God’s Own Blacksmiths: working with Keralan blacksmiths to investigate microstructural analysis

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I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

Signature: …..

Abstract

The skills and techniques of past metal smiths are gauged through the analysis of the microstructures of artifacts using standard metallography. Little or no work has been carried out to test or verify microstructural observations through ethnographic and experimental re-enactment of techniques. This study will offer a way to establish the veracity of this approach to studying iron objects and will draw on direct practical engagement with remnant Keralan blacksmithing communities. In addition, controlled experimental re-enactment, deconstruction of techniques and comparative microstructural analysis will be carried out. How local agricultural tools are forged and what makes up the smithing toolkit will be assessed as well as how each forging space is utilized. This research aims to conduct the study using a range of methods that includes experimental re-enactment in a manner that assesses their applicability to other regions and periods.

Covid Impact Statement

Covid-19, in particular the travel bans, dramatically impacted the data collection and analysis phase of my research. A core element of my thesis was the blind analysis of my metallurgical samples by two independent specialists. It was not possible to courier the samples to the specialists and because travel was not allowed for several months there was a delay in progressing the blind analysis.

This analysis was delayed further because one of the specialists had to take time off due to family complications related to covid. They were able to complete only half of the analyses and the results were returned to me one month before the submission date. I am very grateful that they took the time to finish a portion of the analysis, but the lateness caused the comparison to other data difficult. The data are presented in the thesis, but the presentation is not as polished as the data from the other researcher, and a thoroughly explained analysis of this data was not within the time constraints.

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Preface

Tvastar had just stepped into the forge when a young boy came running in to tell him that the king wished to see him. "Right away. Now." the boy said.

As he walked down the narrow path through the paddy field, Tvastar worried about what the king could want in such a hurried way on this morning. Had something gone wrong with the fittings that he had made for the king's new palace? Work had only been finished for a week now, and preparations were being made for the celebrations to officially reveal the kings court. It was to be a very splendid and lavish show. Everyone would be dressed in elegant clothes with dancing and a grand feast. They even say that the king is going to arrive riding an elephant! When building the palace, we created the doors high enough to enable an elephant and a rider to easily be able to travel into the main public areas.

When Tvastar finally reached the palace, the king's guard ushered him quickly into the meeting room. The king was sitting on the floor of a raised platform at one end of the room with silken cushions all around him; he quietly motioned for Tvastar to stand before him. As they waited, many other crafters from the village began to fill the meeting room. The stonemason, the carpenter, the goldsmith and many others that the king had to build the palace were in attendance. Everyone waited in silence until the king, satisfied that all were present, began to speak.

"You are all aware of the lavish celebrations in honour of my palace building being finished?" the king said, his voice echoing off the walls of the large room. "I wish to recognise one crafter for his distinguished work on the palace, and this person will have a special seat next to me during the festivities. To do this, each crafter will need to be arranged in order based on his contribution to the building works. You will all have one night to decide who among you will be first and how you will then be ranked. Return tomorrow, and all will come before me and tell me what you find."

All the crafters were silent as they left the meeting rooms and the palace. Though once on the trail home, all of them began to speak and argue over who should be the one to take the seat next to the king. Tvastar did not wish to be part of the impassioned arguments, as he felt if he were meant to sit at the seat next to the king, it would happen. He did not feel the need to champion his work, and so he returned to the forge to finish his work for the day, then journeyed home early as he knew he would have to be back at the king's palace in the morning. The rest of the crafters debated deep into the night.

The next morning Tvastar was uneasy about not staying and debating with the rest of the crafters. Did he make the right decision? The king might see this as a sign of weakness or unfaithfulness. He hurriedly prepared himself for the early meeting. As he was walking again on the familiar path along the paddy field to the palace, he met up with all the other crafters on the way. They were all quiet, only giving a short greeting when arriving with the group on the path. It seemed as if they all felt they were about to receive karmic returns, which could be good or bad.

Soon they were all at the palace. This time they would all venture in to meet the king one on one in his meeting room to plead their case. First, the carpenter who said, "I have carved beautiful flowers, sculptures of animals and people within your chairs and beams of the ceilings" Then the stonemason who said, "I have built the walls of your battlements and carved exquisite elephants on the floors and walls of your home" Next the goldsmith said, "I have given your palace the warm glow of the sun and adorned your women in exquisite ornament." One by one, they all gave the king the many reasons they had contributed the most to the building of the king's grand palace.

Finally, it was Tvastar's turn; he stepped into the meeting room with a sense of dread. He stood before the king. The king, breaking the silence, said, "Tvastar, Blacksmith, what have you contributed to my stunning palace?" Tvastar shyly said, "I have only made a few items for the palace. I have made the hinges and attachments for the doors, nails and tools for the kitchen." The last part of what Tvastar said gave the king more information than Tvastar realised. The king then asked, "And who made your tools for your blacksmith work?" Tvastar replied that he had made his tools.

Then the king excitedly jumped up and went out of the meeting room, with Tvastar following quickly behind. The king then went to each one of the crafters and asked who had made their tools for them, "The blacksmith, Tvastar." They all would say. After asking each and every crafter, the king turned and looked at Tvastar and said, "I think we have discovered who has contributed the most to the palace and, in turn to me and my family. Tvastar, you are most welcome to sit next to me during the palace celebrations."

From that day on, the blacksmith and all metalsmiths held an exalted status within the king's court.

Chapter 1 Introduction

1.1 Context

The working of metals, especially iron, has been at the heart of technological and economic change across cultures. As such, the origins and spread of metallurgy is a high-profile topic in archaeological research. For this reason, there have been many research projects focusing on the mining and smelting process involved in ferrous metal technology. Their locations range from Sri Lanka (Juleff 1998) and India (Juleff et al., 2014; Srinivasan 2013) across Africa (Serneels 2003) to England (Hodgkinson 2009; Schubert 1957) and the list goes on. While certainly technologically and economically transformative, metal production has also transformed culture and ideology, as discussed in Herbert (1993) and Helms (2013). Evidenced by the wealth of oral history and folklore surrounding them, the socio-cultural significance of metal and metalworkers is significant. The Bible has 12 verses about blacksmithing, with Isaiah 54:16 stating, "I create the blacksmith, who builds a fire and forges weapons. I also create the soldier, who uses the weapons to kill (GNT)", probably being the most well-known.

Stories about metalsmiths have circulated since metalworking began, like Tvastar, the humble blacksmith who won a place at the king's side (see Preface). Indeed, a recent study by de Sliva and Tehrani (2016, 9) suggests that one of the oldest surviving folktales, which they trace back to the Bronze Age, was *The Smith and the Devil.* This story is about a blacksmith who agreed to live peacefully with the devil to obtain specialised skills in blacksmithing. As with most folktales, there are many variations through time and different locations. All these tales have in common that they all speak of the high status of the smith within the village community, and many convey the belief that the metalsmiths had magical powers (Jennings 2014). Within the classical tale of the sword in the stone, one could even see the magic of the smith—the literal taking of the stone and creating a sword from within it.

Figure 1.1 Premanath T.N. in his forge in Vypin adding a wooden handle to a knife (Edwards 2017).

Having spent time observing blacksmiths at work (fig. 1.1), it is unsurprising that people in the past believed that they possessed magical powers. To realise this, one only need to look to mythology the world over and find some of the most powerful creator gods hold the secrets of the blacksmith. Starting in Greece with Hephaestus, Vulcan is the Roman god of fire with his forges being volcanos; Vishwakarma, a Hindu god, is considered the divine architect and creator of the world. The Hittites have Hasameli and the Persians the god Gavah. These are just a few names of gods that are said to be metalsmiths and creator deities.

When researching blacksmiths, it is almost impossible not to consider the material that they work with while forging. Iron is the properties of the material and the symbolism that would have surrounded the material in the past. The iron itself is thought in some cultures to have magical properties to heal and can be seen in many cultures in offerings to the gods. It would not be uncommon in the British Isles to see iron offerings such as nails, pins, buckles, buttons,

Figure 1.2 A money tree at Becky Falls, Dartmoor, Devon, UK.

fishhooks and keys left or attached to trees or thrown into wells (Houlbrook 2015: 131). Many of these trees are still in existence today, known as money trees (fig. 1.2), Believing that metals, particularly silver, iron and steel, held magical properties that would ward off the ire of creatures such as fae or faerie folk.

