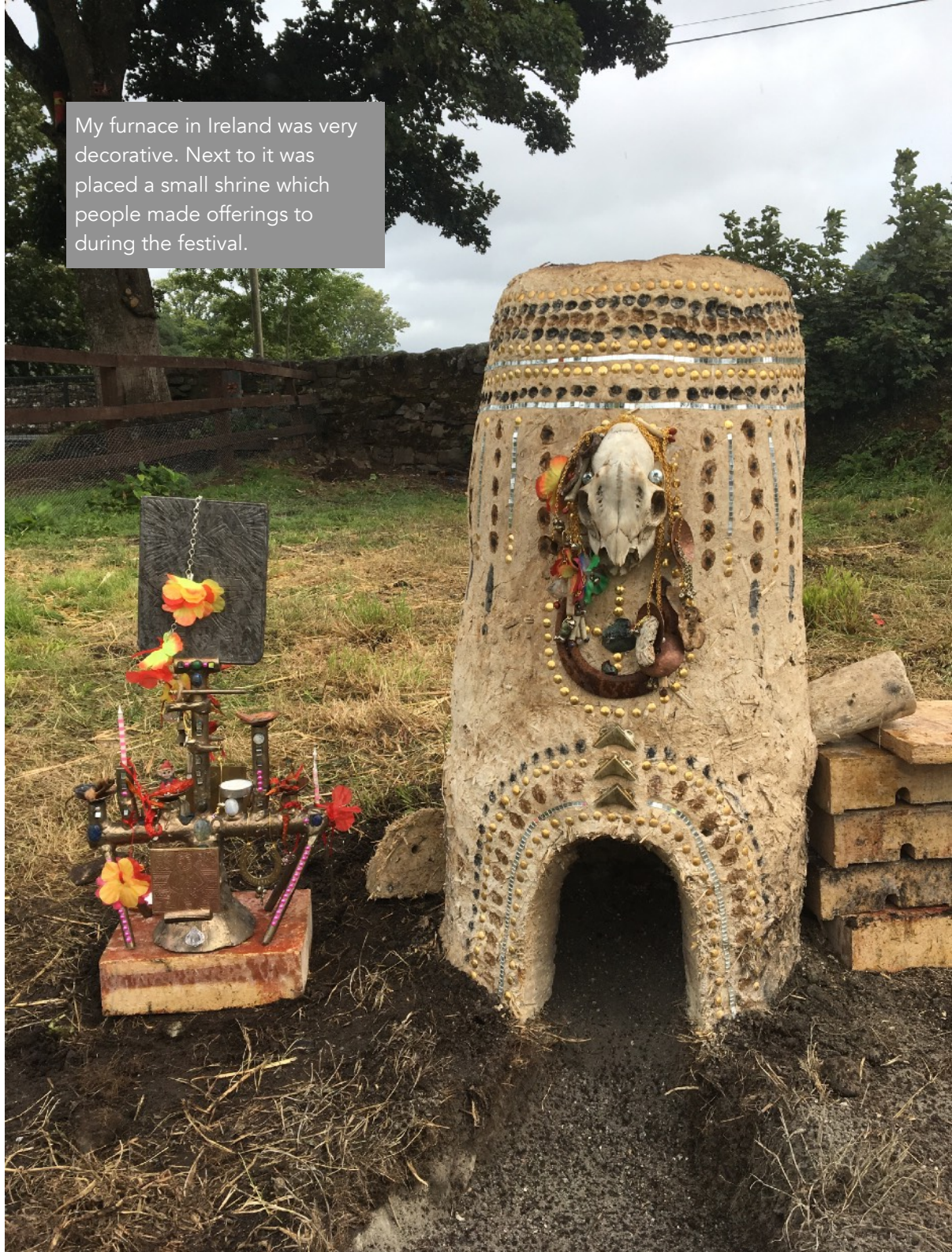
Clay paddle for shaping clay.

Part 4 - Social, cultural , and religious aspects of smelting.

I am a strong believer that the experience of making iron from ore should be treated with respect. There is some thing very humbling to make iron from ore. The power of the fire and the furnace is stronger than your self. Some consider the furnace almost as a living being which must be tended to and fed. It can be read through its flame colour, this can tell you what it needs or what is happening inside. The key to a successful smelt is to work together with the materials and reading the signs the furnace gives us. I often caught Mr Kihara and Jake staring in to the flames. The were reading the signs they have come to understand through experience.

I spoke in some detail with Jake before I left about furnaces and ritual offerings he had come across in his time. 'In India alcohol, a chick and a piglet were offered to Lhohasa, the god of the furnace. In Japan a big religious ceremony was conducted before starting three days of Tatara smelting. Lee offers hot peppers to his furnace before the first charge of ore. In Burkina Faso several of the furnaces were shaped into animal forms. That is not uncommon in Cameroon too. Sometimes I have painted my furnaces if suitable earth pigments are available but I do not usually do this. However I always seem to care a lot about sculpting the furnace into a pleasing yet functional shape. Somehow, a beautiful furnace is more likely to produce beautiful results.' This lead me to dedicate a chapter of this report to sharing and discussing social, cultural and religious things I witnessed and how this can impact a smelt.

As a result of this I made my own furnace decorative built my own shrine to take to Ireland and invited people to make offerings to it over the course of the festival. This was my way to celebrate the history of smelting, and paying respect to those in the past who discovered the creation of iron, something inherently world changing. It is worth taking a moment to think about how much has changed today because of one small clay furnace, some charcoal and ore, somewhere in history. I will continue to develop the idea as the furnace as a work of art in its own rite within my investigations, and believe it is an important part of the design process.



My furnace in Ireland was very decorative. Next to it was placed a small shrine which people made offerings to during the festival.

Shinto priest blessing the space.

Kanayago shrine present in all workshops.

In Japan, as Jake mentioned, I witnessed a Shinto priest bless the takadono before the process started. Once this had happened the workshop was designated a holy space and no eating or drinking was allowed inside. There was a shrine set up above the iron sand and constant offerings of Saki arrived dedicated to Kanayago .