For this reason, children's clothes would have bits of metal sewn into them, and parents would place iron objects under beds to protect their children from being taken by angered spirits. (Houlbrook 2015: 132). Travel to many rural locations in the British Isles and North America, and one could find a home with a horseshoe above a doorway or hung close to the main entrance to a house (fig. 1.3). Today this is done under the understanding that it is to bring good luck as the horseshoe itself in the present-day is a lucky symbol. In the past, people would hang an iron object to ward off witches (Lawrence 1898: 7). If the material holds magical properties, it is not an effort to think that the person who owns the secrets to creating the iron from stone and then transforming the sponge-like bloom into a finished usable iron object would also know all the secrets of necromancy.

Figure 1.3 Horseshoe decoration on a door in Chulmleigh, Devon, UK.

Traditional metalsmithing is a sensory extravaganza, little different today than it would have been in the past. Aurally, the bellows whoosh, roaring the air through the base of the furnace, heating the charcoal so that it crackles and pops. The temperature and glow from fire radiate onto skin, heating it to an almost unbearable level. Visually, the incredible beauty of the iron as it smelts, transforming from bright yellow, flaming orange, then eventually back to cold grey-black, and the distinctive smell of the forge. They probably would have watched in fascination as the trained smith would shape, mould, twist and even re-join two pieces of metal. With its distinctive ping-ping, the smiths' hammering would have been an indication to the village that he was open for business for the day, much like the baker's call bringing people to the street to purchase or socialise.

Based on historical sources and ethnoarchaeology, it is clear that metalworking is and has always been experiential and social. However, it is difficult to reconstruct such narratives from an ancient metal artefact, and, by comparison to other forms of material culture, ancient metallography remains little understood. Hodges (1976: 209) suggested that this is due to the destructive nature of the analysis, which is not permitted for many objects, reducing opportunities to advance knowledge.

In archaeology, blacksmithing has been understood primarily using microstructural analysis through standard metallography, whereby sections are cut from the objects and mounted for analysis. A large portion of studies look at carburisation, quenching and heat treating, such as Lang (1988), who looks at Roman swords, Scott (1977), who researches Irish tools and weapons and Abdu and Gordon (2004) that investigate iron objects excavated from Arminna and Toshka West in Lower Nubia. Some researchers focus on analysing the chemical makeup of the iron. Others, including the Human Population and Paleoenvironment in West Africa project (Soulignac and Serneels 2013), have focused on the waste products and smithing residues produced during the final forging processes (see also Unglik 1991, Dungworth and Wilkes 2009). When an iron object is discovered the blacksmith’s skill set is determined by analysing the microstructures within the artifacts using metallography. The process of metallography has had little to no research to test its veracity in understanding blacksmith skills through microstructural observations.

In many ways, ethnographic studies are providing more advanced insights into blacksmithing. Approaches can be split into two main strands: the social and the technical. In *Cognition and Tool Use* (2008), Keller and Keller found that smiths will have a set of skills that they recall to manufacture an object. They label this as "taskonomy," a series of tasks that are unique to any iron object that is forged. This also includes those tools that would be used in the forging of the iron object. Many of the theories that arose from this study are discussed in the methodology section of this research. Another seminal ethnographic work is Ann Dunham's *Surviving against the Odds* (2010). This ethnographic research is focused on the economic changes that were taking place in the small villages in rural Indonesia. Dunham mentions technical aspects of the metalworking but does not go into detail.

There are also many ethnographic studies in Africa on blacksmiths. One such study in West Africa involves how children acquire the life skills that would be needed for a blacksmith to become a big-man or medicine man within their community (Lancy 1980). Another study attempts to understand the process of learning blacksmithing skills during apprenticeships among the Yoruba blacksmiths of Nigeria. This study does not focus on any of the technical skills needed for smithing, but rather only how these skills are acquired through the process of apprenticeship (Obidi 1995).

The insights obtained from ethnographic analysis provide compelling information about the social aspects of metallurgy. However, there have been few attempts to combine high-quality ethnographical analysis with detailed metallography to understand blacksmithing technology in the past. This thesis sets out to achieve precisely this: to conduct ethnographic interviews with modern traditional blacksmiths, observe their procedures as they manufacture a series of tools, and then conduct metallurgical analysis - including blind studies - before reintegrating the datasets.

1.2 Location – Kerala, South India

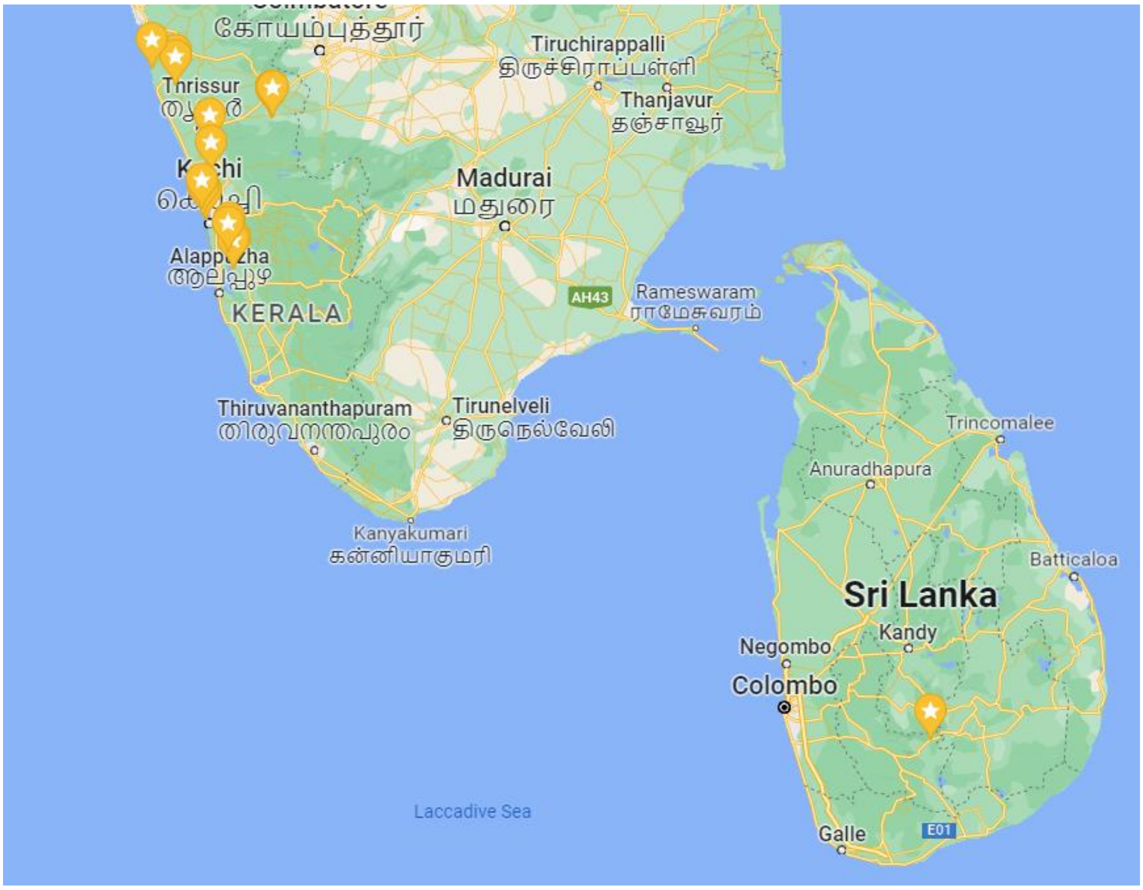


Figure 1.4 Map showing South India and Sri Lanka, indicating specific research locations (Google: 2022).

This thesis focuses on the remnant blacksmithing communities in Kerala, South India (fig. 1.4). It involved direct practical engagement combined with controlled experimental forge work, deconstruction of techniques and comparative microstructural analysis. Detailed documentation of the forging processes and what makes up the smithing toolkit is assessed, and how each forging space is utilised. Ethnographic investigations also look at religious and social aspects of these remnant crafting communities, with the understanding that documentation of these surviving crafting communities is not just documenting a traditional technology but chronicling an ancient way of life that is quickly disappearing.

1.3 Research Aims and Objectives

The overarching aim of this thesis is to create a known socio-technological baseline for future archaeological ferrous metals analysis.

Research Questions:

- What is the contribution of the blacksmith within the social and political environment within central Kerala?
- What are the skills and techniques of traditional blacksmiths in central Kerala?
- What knowledge can be gained about blacksmithing through metals analysis?

Methods:

- Study past ethnographic and archaeological evidence of iron smithing technology and socio-political status
- Ethnographic study and experimental forge work with Kerala blacksmithing communities
- Microstructural analysis

The primary objective of the microstructural analysis for this research is to understand the potential information that can or cannot be obtained about blacksmithing technology through the methods used in standard metals analysis. For this purpose, a blind study was conducted. Blind due to the author not knowing, in the beginning, the data obtained during the initial forging work undertaken with the blacksmiths in Kerala. The data was documented with the aid of a research assistant responsible for the proper running of the documenting sources and sealing all the data to be stored for later documentation and analysis.

The items used in the microstructural analysis are the iron objects forged during the ethnographic and experimental research in Kerala, iron objects forged during the author's masters research and research conducted by Gill Juleff, both in Sri Lanka and discussed in detail in chapter 4. Since the traditional blacksmithing technology in these areas has remained similar for hundreds of years, it could be said that it is approximately what would be found in the archaeological record. These forged objects will be made using the same tools and work areas that are found in the archaeological record throughout the world. Until now, this type of study has never been conducted in conjunction with objects forged with traditional skills and analysed in a blind study to observe if the data matches.

1.4 Thesis Outline

Having set out the rationale for the thesis, Chapter 2 moves into background material, reviewing the birth of iron technology in Sri Lanka and South India and past research in both areas. The section also includes ethics during fieldwork. Chapter 3 discusses the theoretical framework behind the research and fieldwork. This section also discusses choices that were made during the study and the rationale behind them. Chapter 4 will be a short introduction to traditional iron technology, covering some of the research to date and the technical steps required to produce an iron object. This will cover the basics of mining, smelting and lastly, forging of the object.

Chapter 5 covers information on the ethnographic findings during the fieldwork in Kerala in South India. This will include surveys of smithies and small private Hindu temples, interviews with blacksmiths and a Pujari, and documentation of a Puja.

Chapter 6 covers the step-by-step processes involved in the forging of the iron objects and relevant data collected. Chapter 7 will provide results found during the lab analysis. Chapter 8 will conclude the research with a discussion on the research findings, thoughts on future research, impact and looking forward.

Chapter 2 Socio-Political History and Past Research

2.1 Introduction

This chapter will begin with a broader look at iron smithing studies to help get a better picture of how this research fits into the growing chain of knowledge related to blacksmithing. Then will move on to the ethnographic sources for this research, placing them into context, explaining some of the circumstances behind the writings, and position the authors in time and space.

The socio-political climate will then be examined, covering the political history, the land tenure system and social structure of both areas. Then focus on the blacksmiths themselves, covering the importance of the origins of the caste system and why this system of living was not just a part of the socio-political system of the smiths but also ingrained into the smiths' religious beliefs and an integral part of their world view. The section will then discuss some past ethnographic, experimental and analytical research on iron technology in South India and Sri Lanka. Lastly, the chapter will link the two areas by looking into the ancient and historical interactions between the two regions.

2.2 Broader Research: Crossing Continents

Valuable research has been conducted on the mining and smelting process involved in ferrous metal technology in many locations worldwide. Books can be, and indeed are, filled with the work completed in many continents across the globe. A complete review of this work is beyond the reach of this writing.

What is pertinent to this study is the research that focuses on the blacksmiths and ferrous smithing technology. This body of work is much smaller than the work on smelting but very valuable to the study of past iron production as a whole and will be the focus of this section.

Many ethnographic studies highlight blacksmithing in some way. These usually are interested in two different aspects, the social and the technical. While both of these will usually intermix, the main objective is usually one of these. In *Cognition and tool use* (2008), Keller and Keller work with blacksmiths from New Mexico, USA, to understand how blacksmiths remember and learn while smithing. After spending time as an apprentice at a smithy and conducting many interviews and hours of ethnographic observations, the study leads to many new thoughts on how crafters work, not only within their mind but also within the forge space as well. Much thought was given to what knowledge needs to be understood before an object is formed and what skills must be recalled. They call these skill sets a “taskonomy,” that is, a series of tasks that are unique to any iron object that is forged. This also includes those tools that would be used in the forging of the iron object. The tasks and smithing tools become imprinted within the blacksmith’s understanding of the object and are recalled while the smith is working. Many of the theories that arose from this study are discussed in the methodology section of this research.

Another seminal ethnographic work is Ann Dunham’s *Surviving against the Odds* (2010). This ethnographic research is focused on the economic changes that were taking place in the small villages in rural Indonesia. Many agriculturalists were moving away from crop production due to loss of land and no longer being able to share crop land. The focus is on metal workers and the economic and social aspects that affect the workers' profits. It mainly focuses on blacksmithing but also includes silver and cast iron. Dunham mentions technical aspects of the metalworking but does not go into detail. It is noted that surveys of the smithing villages were done, but the author does not include them in her writing.

There are also many ethnographic studies in Africa on blacksmiths. Africa has a vibrant and long iron industry heritage. Many of the studies are on how the smiths learn skills. One such study in West Africa involves how children acquire the life skills needed for a blacksmith to become a big-man or medicine man within their community. It was discovered during ethnographic work that the local children would play as if they were blacksmiths, setting up a mock forge area and tools and re-enacting making iron objects. The other children involved would play the other villagers (i.e. a wife to bring him food and villagers to bring work). In these play scenarios, the 'smith' takes on a leadership role, thus teaching the child how to handle social interactions that will benefit the adult they will become in later life (Lancy 1980).

Another ethnographic study on understanding the process of learning blacksmithing skills focuses on apprenticeships among the Yoruba blacksmiths of Nigeria. For this study, they interviewed 55 people within the age group to have been taught blacksmithing skills through the old apprenticeship system. They explore questions such as what was required to start study, how long did training last and what were the different skills to be met before one could move on to another level of training. This study does not focus on any of the technological skills needed for smithing as such, but rather only how these skills are acquired through the process of apprenticeship (Obidi 1995).

Another study on the blacksmithing society of the KuKu peoples of Sudan discusses the blacksmiths social status and how the smith has contributed to their community. The areas where contributions were made were highlighted, such as agriculture, marriage and warfare. The first and last on this list should be obvious, but the contribution in marriage is listed due to the blacksmith forging all the objects required for a bride. The groom must pay the family in agricultural tools for his new bride, so the blacksmith plays an essential role in the marriage of people in the community (Poggo 2006).

A large body of work from East Africa is Schmidt's *Iron Technology in East Africa* (1997). This book includes research on both the smelting and forging of iron objects in East Africa. Some interesting things to note about Schmidt's work are that he proposes that iron technology in Africa developed independently without outside influence. He also states that the high status of blacksmiths in the society could be due to the blacksmith being so involved with the objects needed for the king and any festivals the king may have. Stating the importance of this role and the tie between the king and the blacksmith due to this. Very detailed drawings of the forge area are also given, along with documentation of the tools used by the smith.

Human Population and Paleoenvironment in West Africa is a multidiscipline group of researchers with backgrounds in geology, archaeology, ethnography etc. that has been conducting detailed research in West Africa since 2002. For this writing, I will focus only on the work pertaining to the forging of iron. The majority of the work with ironsmiths in this study focus on smiths in the Dogon plateau. While this study does discuss some of the techniques and skills used by the smiths while forging, the main focal point is on the waste products produced from forging and the relation to loss of iron in the object forged. For this, they watch the smiths forge agricultural implements for a day, documenting the social interactions and breaking down the steps used in forging the iron implements. At the end of the day, they collect the slag deposits accumulated at the bottom of the hearth and the hammer scale located on the smithy floor. They then take the slag and hammer scale back to the lab to look at the iron content found to relate this to the beginning bar of iron with the end iron implement to calculate how much iron was lost during the forging. Also, it is in hopes that they might be able to see a pattern in the waste material that will lead to clues as to what object was forge in correlation to the waste product (Soulignac and Serneels 2013).

2.3 Traders, Captives and Colonists

India and Sri Lanka at times seemed to be at the centre of disputes between countries attempting to gain a stronghold of power in the Asian market. Some came for the excitement of exploration and some for the profit they saw in the strategic location and bountiful environment. To better understand this time, it is important to consider the explorer's published works and the people behind those books, the men who wrote them, and the environment they were recording. This is not a study of the authors themselves and is not an exhaustive list of writers on this subject, but an introduction. A picture of the ties between South India and Sri Lanka will emerge within these books and why these ties are significant. The writers also recorded accounts of the political history and social structures of these areas. These are invaluable to our knowledge of the caste system, village structure and land tenures in the region during this period.

The first attempt, for the West, at significant trade with India and Sri Lanka was carried out by the Portuguese in the early 16th century. The Sri Lankan King granted the Portuguese permission to build a factory with battlements in Sri Lanka. At this time, works by the Portuguese historian Diogo Do Couto and later João Ribeiro would be written. Ribeiro would advance to a captain's status in the Army, first serving in Sri Lanka and later in India. From Ribeiro's accounts in his book '*The Historic Tragedy of the Island of Ceilao,'* dedicated to King Dom Pedro II in January of 1685, that Europe gained the first account of Sri Lanka. (Ribeiro and Pieres 1999).