Kanayago (whose name is written with characters that literally mean “child of the metal worker”) is the god of the tatara and metal workers in the Chugoku region. She taught the people there how to make iron. According to legend she rides on a white egret which lands in Katsura trees, hence why these are sacred and planted near the takedono and shrines dedicated to her.

According to legend when she descended from the heavens a dog attacked her. She tried to escape by climbing a vine but it broke and she died. For this reason she is meant to hate dogs and none are allowed in the vicinity of the tatara (this could pose a problem to my smelting as I have two!?)

Kanayago is a female deity, she supposedly hates women and is very jealous. In the past a murage would not enter the tatara when his wife is menstruating and shuts it down whilst she is in labour. I experienced no problems in working or entering workshops because of this but was aware that in the past my presence would not have been allowed.

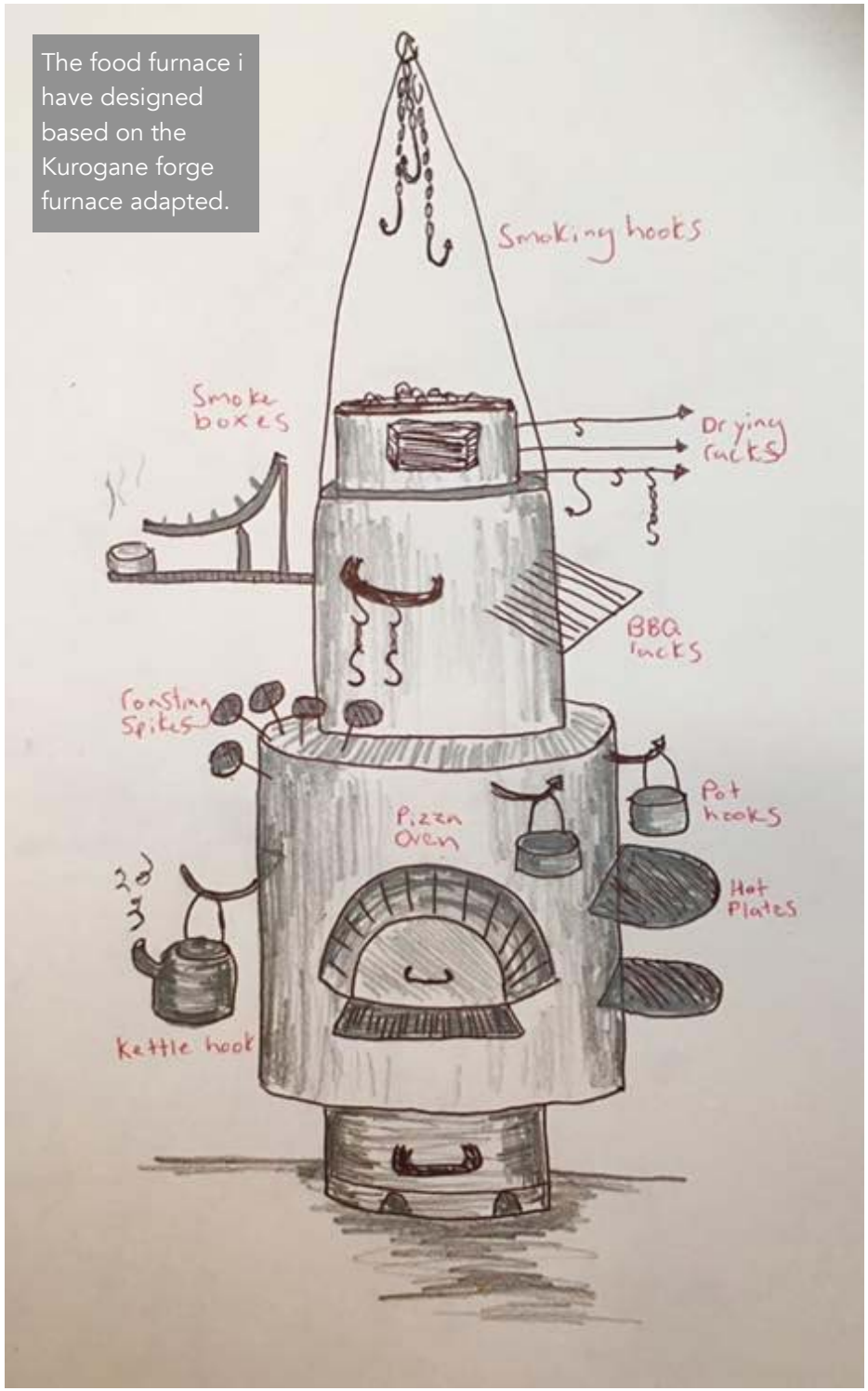
Kanayago became part of my daily life in Japan. Every metal worker I visited had a shrine to her or held her in respect. I like the Shinto way of believing everything has a soul and could be a god. This is something I will take away from Japan. I believe it teaches us respect for our surroundings and makes us a-lot more considered in our actions. I am not religious but the belief in Kanayago is something I can relate to. She has a powerful impact on smelting in Japan and I think the respect people have for her is some how reflected in how seriously people took smelting and thus the incredible results achieved.

Kanayago watching over the tatara process.

Festivals are held at the main shrine Kanayago-jinja in the spring and also early autumn, I was lucky enough to be in Japan at this time. In respect the Murage and his team, plus other people in the metal industry participate in a ten mile bare foot pilgrimage from the Nithotto tatara to the shrine, and I was invited to join. It was an incredible experience and I felt honoured to be asked. I think it is important to pay respect to tradition and belief.

We shared a big meal after the pilgrimage. Similarity there was a celebratory meal before the smelt in Niimi. Someone said to me this is ‘eating a meal with your new family’. I think this can be translated as respecting the close bonds which form during hard work of smelting, and proved how important the group concept is in this work. For the success of a smelt a team is very useful, this was experienced in Niimi where we ran the furnace for 24 hours and on a smaller scale in Ireland where everyone pitched in on jobs on other furnaces. The group is invaluable part of smelting and I expect it always has been a community event.