The arrival of the Portuguese was the start of a new type of trade with the outside world. At first, the new arrivals wanted to dominate trade within the area, but soon they were pulled into politics by offering protection to warring cities within Sri Lanka. This arrangement would mean security for the chosen city in exchange for trade and the freedom of missionaries to live in the villages. This was a time of constant changing of allegiances between the Portuguese and different kingdoms within Sri Lanka, trying to get the upper hand and rule. Attempts at peace became ever more complicated, with mistrust and misunderstandings and village leaders unable to forgive past invasions (De Silva 1981). The harmony between the local people and the Portuguese did not last long due to the Portuguese reportedly being "cruel and hard of heart" (Coomaraswamy 1979: 10).

During this time, Sri Lanka began to break into two different regional sections, two separate groups of people, the 'Kandyan' in the highlands and the 'Low-country' who lived along the coastal areas. The individuals in the low-country became more peaceful with the Portuguese, adjusting to the different culture and absorbing many Portuguese ideas and words into their own. The Kandyans, who made up the more significant part of the Sinhalese population, did not care to integrate into the Western ways and held on to their traditions and customs for many years after the arrival of the Portuguese. The fact that the Kandyans were strategically located in the central mountains of Sri Lanka aided in the Sinhalese enduring and keeping their independence and cultural identity for so long (Coomaraswamy 1979).

In 1595 the Dutch arrived with the Vereenidge Oost-Indische Campagnie or Dutch East India Company. They quickly began to dominate trade within Asia, becoming the largest mercantile trade company of the time. The King of Kandy, Parakrama Bahu VIII, saw the arrival of the Dutch as a way of expelling the Portuguese from Sri Lanka. The Dutch were interested in the monopoly of the cinnamon trade in the area. Agreements between the Dutch and the King quickly led to arguments among the two powers and many years of battle between the Kandayns, Portuguese and the Dutch (De Silva 1981). In 1658 the Portuguese were supplanted by the Dutch with the help of the Kandyan King, Raja Simha II. In the long term, however, the Dutch activities did not result in better relations with the Kandyans, while the people in the low-country who had at this point been exposed to outside influence to a more considerable amount, interacted with the Dutch in much the same way as they had with the Portuguese (Coomaraswamy 1979).

In 1670 the French came to Sri Lanka, and, as with all the others, they arrived with the desire to establish themselves in the trade market in Asia. The

Kandyan King saw this as an opportunity to eradicate the Dutch from the island. King Rajasinghe II allowed the French to establish a small trading port and began raids on Dutch ports hoping that the French would be compelled to intervene in the fighting between the Kandyans and the Dutch. The French were not interested in fighting the Dutch, but the Dutch were not happy about the French trading and establishing ports in Sri Lanka and India. The Dutch forced the surrender of the French in 1672.

British interest in India started as being particularly focused on trade and commodities. It began with the East India Trading Company organisation, a business endeavour concerned with trade with India and China, with wealthy persons owning stock in the company. This company grew to own much land and hold much power in India and even had its own military. The East India Trading Company also hired persons to look into the flora, fauna, geology and different aspects of Indian life. This period in India has many writings from people experiencing India for the first time and reporting back to the government in England (De Silva 1981).

Figure 2.1 Captain Robert Knox (Royal Museums Greenwich 2022).

During this time, one of the most famous prisoners of Sri Lankan history was held captive by the Kandyan King. Robert Knox (fig. 2.1), whose father was a captain for the English East India Company, was captured when his father's ship was anchored off the coast of Kottiyar Bay in Sri Lanka. Kottiyar Bay, also known as Trincomalee Bay, is located on the northeast coast of Sri Lanka. Knox's father's ship was damaged during a storm in November of 1659 while loading wares at Masulipatam, India; the storm broke the ship's mainmast. Knox's father was sent to Sri Lanka as this would have been the best place to get the timber to replace the mast (Frank 2011: 32). Knox, along with his father, was discovered by the Kandyan

King and taken hostage along with several other men of his ship. In 1660 both Knoxes' fell ill with a fever that was decimating the Sri Lankan countryside. It is suspected that this was an outbreak of cholera, the younger Knox, with time, recovered from the illness, but his father would succumb to his illness in February of 1661 (Frank 2011: 47). Knox was a prisoner of the king for 20 years and stated that he was treated fairly during his time, and some of his shipmates later married and had children within the community. Through his writings, it is apparent that Knox never felt comfortable in the Kandyan community and did not settle down like his shipmates. Knox chose to escape from his captors as soon as the opportunity for him permitted (Knox 1818). Thankfully, he did because his capture and escape resulted in him writing one of the most interesting and informative books on Sri Lanka during this period. His book '*Historical Relation of the Island Ceylon*' (1681) published just one year after his escape and caused a stir within western society and quickly found its way to the best sellers list (Frank 2011: 5). Knox's book is rumoured to have influenced Defoe, who wrote '*Robinson Crusoe'* (1781), a much-beloved book about a castaway and his many adventures when he becomes stranded on a remote island. Whether this is true or not, it can be said that '*Historical Relation of the Island of Ceylon'* is almost a guidebook for the great years of the Kandyan Kingdom.

The arrival of the British begins a period of exploration and renewed interest in then Ceylon and India. The British government sent military personnel and various specialists to the countries to document everything that they could. One of these specialists was John Davy, an army surgeon, a member of the Royal Society and author of '*An Account of the Interior of Ceylon'* (1821). In this book, he interviews many people from different parts of the island and of various backgrounds. The book covers the natural history and many crafts of the time and many other observations made during his four-year stay in the country. Also, in this category of Sri Lankan works from this time would be *'Ancient Ceylon'* by H. Parker (1909). The British government hired Parker to work with the irrigation department in Sri Lanka from 1873 to 1904. His drawings and subject coverage are invaluable to the collection of knowledge of Sri Lanka.

In 1784, William Jones and 30 other like-minded individuals established the Asiatic Society in a meeting at Ft. William in Calcutta, India. This organisation began a discourse about and inquiry into the history, natural environments, science, literature, art and archaeology of Asia. To this, the individuals would submit articles on the research and observations they obtained during surveys. Starting in 1789, the organisation began to publish these articles into *Asiatick Researches.* It is also due to the influence of the Asiatic Society that much of India's national heritage remained in its native country. The researchers within the society held a vested interest in keeping it where it was. The British began extensive surveys of India; these would not only cover geographical data but would cover many archaeological discoveries as well. One surveyor of particular importance to this study is Dr Frances Buchanan (Keay 2001). Buchanan, who was a medical doctor by training, was asked to carry out surveys throughout Mysore in 1800 and later Bengal in 1807, areas under the jurisdiction of the British East India company. These surveys would cover various subjects and, like Knox's accounts in Ceylon, are some of the best sources of information we have on these areas at that time (Keay 2001).

Figure 2.2 Ananda K. Coomaraswamy (Unknown Author 1907).

The last group of writings worth mentioning are from a giant in Indian and Sri Lankan studies, a historian and philosopher of art, literature, and religion, Ananda K. Coomaraswamy (fig. 2.2). Coomaraswamy was born in Colombo in 1877 but moved to England at the age of two, where he lived out the rest of his childhood. In 1902, Coomaraswamy travelled to Sri Lanka to begin field research for his doctorate in mineralogy. This began a lifelong devotion to promoting the arts and introducing the West to the art and culture of India and Sri Lanka. During this time Coomaraswamy wrote many works on India and Sri Lanka covering subjects ranging from geology to the socio-political climate of Mediaeval Sri Lanka and India. Many of Coomaraswamy's writings on the art of India and Sri Lanka would compare and contrast work from the two areas, emphasising that the two could be interchangeable but that they both still held a unique character to themselves (Coomaraswamy 1979).

It is from the exploration and research during this period in Asian studies that the West received its first glimpse of the exotic east, with detailed drawings full of strange looking creatures and plants. These pictures would also include individuals who were dressed elaborately, possibly a little odd to them, but beautiful nonetheless. This is when the love of all things eastern began for the western world.

2.4 Socio-Political History

From the 16th century to the early 18th century, the political history of Kandy and Kerala was a time of significant change in both areas. During this period, Europe began expanding interests not only in Asia but also on a global perspective, sailing to Africa and the Americas. It became apparent early that India and Sri Lanka had valuable commodities within them. Still, their position within Asia was also vastly important to the colonial trade networks emerging across the globe. This time would see not only traditional power groups within India and Sri Lanka struggling to maintain a hold over critical areas but also the arrival of the Portuguese, Dutch, and the British. Despite all of the adjustments made during this time, they still held their traditionally reasonable rigid social structure. Although the political and economic realities might have changed through kings and locations, they stayed wedded to past governmental structures. Much of the political system was led by a social caste system which changed very little over time, and the system in both areas had slight differences.