I took great inspiration artistically from these experiences and they made a big impact on how I want to continue with my smelting. The idea of showing respect and making offerings is something I like as a means to focus on. I want to incorporate sharing food with a team and have designed the food furnace which uses residual heat from the process to cook for everyone involved. This will be my first furnace I develop oreturn. The power of belief, religion and community has always been present and through this will continue to influence smelting.



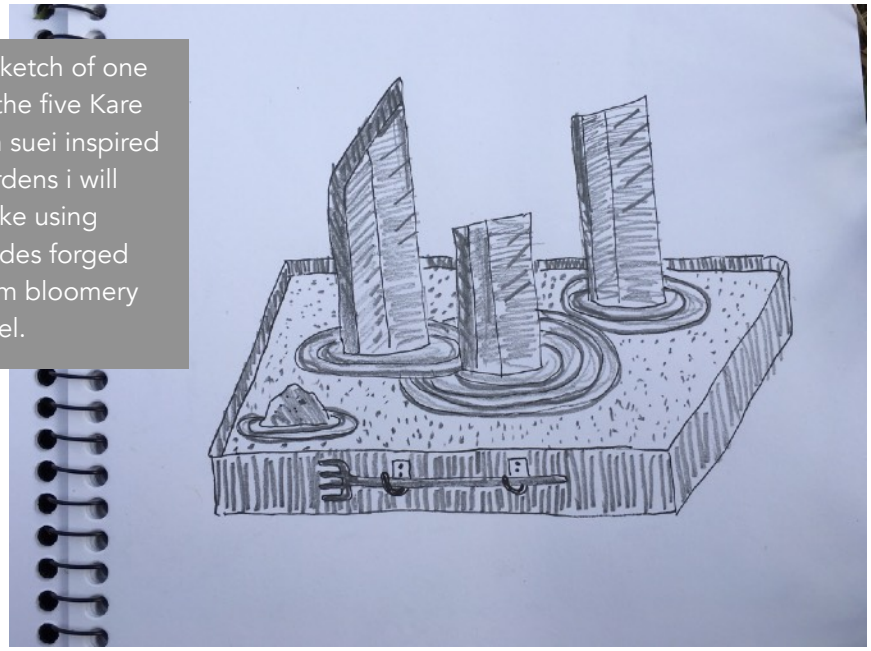
The food furnace i have designed based on the Kurogane forge furnace adapted.

Part 5 - Smelting for a sculptural use. Techniques and surface design.

Before I left the UK I had no plan of what I wanted to make with the smelted steel. I wanted to let my journey inspire me. The main inspiration in Japan was the Adachi museum of art and gardens. I had gone to look at the art, but in the end the gardens inspired me the most. Kare San Suei, translated literally as 'dry water gardens' are rock gardens where gravel is used to represent water, around stones, which symbolise mountains. The gravel is raked by monks as a mediative practice.

Kare san suei gardens at the Adachi museum of art.

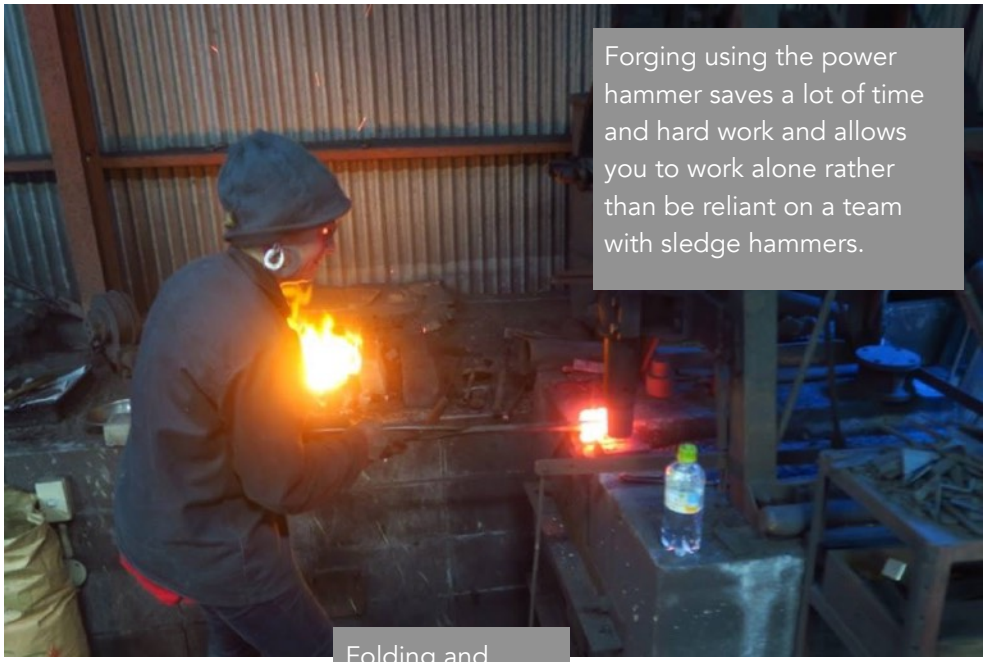
My final sculpture uses this idea on a minute scale, using iron sand instead of gravel and knife blades instead of rocks. Each of the five parts gardens uses a different blade cut up these parts set in a small Japanese dish. Alongside each are hand forged tools for the viewer to interact with the piece and make patterns in the sand. My decision to forge blades was from the fact I had never done this sort of work before, and so wanted to learn the most I could at Kurogane which specialised in knife making. It was important to keep an open mind and let the situation or steel itself help inform the final work.



A sketch of one of the five Kare san suei inspired gardens i will make using blades forged from bloomery steel.

Techniques of notable importance to the sculptural development are -

Consolidation of the bloom and pattern welding.
This started with heating the bloom till an even colour and carefully tapping in the extremities to create a shape which could fit under the power hammer. The power hammer is an indispensable piece of equipment for working with smelted steel. Dipping the bloom in burnt straw acted as a flux and a clay slip on top of this protected the outside from decarburising. At first it was light sledge work and then we switched to the power hammer when it was a
more uniform shape. When it was consolidated enough a handle was welded on to make the bloom more manageable.



Forging using the power hammer saves a lot of time and hard work and allows you to work alone rather than be reliant on a team with sledge hammers.

Folding and consolidating the bloom in to useable steel

It was drawn out and cut and folded 6 -10 times, obviously the more you do this the more layers it creates and the more uniform the material becomes. It is important to bring it up to a nice fire welding temperature, making sure it has a long slow soak in the heat to ensure the centre is hot. We are looking at the surface to become molten and glassy and bright white sparks seen above the fire. Use plenty of fuel and keep the surfaces clean either with a wire brush or using water on the anvil and hitting down to blow off any scale. The pattern made is dependant on how it is folded, and something to consider if this is a feature of the finished sculpture.

Slag casting

This was an interesting discovery for me. I was able to cast it in to small decorative cake tins. I like the design of the Kurogane furnace as it allows for the slag to easily be caught, where was my design in Ireland and the different ore didn't lend to this so well. It was important to get a good reserve built up and casting it this meant it held together.

Experimenting with casting the slag in to metal containers.

Etching

Etching was a process I tried for the first time as Nobuya had not done this before either so my methods were trial and error. First the steel was polished and when a smooth surface had been achieved it was cleaned with acetone (wearing gloves) to remove any surface dirt and oil. The blade was submerged in a bath of 1:3 ferric chloride and water mix. I found that it was best to remove it after five minutes, wash it in cold water and then replace it in the acid. This produced a clearer etch and removed the layer of scum which seemed to form around it protecting the steel from etching. After 10 - 15 minutes I removed it and boiled it in baking soda and water to neutralise the acid. The pattern did not come up too heavily because only one type of steel is used. It would be interesting to pattern weld different smelted steels together to increase the visual effect.

Sanding and polishing

This was all done by hand at Kurogane forge and highly time consuming. I learnt how to work through different grits of oil stone starting at 100 up to 800, and then moved through different papers up to 10000 grit to get a polished surface. It is important to make a uniform surface on the steel before changing to the next grit up or any scratches will remain.

In my own workshop I will use polishing mops and compounds to reduce some to this manual work and time involved in this process.

Engraving

I also explored engraving using small hand chisels. It is important to work on a lump of lead and clamp the worked item to this to hold it in place, but using cloths to protect it. I really enjoyed the engraving process and know that there is a-lot of scope for decorative surface finish through this.

Tools used in the engraving process

Textured tooling

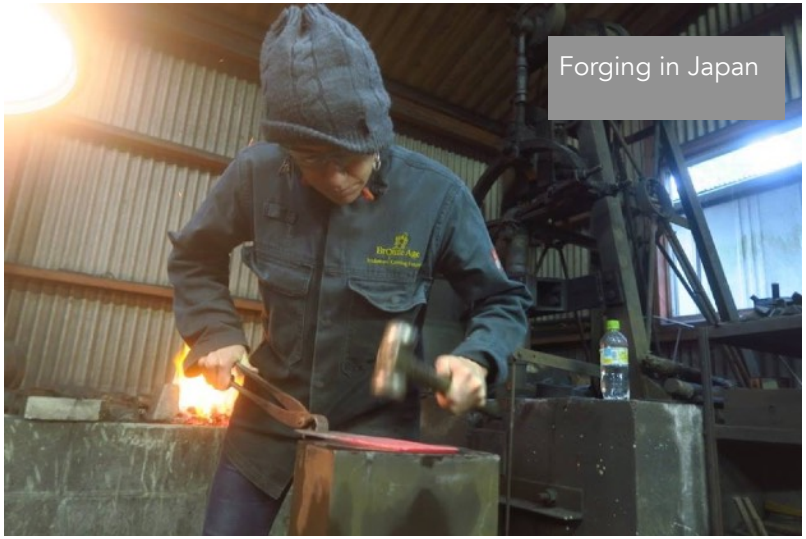
This was fun to explore and a good way to change the surface of the work. Tools can be made or bought and adapted. The possibilities are endless.

Zuku oshi

This is a method of smelting which I witness at Niimi where Zuku, or cast iron is made. This has a much higher carbon content and cannot be forged it is too brittle. In the past this iron must be processed again (Seiren) to reduce the carbon content for steel or used directly for castings (Imono). A different quality iron sand is used, and the temperatures higher for longer. This idea of casting from ore is something I would be interested in but a whole new area of research.

Forging

In Japan I was working in a dedicated shop with all the tooling at hand. I was able to use the power hammer and work in a organised manner. A workshop is essential for the sculptural use of steel.



Forging in Japan

In Ireland the working conditions were quite difficult as they were outdoors. I met an interesting poet in the village and had wanted to use his text and try and stamp it in to a sheet of steel however I was unable to do this. The festival was amazingly well set up to smelt but I had a few problems. Firstly I had never forged on charcoal before and it took some time to get used to. One of the blacksmiths taught me how to

Irish poet at the furnace festival.

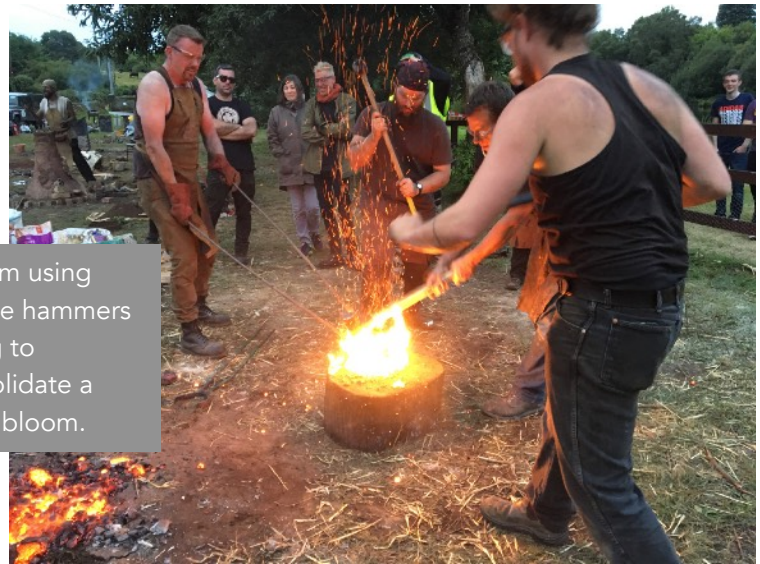
control the fire with a watering can to keep the heat concentrated and not to waste charcoal.