First, it is necessary to begin with the foundations of the caste system and why this was so important to the people's everyday lives. It would be difficult to understand the blacksmithing communities of India or Sri Lanka without a basic understanding of the caste system within which they lived and functioned. It is this caste system that reflected cosmological beliefs and created them as a reality in the world. This background will explain this system and illustrate its importance for the craftspeople and how they lived and viewed their part in the world. It is this relevance that kept this system of political and social organisation functioning for so long.

2.4.1 The Cosmic Man

The caste system did not emerge quickly; it resulted from the merging of many different social groups from several different origins over a very extended time. As such, defining caste and the origins of social stratification within societies is not a simple task. They are both subjects that fill books from various topics in academia, and that level of minute detail is beyond the scope of this research.

To look at the European tradition of though, for example, Rousseau believed that people started inn a "state of nature" where the only differences separating people was "strength, agility and intelligence" then as societies grew "self-respect" gave way to "self-love" and this caused people to want more material things and to rule over others. (103) as societies grew so did the gap in social inequality. That is not to say that these changes were never met with resistance, each large escalation would need to be fought out (116).

The word caste derives from the Portuguese word *castas*, which means race or breed. In ancient Indian texts, they did not use this term (Dumont 1980). The first writings or representation of a system of social stratification in India came from a hymn in the *Rigveda* known as the *Purusa* or Cosmic Being. The *Rigveda* is one of the earliest Sanskrit texts and a foundation of the later Hindu tradition. The *Rigveda* does not have the elaborate, much-divided system seen in later classical Hindu texts. There is evidence of a division of society into four parts called *varnas*. The term *jati* is believed to have come later and is sometimes interchangeable with the word caste. The term *jati* is often used to represent the sub-divisions within the four larger *varnas* (Ghurye 1969: 51).

Figure 2.3: The Cosmic Man (Victoria and Albert Museum, London 2021).

The *Purusa* describes the creation of the world formed from the sacrifice of a Cosmic Man (fig. 2.3), from whose mouth, arms, thighs, and feet emerge the four classes, or *varnas*, of society. From this man sacrifice, the three upper *varnas* are distinguished by the higher parts of the body. The Brahmins are masters of knowledge and speech, so they are the mouth. The warriors are the possessors of power and become the arms. The thighs are the workers who are the support and productive part of society. The top three parts of the man are said to be the sacrifice for the gods, and these *varnas* are considered upper class due to being the only ones able to participate in the sacrifice. Lastly, the *Sudras*, or servants, are said to come from the offerings feet. This exclusion from the sacrifice and emergence from the feet symbolises the low status of the *Sudras* (Jamison and Brereton 2014).

The *Bhagavad Gita*, or Gita, is part of the Hindu text known as the *Mahabharata*, another epic narrative written in Sanskrit which is believed to have been recorded in the third or fourth millennium BCE (Johnson 1994). In many sections of the Gita, Lord Krishna, a Hindu deity, clarifies and states the purpose of the four-level organisation indicating that he created the system and that the divisions were based on the quality and work of the individual. The divisions were the *Kshatriya*, who participated in ruling or defence, such as kings, soldiers or politicians. The *Brahmin* was the people that did work related to books and knowledge as teachers and scientists. Then there were the *Vaishya*. These were the people who did business, essentially the shopkeeper or businessman. Lastly, the *Shudras* were the people who produced food and labour, for instance, a farmer or cleaner. The emphasis in the Gita is on *guna*, or aptitude and karma, or function. For example, if a person were born into the Brahmin caste but worked as a shopkeeper according to the Gita, the person would be considered not a Brahmin but a *Vaishya* or of the shopkeeper community. The Gita also refers to *Dharma*, which is the right way of living that supports the order of the cosmos. It is the natural law that creates social order and the sense of duty attached to each *varna*. The focus is not on birth or heredity, as it is in the present day. In the present day, a person can be prime minister and still be an outcaste. In the past, the *varna* a person belonged to was determined by temperament and vocation (Johnson 1994).

In parts of South India caste is also divided further into a right hand and left hand. The origins of this classification are not known, and the specific meaning is unclear. Attempts to make an exact list of groups on each side of the system have not been consistent due to the variation found throughout India. This division refers to the original Cosmic Being with the four horizontal subdivisions of the mouth, arms, thighs, and feet, which correspond to the caste system's four classes, or varnas. This idea of the right hand and left hand then sub-divides the cosmic being vertically, creating a right side and a left side. This visual is not lost in the significance of meaning where the right hand could be seen as the clean side, and the left the soiled. The variation in caste between the right hand and left hand is less prominent in rural areas. This could be due to agricultural groups and artisans who are itinerant versus landowners. This binary classification system is not found in Kerala. This has been hypothesised to be due to there being no monumental architecture were it is speculated that this classification scheme might have started (Appadurai 1974). The left-hand side caste is usually made up of merchants, traders, and artisans. The right-hand side caste is made up of *Sudras,* of higher standing within their own caste, and many of the castes that own land (Dirks 2001: 76).

Another considerable influence on the caste system was Kautilya, sometimes also called Chanakya, a chief advisor of Chandragupta, the first ruler of the Mauryan Empire from about 324 to 275 BCE. Kautilya was part of the Brahmin caste and was known to be a statesman and a philosopher. He is probably best known for his authorship of the *Arthashastra*, which means the science of material gain in Sanskrit. This book was intended to be an outline for how an ideal empire should be run effectively. The *Arthashastra* contains detailed descriptions of diplomacy and war and includes sections on law, prisons, taxation, fortifications, coinage, manufacturing, trade, administration, and even spies. (Prasad 1978).

Kautilya advocated the use of force to strengthen the powers of the state. His belief that the end justifies the means, and his seemingly callous behaviour has led some to go as far as to call him the "Indian Machiavelli" (Prasad 1978: 241). Machiavelli, a product of the Italian Renaissance, was a statesman and a modern political thinker. By separating personal from political morality, Machiavelli promoted political crimes and treachery as an effective governance tool. Both wrote from the standpoint of a political elite that was focused solely on government as a means to strengthen, maintain and enact power. They were not interested in discerning between good and evil or in ethical terms. It is hard to ascertain Kautilya's ethics based on moral assumptions of modern ethics; what he wrote was a product of the Indian socio-political arena of the time he lived (Prasad 1978: 241-243).

Kautilya did not shy away from using religious theology to assist with the governing of people. For example, he would encourage the military to fight with the promises of gains in the afterlife. Kautilya also thought that the enforcement of people staying within the caste system was the king's job. As such, a king should use force and laws to keep the fourfold system running, and that this "protection of morality" would assure the king would obtain gains in the afterlife (Prasad 1978: 247).

The *Arthashastra* assisted in strengthening the superiority of the Brahmin. It is no surprise that this would be the case due to Kautilya being from the Brahmin caste himself. He followed the Vedas in that he divided society into four varnas. Many laws are discussed based on caste and the consequences if one dared to rise above their status in society (Ghurye 1969). Kautilya did not invent a new social order or status; he used the moral laws already in use and empowered by the Vedas. The *Arthashastra* was unique in that it backed up the previous moral law with the power and enforcement of the King (Prasad 1978). This book was lost for many centuries, but a copy of it, written on palm leaves, was rediscovered in India in 1904. When the East India Company was transferred to crown rule in 1858, the British needed to find a way to govern the people of India while still trying to encourage, if not outright force, the practices of the West onto the people of India. The British would use the writings in the *Rigveda*, the *Mahabharata,* and Kautilya's *Arthashrastra* to help them form laws and keep individuals in order.

British colonial rulers would have used the familiar caste system already used in India to their advantage, thus facilitating the system to promote more power for themselves. They would have self-imposed themselves as Brahmin during this evolution of the Caste system. This demonstrates that the British were typical of any rulers, adapting systems to suit their means (Porter 1895). It is inevitable for a ruling power to embrace local traditions and utilise them for their means. The caste system during colonial rule would take on a new form; its functional differences, hierarchy, cultural and belief distinctions would all change. To suit their ends, the British reorganised, reclassified and altered the meaning and connotations to the caste system to suit their agenda of "divide and rule" (Dirks 2001: 250).