Forging the smelted steel at this point was a totally new experience. The sponge iron needed consolidating and also is full of slag and waste materials meaning it wants to crumble. At first this must be done gently tapping in the extremities and increasing the blow strength as it joins pushing out waste.

The forge was makeshift on the floor and I struggled working directly above the heat. The tooling available was limited. There was also no modern power hammer and so I was reliant on a team of people with sledges. This leads me to a main discovery which is the importance of a power hammer if I am to explore this seriously in sculpture.

Working with so many people became very demanding at times with everyone having their own opinion. These situations are not ideal for making creative decisions . It was a learning experience and good for me to explore bloom consolidation by hand and realise it's hard heavy work.

Another key lesson here was to consider the size of the bloom made. Many people seemed to believe bigger was best but then ended up with huge unworkable blooms, and required a big team using sledgehammers which became dangerous at times. With a power hammer this is easier but the weight of the bloom is difficult to manage alone if huge and the reach of the power hammer is not unlimited. I must bear in mind the amount of ore added to the furnace when smelting.



A team using sledge hammers trying to consolidate a large bloom.

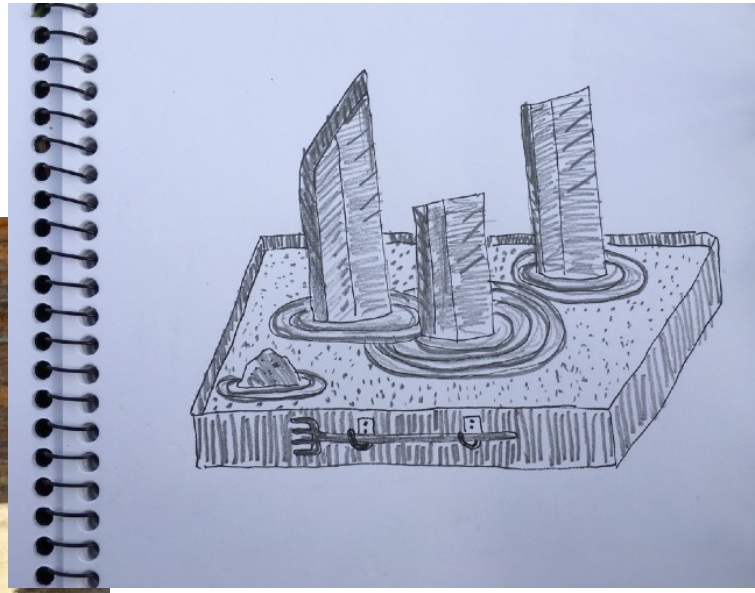
Trying to consolidate my bloom on a makeshift floor forge.

Conclusion

Work made in Ireland

These photos show two small items I made in Ireland. The steel we made had a high carbon content and made it very tough to forge by hand. The consolidation process was reliant on a team rather than a power hammer and it was hard work. Baring all this in mind I think it is important to see the beauty in what was made. I love the cracks and imperfections which can be achieved using hand made steel .

Work made in Japan



This photo shows the five blades I made with the bloomery steel in Japan.

They were made in a workshop with a power hammer and all the tooling needed at hand, and over the course of a week rather than a few hours.

These blades will each be cut in to three pieces and used in my small Kare san suei inspired gardens.

Although not yet finished they demonstrate the potential for hand made bloomery steel .

Major findings

1) There seems to be a gap between those people who have the knowledge and understanding to consistently create good quality iron or steel, and those whom have the ability to use this sculpturally.
2) The time taken and physical work involved in producing blooms of iron, combined with the cost of materials used to smelt does not make it economical. I believe that the value items gain through the love of the process of making is more important that what can be quantified.
3) Items made from hand made steel or iron take on a whole new meaning and value. This is beyond monetary costs and perhaps reflects back to the original use of iron in ceremonial or ornamental objects. Art objects I make this way will be treated as such.
4) Working with others people is an important part of the smelting process. Although possible alone, I believe it was a communal activity in the past and this is something I wish to continue in to my own smelting process.
5) The use of hand made steel in the UK seems to be predominantly for research purposes or used by blade smiths or tool makers, not sculptural artists. I believe that the best way to develop my art work is through the study of these techniques and then adapting the precision they require for a artistic outcome. The result will be better art work with more technical skill.
6) Once the bloom is made and I start processing it in to a useable bar a power hammer is essential and should be the next piece of workshop equipment I purchase. It is much more efficient use of time, less labour intensive, and possible by a person working alone rather than being reliant on a team of sledge hammers.
7) Variations in the furnace specifics effect the outcome. This may seem an obvious point to an archeo-metallurgist or archeologist but this report is coming from the view point of an artist blacksmith. Although I am interested in the means of producing iron my ultimate goal is to produce bloomery iron for a sculptural use. For this purpose it is important for me to identify a accessible source of ore, clay, charcoal etc that I can work with and get consistently productive results.
8) A beautiful furnace makes beautiful iron - although this is not necessarily true I believe in the promotion of the furnace as a sculpture in its own right.
9) The use of ceremony in the creating of iron is something which I enjoyed learning about and wish to develop.
10) The process of creating iron from ore is an incredible spectacle. So much of the world around us is made of it and it has played a huge part in our societies' development. For these reasons I think smelting is an important thing for people to witness. This will help others to understand our history and development through the use of iron, and help promote the value of the hand made.
11) It is important to keep an open mind and let the situation or steel itself help inform the final work when using it sculpturally.

A few of the different furnace designs at the furnace festival in Ireland.

As a result of the trip I have come up with several main points to summarise my findings and recommendations. I hope that this report has been able to give an insight in to what I learnt and experienced. Of course it would be impossible to explain every aspect and this report is a summary of some key points and the parts I found most interesting,

At this point it would also be unwise of me to lay claim to be a experienced smelter. I am very aware that this is just the tip of the iceberg and the learning will continue to develop as soon as I physically put in to practice what I have been researching. I think only through trial and error will I develop my own way of working. I know that there may be failures ahead of me but I look forwards to being able learn from this, and take comfort in the knowledge that this journey is about learning.

I hope that the reader will learn from this report and understand the aim of this project to develop iron smelting for a sculptural use. I hope it may inspire other metalworkers in the UK to think about how they use and make their own materials.

The trip was an incredible experience and this wouldn't have been what it was with our some problems. Language was a barrier in Japan and even with translation the very nature of the language made some things difficult to explain to be literally translated. Sometimes my own lack of experience held me back mentally as I was worried to get involved in high pressure situations. Finally there were some gender difficulties I experienced but it is not within my own personal philosophy to dwell about this and I believe that through experience and learning this can be changed.

<u>Recommendations for the UK</u>

1) Collaborations and networks should be promoted and developed between different interest groups in the UK using or researching the bloomery process. For example archeo-metallurgists and artists should work together to enable the production of good quality steel for use in thought provoking sculptures.
2) Exposure and promotion of new people to this knowledge will help preserve it, there needs to be a UK data base of smelting events but also contacts made abroad.
3) Through live smelting demonstrations I want to bridge the gap between the past and the present.
4) The best way to learn is through hands on practical experimentation. I have witnessed only a handful of smelts and it is important that I continue to create opportunities to develop my study in to making and using iron for sculptural purposes. As I currently am between workshops this means applying for residencies and funding projects which will help with the costs of this process and allow me the continue to share.
5) The process of smelting is labour and time intensive. By setting up a community of UK smelters and opening smelts up for people to help it will help overcome these issues, as well as helping to make it more cost effective if a small fee is involved.
6) The social aspect of smelting is important and should be promoted to continue the sharing of knowledge. I aim to do this through the use of food and development of my food furnace.

Me and Mr Kihara at the Niimi city Tatara festival.

Dissemination Plan

My research will continue to develop and expand. This will mainly be implemented through practical experimentation. The focus of this will now be on artistic ways to use what I learnt with in the UK as I believe this is a unique and interesting angle that I am passionate about. The following are ways to do this.

SISI (Society of Iron Smelters in Ireland)
I have helped form a group of smelters in Ireland who will continue to learn and smelt together . We will share equipment and costs to allow further research.

Scottish sculpture workshop
I have just been selected for a residency in January 2019 to expand and develop my use of sculptural food furnaces and their use in creating iron for art.
http://www.ssw.org.uk

Leitrim sculpture centre
I have submitted a report to the LCC and hope to be running experimental furnaces to make sculptural Iron works from in September 2019.
http://www.leitrimsculpturecentre.ie

Furnace festival 2019
The next festival is confirmed and I will return with my adapted food furnace design, based on my WCMT research. I want to promote the use of food and smelting and use it as a means to share the knowledge I got in Japan.
https://www.furnaceproject.org

From scratch
The trip has inspired me to start a major new long term art work titled ' From scratch'. This will look to prepare a meal and everything in if from scratch. In terms of smelting this means making iron to forge in to pans and cutlery, but everything else will also be handmade , for example the table from wood and growing all the food.

Fire and iron
I will have an exhibition of the work I made and research carried out towards the end of 2019. This will be accompanied by a smelt in the gallery grounds.
http://www.fireandiron.co.uk

My workshop
By June 2019 I will be moving into my own purpose built metal workshop. From here I will continue my experimentation and create a smelting hub for the UK. I hope to be able to offer classes eventually. I will have my own power hammer, essential to this development.

Disegno podcast
Whilst away I was recording for Disegno magazine who are making a 10 minute pod cast about my journey and research to share on many public networks and platforms.
https://www.disegnodaily.com