Depending on which author one refers to, the blacksmiths of Sri Lanka fall into different levels of the caste system, and sometimes not even the names are agreed. Most agree, though, that blacksmiths were considered a reasonably high caste, falling into the Navandanno caste said in the Janavamsa to be made up of artisans and separated into two basic categories: metal workers and the non-metal workers. The Navandanno are then broken up into several sub-groups based on the different specialities of the craftsperson. Blacksmiths fall into the Achari sub-group, and most agree that they fall in status position just under the Goyigama, or agriculturist (Pieris 1956, Knox 1818, Codrington 1909, Davy 1821).

Percival and Knox vary in their description of the precedence of the *Navandanno* caste. They state that the group of artisans falls in the rank of importance just under the nobles and that they were almost identical in dress. The only difference being that they were not able to mix in noble society or eat with them. Percival goes on to state that the fact that the artisans being higher in rank than agriculturalists and even soldiers were very different and something unique to Sri Lanka (Percival 1805). Davy places the *Achari*, or *Aari*, in a position much lower, with the cultivators, shepherds, fisherman and toddy-drawers above them in caste. It has been theorised that this difference in status may be due to changes made over time in the caste system. The *Navandanno* of the Kandyan kingdom are descendants from the Pandyan, or south Indian; craftsmen settled by the kings many times over the centuries.

2.4.2 Defining Kandyan

The term Kandyan can take on many different meanings in Sri Lanka. It can mean the city of Kandy, the Kandyan Kingdom, or the Kandyan period as a whole, and is not only limited to these three terms. This section will start with a short survey of some of the other city centres of Sri Lanka and what led up to Kandy's rise as the city centre of the Kandyan kingdom.

Compared to other cities within Sri Lanka, the city of Kandy is new, but what stands out about Kandy is the events that led up to the founding of this capital and the sense of carrying on the traditions of the capital city that preceded it. In this way, it is not difficult to see the city as a treasure that holds the ancient knowledge of Sri Lanka. This history and the fact that the Kandyan kingdom withstood for so long against outside forces as the keepers of this knowledge make this city important to anyone desiring to study Asia's past.

The first capital city in Sri Lanka was Anuradhapura (fig. 2.4), which was a large and important urban centre by around 800BC (De Silva 1985: 416). Duncan (1990) says that the city has traces of settlement in the area from around 500 BC, but it did not have a thriving city until the 4th century BC. Anuradhapura was the capital city in Sri Lanka for about 1500 years. During this time, the people of the city enjoyed a mostly peaceful existence. Many factors led to the shift of the city capital, primarily the Cola invasion during the 10th century. Still, it is also believed that the city had been weakened due to prior dynastic conflicts and succession disputes (De Sliva 1985: 435).

Once the Colas had control over the city of Anuradhapura, they decided to change the location of the capital city in Sri Lanka to Polonnaruva. This move was thought to be due to the perceived need to keep the city secure from others trying to take power or take back control of Sri Lanka. Another reason for the location change could have been the new city's location on the Mahaveli, which is the longest river in Sri Lanka. This move to the extensive river network would aid with travel in the area and trade networks throughout the region. The Colas

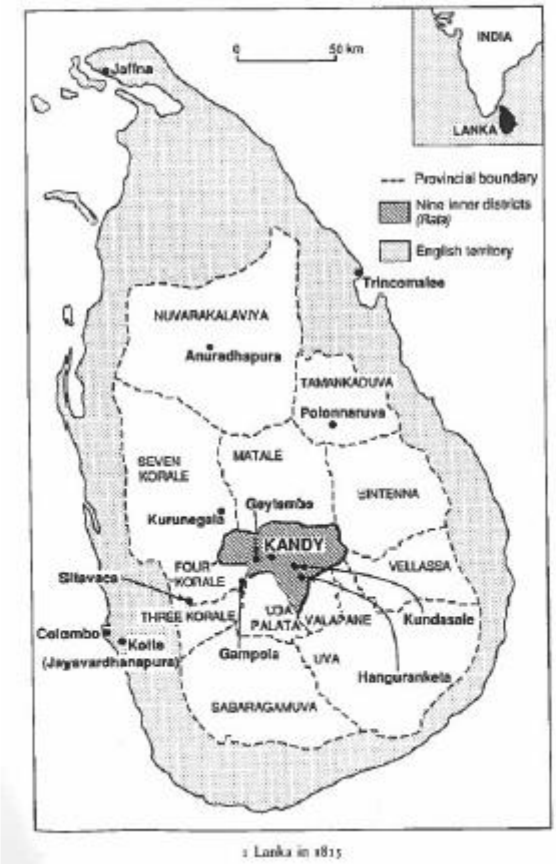


Figure 2.4 Map of the capital cities discussed (Duncan 1990: 142).

did not retain the capital city for long; sometime between 1055 and 1110, a resistance movement within Sri Lanka drove the Colas out of the city, and the capital of Sri Lanka was re-established under a Sinhalese king (De Silva 1989).

After this time, the capital city changed from many different locations, from Dambadeniya, Kurunegala, Yapahuva and at times, the capital was back in Polonnaruva. The factor of where the capital was located depended on where the king decided to live and threats facing the king at the time. The most significant threat coming from Pandyan invasions in the 14^{th} century, but the moves can be seen as economical. Then in 1415, the capital city of Kotte was established. It was in this city that the Portuguese would make the first contact with a Sri Lankan king. This city has been seen as having many internal conflicts surrounding the royalty, which brought about political instability. This political uncertainty has been seen as reasons for the decline of the capital in the late 15^{th} and early 16^{th} century (De Sliva 1998).

Figure 2.5 Kandy in 1602 (Pieris 1956: 82).

As Kotte was in decline, the need for a more secure capital city became more vital to the king. The area of Senkadagalapura offered natural barriers of mountains and forests while still offering the essential rivers that would allow for trade to continue (Wickremesekera 2004). This city would later become the capital city of Kandy. The mountains around Kandy were seen at the time as harsh and usually left to bandits and rebels. Still, the need to have a secure area since the almost non-stop invasions from South India and internal turmoil made this move to the mountains an important one. The city of Kandy would remain the capital of the Kandyan period from around 1591 to 1815 when the British took hold of the island.

The Kandyan kingdom was located in the *uda-rata* or the up-country, the mountainous region in the middle of the southern half of the island of Sri Lanka. Shortly after the Portuguese arrival on the island, Sri Lanka began to break into two distinct regional sections: the 'Kandyan' in the highlands and the 'Low-country' along the coastal areas. The individuals in the low-country became more peaceful with the Portuguese, adjusting to the presence of this new culture and absorbing many Portuguese ideas and words into their own. The Kandyans, who made up the larger part of the Sinhalese population, did not care to integrate into these Western ways, and so were able to hold onto many of their traditions and customs for many years after the Portuguese arrival. The fact that the Kandyans were strategically located in the central mountains of Sri Lanka aided in the endurance of this Sinhalese identity, keeping their independence and cultural identity intact for so long (Coomaraswamy 1979)

A king ruled the Kingdom, and he ruled as an absolute monarch. The monarchy was hereditary, passing to the firstborn son. If the king did not have a son, then he could nominate a successor. Officers of the state carried out the king's orders. Like most socio-political entities, the Kandyan Kingdom used laws as its primary method of maintaining order within the villages. There are no written laws known from the Kandyan time; instead, the rules were followed through cultural understanding and customs passed down (D'Oyly 1975). Society was primarily agrarian, and the land was key to the social economy. All land belonged to the king and was worked for the king, the only exception being in *praveni,* or land belonging to the temples (Coomaraswamy 1979). The economy was run as a feudal system that was dependent on a highly structured land tenure system. The king was the sole possessor of the land due, a position justified through reference to the mythical actions of the first king fighting off demons that infested the island and clearing the land to be. This payment was in the form of work, goods and shares of the harvest, and the people were divided by the land they occupied and the job they possessed from the land. The type of work was directly related to the land held, and the land would be passed to the next of kin at death. Since the kind of work was directly tied to the land, the land could not pass to a person who did not work in that job. For example, upon death, an individual who was a soldier could not leave his land to a weaver (Davy 1821).

No land was sold without the express permission of the king. The king could grant lands, and the king could take them away if and when he determined that to be a fitting punishment for a misdeed. When the king would make a decree about land granting or removal, an assembly would be present, and drummers would announce the royal commands. They would then send messengers to deliver the decree to the areas affected by the changes. The king did not personally oversee all of the tenants himself. Lands would also be given to temples and town leaders or state officials responsible for the land and making sure the services were carried out and payments made. The tenants, in turn, would pay or give services to not only the king himself but to these state officials. The state officials could also take lands that were deserted and give them to another tenant.