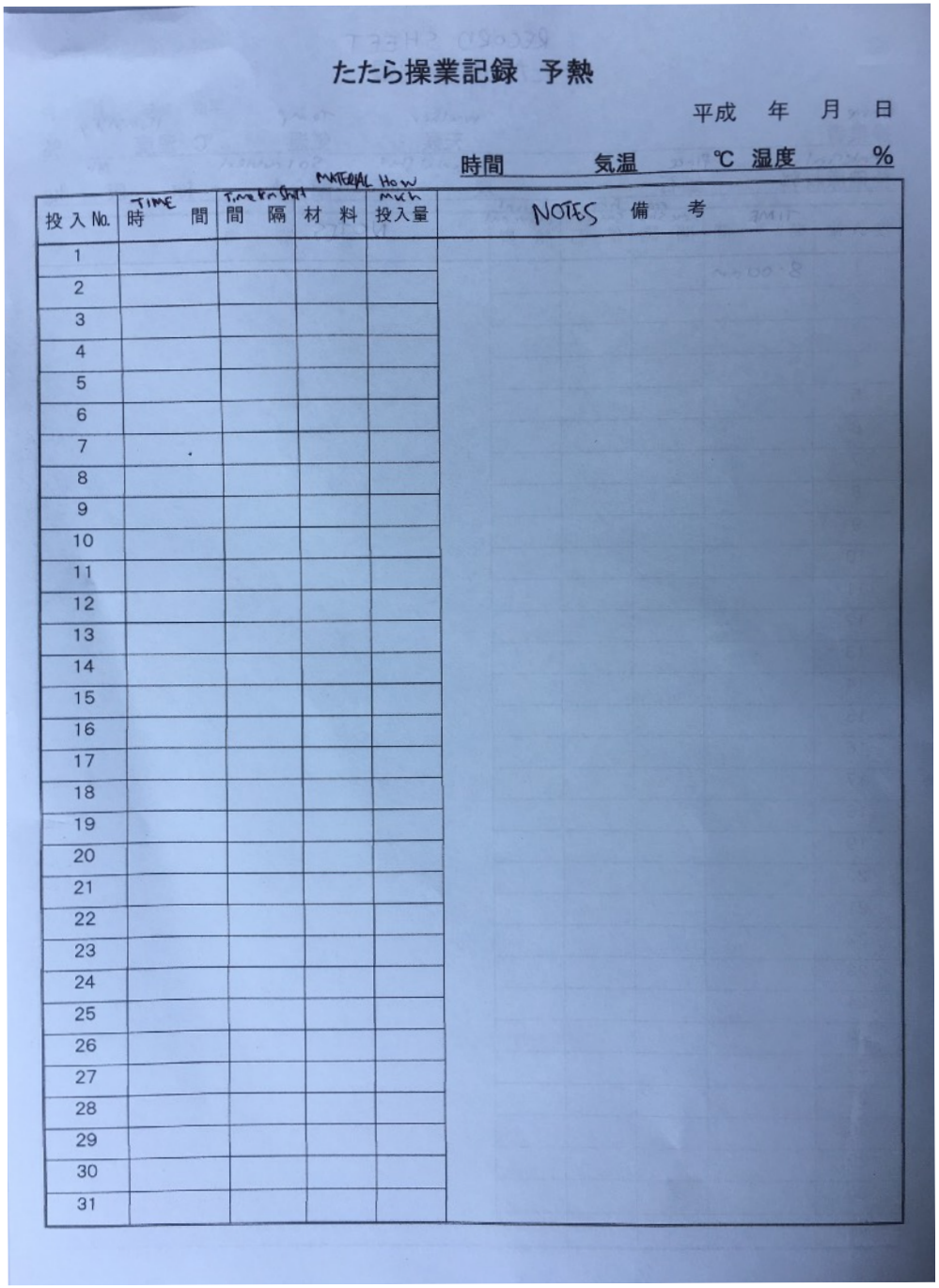
Coles castings
They run an annual iron pour in Dorset and my contribution to this in July 2019 will be running a live smelt at the event.
http://www.colescastings.com

BABA report
The British Artists Blacksmithing association have asked me to present a report of my trip which will be published in the magazine.

National school of blacksmithing
I am in conversation with tutors about holding a smelting event here to train students.

Iron smelters of the world Facebook group
I will post my finished report here for feed back and help to develop my learning.

Blog
I will continue to update and manage this as my project develops.
https://ironoreadventures.wordpress.com



たたら操業記録　予熱

平成　年　月　日

時間　　気温　　℃ 湿度　　%

投入 No.	時間 TIME	間隔 Time Between	材料 MATERIAL	投入量 How much	NOTES 備考
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A useful record sheet for recording notes, times and amounts of materials whilst smelting. Keeping good notes and records allows you to monitor what may have impacted the results of the smelt.

2018年（平成30年）10月20日（土曜日）　山陰中央新報

奥出雲訪れ砂鉄採取や見学

英女性彫刻家 たたら学ぶ

イメージ膨らませる

日本古来の伝統のたたら製鉄を学ぼうと、鉄を素材にした芸術作品を手掛ける英国の女性彫刻家ケイティー・サーリッジさん(33)が、奥出雲町を訪れている。「とても神秘的だ」と、日本刀の原料となる玉鋼を造る技に魅了され、たたらの歴史や広がりを教わりながら、自らの作品づくりにイメージを膨らませている。

鉄穴流しの跡地に造られた棚田に見入るケイティー・サーリッジさん（左）

ロンドン在住のサーリッジさんは、英国の美術学校研究科を経て、国立鍛冶学校で3年間学んだ。鋼を生み出すたたら製鉄に興味を持ち、工程や歴史を研究するため、初めて来日した。

17日に奥出雲町に入り、同町横田の奥出雲たたらと刀剣館などを視察。同町大呂の日刀保（日本美術刀剣保存協会）たたらでは、技師長の木原明村下(83)に会い、映像を見ながら三日三晩、砂鉄と炭を交互に炉に入れるたたらの工程を学んだ。

19日は、同町竹崎の羽内谷鉄穴流し本場の横の川に残っていた砂鉄を採取。同町福頼で、鉄穴流しで山を削った跡に造られた広大な棚田景観に見入った。

サーリッジさんは「たたらの技を肌で感じることができて感動した。砂鉄からさまざまな道具が作られ、日本中に広がったことが素晴らしい」と笑顔で話し、「鉧から芸術が生まれるような作品を作りたい」と意欲を燃やした。

21日には大田市の石見銀山を訪れる。（引野道生）

A newspaper article published in Japan about my project and interest in smelting.

Minutes of Meeting

held on
Saturday 22nd September 2018
at 1.15pm

Woodford Heritage Centre, Woodford, Co. Galway.

In Attendance:

Paul Rondelez, Ronán O'Caoimh, Kevin Keary, Keith Armitage, Katie Surridge, Richard Lyons and Monica Hynes

Paul chaired the meeting and Monica agreed to take the minutes of the meeting for now.

1. Name and Rules of group, after discussion about the name, the group agreed on the following name: Society of Iron Smelters of Ireland (SISI).
2. The group also agreed that everyone has one vote and can vote by email; Whats App or Skype. The votes per email, Whats App, Skype etc were confined to matters brought up for voting during the preceding meeting.
3. Some discussion around membership also took place with rules on same to be discussed at the next meeting.
4. The frequencies of the meetings were agreed also, October, March and August.
5. After input from the group on the CLG option and insurance issues, it was agreed that Monica would investigate if insurance was a possibility under the East Galway Family History Society's existing insurance policy to add Smelting activities under heritage activities and to find out how it would work as employees and volunteers of the East Galway Family History Society CLG. Separately if insurance was possible then the board of the East Galway Family History CLG to be contacted regarding the smelters to become volunteers of their CLG.
6. Paul said he will check with the Mining Heritage Trust of Ireland and Ronán with Umha Aois (copper casters). Paul had discussed personal insurance with Jeremy Stanley, which did not seem a possible route.

Any other Business

There was no other business to discuss and the meeting finished at 2.30 pm.

Signed: _____

Date: _____

Signed: _____ **Date:**

_____

Minutes from the first meeting of SISI which I went back to Ireland for . this group will continue to develop smelting techniques together and is formed of people I met at the Furnace Festival.

Bibliography

Websites

- https://www.leesauder.com/smelting_research.php
- http://www.hitachi-metals.co.jp
- https://www.wealdeniron.org.uk/hist.htm
- https://www.furnaceproject.org

Books

- The Forge and the Crucible. by Mircea Eliade. 1956
- The art of the Japanese sword. By Leon and Hiroko Kapp

Reports

- Survey report on the selected conservation techniques . 1 Japanese steel. National research institutes for cultural properties.

Professional experience / bio

Katie Louise Surridge (1985), was born and raised in London. She studied for her art foundation at Chelsea school of Art and her BA at the Slade, UCL (2010.) Upon graduation she was selected as one of four finalists in the Saatchi's New Sensations competition, and later as a Royal British Sculpture Society, bursary winner (2011).

In 2013 she spent four months in China as Swatch Watches artist in residence, where she started Little Victories gallery, which operated from a converted waste recycling bicycle. This gallery allowed artists to display what they want, where they want, an interesting concept in a society where art is still heavily censored. This has now been remade in London.

In 2016 Surridge finished three years training as a blacksmith in Hereford at the National School of blacksmithing. Using and developing these skills is now one of her main passions. She recently completed a residency in Wales where she researched local folklore and stories which inspired a large sets of hand forged wings, appropriating the traditional acanthus leaf motif as feathers.

Her forged metal work was also on display at the Biscuit factory in Newcastle as part on the Young contemporaries, and Oriel Davis gallery commissioned me to create work for the Litmus project. Other commissions include the B-side arts festival where she ran a mobile bronze foundry casting live for the public and a permeant piece of public art for an Iron Age hill fort in the New Forest.

Surridge has been selected for numerous residencies, she was artist in residence at 'The observatory' in Lymington where she worked with locally collected coloured sand to create work which responded to the Victorian fad of sand art in bottles. She will next be attending a residency at the Scottish sculpture workshop (2019) to continue to develop the techniques of making iron from ore. This major new area of exploration and will culminate in a project and exhibition with Fire and Iron gallery.

Artists statement.

The ages of civilisation are named after materials because they transformed society. To me, there is something therapeutic and grounding in revisiting ancient techniques. If we distance ourselves from creating and live as consumerists, we have a danger of becoming illiterate in a making sense. Perhaps this material based ignorance is as dangerous to society as illiteracy, and we are becoming uncivilised in a new way.

Learning skills such as blacksmithing and casting metal creates links with the past and helps me understand the origins of my own practice. Now confident in forging metal, I am experimenting with infusing these ancient techniques with a contemporary outlook. I am interested in mixing other materials with my metalwork, intertwining skills and exploring new combinations. A sense of humour and a genuine interest in connecting with people through my art plays an equally important role.

My current work researches the utilisation of other art forms of the past such as smelting or flint knapping. I am interested in how various technical and cultural processes affect the aesthetics of objects which I make. Im increasingly keen to be able to control the whole process of my making, from sourcing raw materials to manipulating them in to final art works.

This has recently led me to learn how to make my own steel directly from iron ore. By researching the space where these ancient techniques meet modern day society, I will investigate how a change of context can effect the dialogue around research based practice.

Challenging myself either physically or mentally is becoming an important element to my work. I am interested in the idea of the artist as ethnographer and using fully immersive research as a means to make. I find completely removing myself from the comfort zone I know and understand is inspiring.

I am passionate about developing the use of hot metal within my work and exposing the viewer to the processes of making a final piece. I want to create a spectacle for the public to witness something different, involving them where possible , with the hope they will inspire new work.

Acknowledgements

Firstly a Huge thank you goes the the WCMT who have given me the ability to change the way I think and work. I have learnt so much through this opportunity and they planted the seeds for this continued development.

I first found out about the WCMT at an iron pour event I was attending at Coles castings (run by Stephen Coles) in Dorset. Here I met two fellows (Abbi Burt and David Wilson) who inspired me with stories from their own scholarship travels to go and research the award. With out this event or meeting of minds I would not have experienced what I did, and learnt what I have so a big thank you is due here.

Perhaps the start of this story could be traced slightly further back with my time spent at the National school of blacksmithing. I owe a lot to my tutors here, especially Peter Smith, who understood how I wanted to develop the use of forge steel, and patiently waited for me to work out the value of technical skill training. This formal start would eventually allow me the freedom to make what I wanted.

The first part of my trip was to the furnace festival in Ireland. Paul Rondalez worked a miracle in organising it all and allowing me to take part. A huge thank you here should also go to Jake Keen for sharing his wisdom and teaching me to build my first furnace, Lee Sauder for his inspiring work and knowledge, and to Eric Dennis for dragging ore out of rivers with me barefoot. Decland Walsh also deserves a mention here for catering for the smelters and offering his pub for the hub of the festival, I dont think Ive ever laughed as much!

The second part of my research was based in Japan. I would not have been able to see and attend much of what I did with out the help on Mo jones and Yukata Ogata. Mr Kihara was amazing in allowing me access to the Nithotto tatara and accepting me on his team in Niimi. A special thanks to all who had me in their homes and taught me on route, especially Nobuya Hayashi.

鉄は熱いうちに打て
(*tetsu wa atsui uchi ni ute*):
“strike while the iron is hot”