The king also owned all the forests, and no person could cultivate the ground or clear land without the king's permission. If no land was owned or used for crops, then usually no service was required except small, infrequent tasks. Mostly this fell to the lowest caste. As stated previously, the land and the service owed from it were immutable. This ensured that no one group or person could indefinitely gather up lands and hold more power or prosperity. People of high status or caste would not want to be required to carry out jobs that typically were executed by individuals of the lower caste. Literature about Kandyan land tenure abounds, most of which affirm what the others say (Codrington 1909, Coomaraswamy 1909, 1979, Davy 1821, De Silva 1981, Juleff 1998, Knox 1818, 1911, Percival 1805, Pieris 1956, Ribeiro and Pieres 1999, Ryan 1953, Yalman 1967).

Tenancies, or land grants, were based on caste and occupation, and a village would have several different classes and tenancies to help sustain the village as a single entity. Each type of land ownership came along with various tasks or services that were due to the king. These services could range from work in the king's court to assisting in a blacksmith's forge. In this way, the balance of land wealth was maintained, keeping the wealthiest of the community from taking over all of the lands, due to the higher caste persons not being willing to perform service work that was deemed only for people of a lower caste. In this way, the system was self-balancing, ensuring that one individual or group did not gain too much power. Also, it is worth noting that women could have land tenancies and once married, this land tenure remained the woman's. The husband did not have any rights or power over the land. Most people not in the ruling classes worked for either the king, a religious foundation or a state official, or chieftain and working the fields and making crafts for themselves and neighbours (Coomaraswamy 1909).

One difference worth noting is Pieris (1956), who goes into great detail on land tenure. Pieris adds that the king could not take land without there being a motive, and sometimes restitution paid for the work and development of the land. Temples were not taxed and owed no dues to the king. The monks were restricted from working the land, so tenants would be used to work the ground. People could not donate their share of land to the temple without the king's permission due to the king losing money from taxes when the land transferred hands (Pieris 1956: 43). Another difference worth mentioning is that of Davy, who says that the people were not bound to the land. This meant they could move and get another piece of land as they wished, as long as they could carry out the required duties. He also notes that the state official was due payment for the use of his land, and that person cultivating the land had rights while this service was being performed. After this time, the cultivator held no obligation to the landowner, basically underlining that the system was not a feudal one (Davy 1821: 187).

In 1762 the East India Trading Company commissioned a diplomatic mission to meet with King Kirti Sri Raja Singha of Kandy. The British were unsure of contacting the king for fear of angering the Dutch with an attempt to establish trade in Sri Lanka. For King Kirti Sri Raja Singha, this was seen as a way to get military assistance from the British. For the British, it was an information-gathering attempt to assess the situation between the Kandyans and the Dutch. The British wanted to see how plausible it would be to set up trading posts on the island and how profitable it would be. The British would then compare the possible profit to the chance that the Dutch might see this as an act of aggression. When the Dutch discovered that a meeting between the British and the Kandyan King took place, it forced them to seek a resolution to the fighting and lack of support from the Kandyan King. In 1766, the Dutch sent troops to force King King Kirti Sri Raja Singha to accept a treaty. The Dutch had power over most of the coastal plains. The king was forced to admit that they were living in isolation in the mountains, with no trade ports, dependent on the Dutch for any trade goods they could receive, and with little contact with forces outside of Sri Lanka. The Dutch lacked the manpower to enforce the treaty entirely, though, and the strict new regulations only succeeded in making the Kandyan King feel more pressure to seek outside assistance in ridding the island of the Dutch (De Silva 1981).

A second mission was sent to the Kandyan King in 1782; by this time, the British were at war with the Dutch, and the interest in Sri Lankan trade ports had increased dramatically. The king, still mistrusting the British, was reassured of the positive intentions of the British and the benefits to both parties if the king would enter into a treaty to assist the British in fighting the Dutch. In exchange for military power, the Kandyans offered provisions to the army persons who remained behind on the island. The king denied this treaty due to a lack of trust and faith in the British military (De Silva 1981).

The British once again approached the King of Kandy, the newly crowned King Sri Rajadhi Rajasinha, intending to gain a treaty. The British wanted assistance with making sure the Dutch were removed from the island without resorting to violence. Still, again, like the previous King, King Rajasinha did not trust the British, and he would not sign the agreement. This mistrust would turn out to be an unwise decision; the Dutch turned over all the land in Sri Lanka without resistance to the British. With this power exchange, all the rules that the Kandyan King agreed with the Dutch were now what the British would follow. Essentially, they traded one bad oppressor who did not have the means to enforce all the treaty rules for another oppressor who had ways to implement the laws and end the Kandyan Kingdom altogether (De Silva 1981). The Dutch leaving created the space for the British to step in and take over, so the king was faced with the reality that he had just traded a known familiar problem with a new unknown one. The king did not feel that the British kept their word with agreements made when the king sought assistance. The disagreement began another time in Sri Lanka, with battles and raids carried out between the Kandyan Kingdom and the British in the low-country areas (Coomaraswamy 1979).

The Sinhalese in Kandy were tested even more when Sri Vikrama Rajasinha became king; he was said to be tyrannical and lacking a level head. The king's behaviour is believed to have caused some in the king's court to carry out a coup. It is unknown the real reasons behind these events, although some have said that it was possibly due to the promise of positions of prestige after the British dethroned the king. Whatever the case, the Sinhalese would not govern the country for many years after. Eventually, this led to the fall of the Kandyan Kingdom, and in 1815 the last Kandyan King, Sri Vikrama Rajasinha, was captured by the British. This capture leads the rest of the Sinhalese to surrender to the British Government (Coomaraswamy 1979).

During the Kandyan period in Sri Lanka, the requirements of the royal household consisted of fourteen departments of public works. One department consisted of different classes of craftsmen, and part of that department was formed of twenty blacksmiths who worked full time and were called upon to execute all forms of typical smith work. An extra eight blacksmiths without regular service, who were called in on an as-needed basis, were also included in it. These eight blacksmiths were required to present to the Disava a knife and a pair of scissors from each at the New Year (Coomaraswamy 1909, 1956; Pieris 1956).

Ten blacksmiths were attached to the royal armoury; these smiths would work on a rotation for 20 days at a time. The armoury smiths were in charge of repairing, cleaning and making sure that around 3000 guns were always in working order. This was their only job (Codrington 1909). Other blacksmiths were given towns or villages that they were required to smith for, and some were given more than one village to look after. Only the smith assigned to the village by the king could carry out work for the people of that village. If a smith took on a job for a person living inside another smiths' village, the smith who did not have the right to work for that village would have to pay the proper smith whose jurisdiction they encroached. In exchange for their work for the village, they were granted land tenures, usually said to be half of an acre.

For the most part, the blacksmiths would repair used tools for the people of the village. People would pay the smith a specific amount of corn to be paid in full at harvest for this work. If a new tool needed to be made or any other work needed to be done outside of this, they would pay not only the agreed-upon rate of corn at harvest but also to pay extra for the extra work. This payment would consist of rice, hens or other forms of provision. When the time came for the tool to be made, the customer would need to provide the iron and the coal. They would also be called upon to work the bellows for the smith, and if the great hammer needed to be used, they were required to handle the hammer. For the sharpening of the tool, the customer was required to file the tool themselves; the smith would perform the final filing and sharpening, ensuring it was performed correctly. They were also required to work for the king when called upon and paid a yearly tax consisting of areca nut cutters, billhooks, and coconut scrapers supplied to the royal stores. These blacksmiths were also sometimes given an assistant, usually from the smelting caste, to help in the forge with bellows blowing or other odd jobs needed by the smith.

Davy, in his writings, compared the skill of the Kandyan blacksmith as comparable to the blacksmiths of any part of Europe and stated that the smithy is just as well equipped, although he does point out that the Kandyan smith does not use a vice as a tool in his forge. Davy also states that the variety of bellows used by the smiths have more variety than he had ever seen. The variety of work they carry out is also very diverse, though sometimes not the most beautiful, but the tools work very well.

2.4.3 Kerala - God's Own Country

In South India, the country was separated into different districts or regions that had, for the most part, their own customs and ways of running the area's social structure (fig. 2.6). The customs and social structure were relatively alike, with slight varying differences that would change over time and be affected by people's movement in and out of different areas. Most of the region was Hindu and held the caste system of social classification.

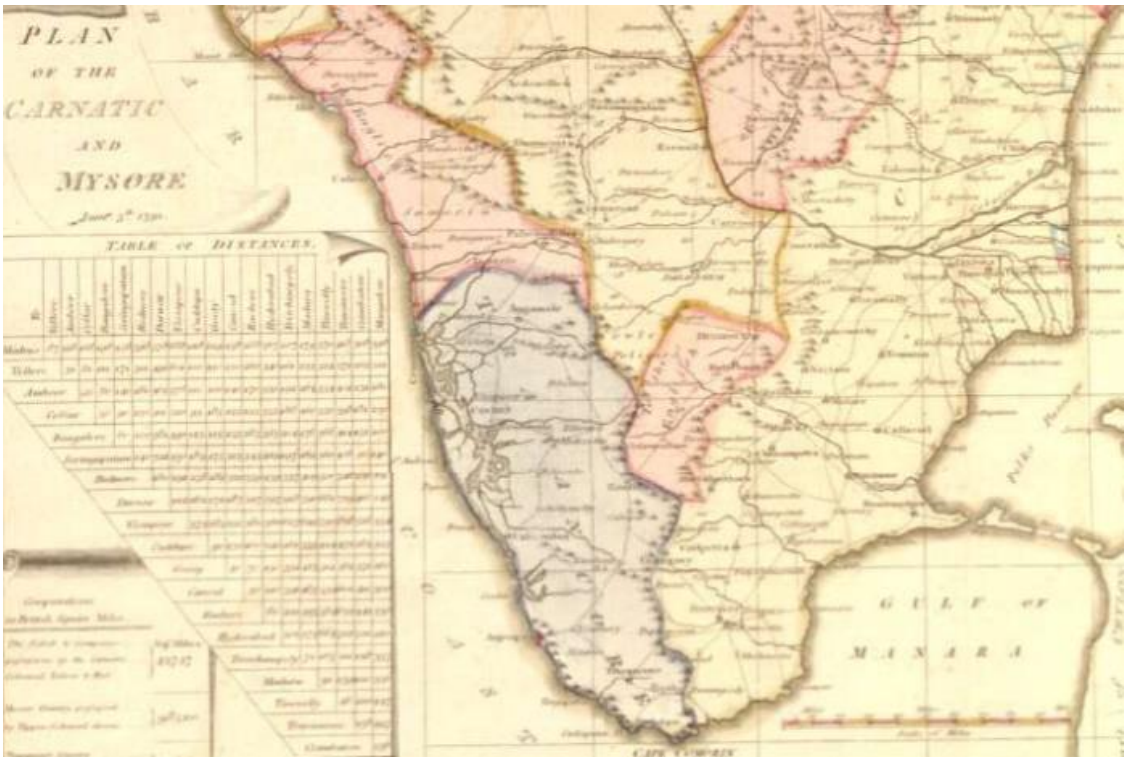


Figure 2.6: 1794 example showing different regions of South India (The Trustees of the British Museum 2022).

Service in government jobs, whether they were civilian jobs or military, were open to all people without class distinction. Brahmins would usually hold higher-ranked military positions, however. Army personnel would often be sought and found in the hills and forest villages. Village heroes would not be uncommon due to villages needing to defend themselves from attacks from other ruling areas and towns. This could lead to loss of life or livestock, so villagers learned to protect their homes and livelihood. Large scale migration was not uncommon when a new leader would invade an area. This would mean new people moving into the new location that has been conquered and others fleeing the new occupiers. This movement of individuals would cause temporary disruptions in social and economic structure throughout South India (Sastri 1966).

The king's court was filled with luxury and extravagance. No matter what the position, all people attending to the court were said to have been highly decorated with lavish clothing and covered in jewels. The king's court would have many attendants and large amounts of military living within the palace walls. The palace would have different departments called *niyogas;* many kings would maintain 72 departments. Once a day, all the nobles and high officials would have to attend when the king would appear to the public. During this public appearance, the king would hear grievances, receive tributes and entertain ambassadors from other regions. During wartime, the king would send his top trusted generals and fight in the battles himself. The use of elephants during battle was not uncommon, and their military depended heavily on cavalry. Upon being crowned, the king would select a group of military men to be his bodyguards. These men were with him until death and sworn to protect him with their lives if the need arose. The responsibility of maintaining order and making sure the conditions of the caste system fell to the King (Sastri 1966).

Temples of the Buddhists and Jains would educate the population locally and were known for their expansive libraries covering all known works without regard to the subject. Not only known for worship, but the temple was also a place to socialise and a location of employment. Hospitals were also located within temple grounds. The temple would employ many planners and craftsmen and several people after construction for ceremonies and maintaining daily routines during building. In this way, the temples would become vital and hold economic power over the region that they served. The Nambudiri Brahmins, in

Kerala, in order to allow men to study and tutor unhindered, would only grant permission for the firstborn male to marry and have offspring (Sastri 1966: 323).

The small villages outside of the temples and palaces were where most of the population would live. Agriculture was the most widely held form of employment. These small villages were primarily composed of non-landowning people who would be employees in the fields for a share of the crops. The state officials would be the ones to make the decisions and run the village, so land ownership was held in great esteem. Land in some villages would change hands to make sure not one person would hold better land for too long, meaning they would have a larger share of wealth. Some of the villages would offer a share of land for different artisans that they desired to have. The land was seen as a way to keep them in the employment of the village, and the villagers would also pay them for the work done, negotiating the prices for the work to be done between themselves (Sastri 1966).

Buchanan, in his travels, described the village housing in a region he travelled through named Navaputty. He describes the houses as "bee-hive" looking with only one door for airflow and light; the walls were only three feet in height and constructed out of mud with a thatch roof that was cone-shaped. Most family groups would have more than one hut averaging three per family, designating one for sleeping, storage, and another for cooking. People with more huts were considered higher in stature and having more wealth. He states that most of the small villages were structured in this manner and did not have very much variation in the construction of the homes (Buchanan 1807: 192).

In South India, the land was not tied to a specific job, and many of the people owned the land they cultivated (Sastri 1966). This land tax, or land tenure system, created a significant portion of the wealth within the government, so it was considered considerably necessary to officials running the government.

Banerjee and Iyer (2005) list three types of economic land system, which are as follows.

- Individual cultivator (*Raiyatwari*) - The renter would be given rights to the land through an agreement or type of deed where how much would be paid in rent would be set before the deed was agreed. The rent for the land would not be established for the entire time of the landholding; the land would be regularly reviewed, and a fair price would again be agreed upon. The period that the land would be reconsidered varied from place to place.

- Landlord based (*zamindari or malguzari)*- the total land tax for a village or group of villages is the responsibility of an individual proprietor. The proprietor decides who rents the lands and sets the prices for the rent. The proprietor could remove the renter when and if he chose, and if at the tax-paying time any amount was remaining, he was allowed to keep the surplus for his own needs.

- Village-based (*Mahalwari)*- the village was responsible for the taxes paid to the government. The lands would be split up based on heredity or who has been cultivating the land in the past. This system made sure that everyone would participate as a group in work and the payment of taxes. In some smaller villages, there may be only one family residing in the area, so they would be responsible for cultivating the entirety of the land and paying the tax to the government.

One of the better-detailed documents about land tax and tenure is by Buchanan (1807). These accounts are from when the English East India Company hired Buchanan to travel and make detailed reports about all the villages and areas that he encountered. He completed more than one excursion for the company. Travelling through Mysore, Canara and Malabar, modern-day Mysuru, Kanara and India's southwestern coast, respectively. Buchanan, on many occasions, documented the system of land tenure or tax for the lands that he travelled through. Most of the systems were the same, with minor differences. Many of the villages had a head farmer who would rent out parts of the villages and pay the government's land tax. Many of the head farmers inherited their position. This head farmer was allowed to keep profits from the rent, but only a small amount was allowed. If nobody could pay rent or only a portion of the rent, the head farmer still had to pay his taxes. The taxes were paid to the king, or later the British government.

The renter could not be removed from the land even in the case of non-payment. If the head farmer manages the land, he does not have to pay rent, but if he leaves the managing to someone else, even in the case of heredity, the person managing the land for the head farmer has to pay rent. Buchanan says that the land has a fixed value. When a person wants to begin cultivating an area, the cultivator pays no rent the first year of renting the land. Each year, the renter will pay an additional quarter of the rent until the fourth year when they reach the total rent amount. The power was seen to be with the renters and not with the proprietors. In most of the villages at that time, Buchanan states that all rent and taxes were paid in money. The only time this changes is in the case of land used for wet crops, such as rice, which was rented for a division of the crops cultivated, and the government took 2/3 of the harvest for a tax on this land. In every village, land was set aside for the priests, the priests were responsible for cultivating their land, and they paid a small fee for rent (Buchanan 1807: 214). In villages with a Muslim leader, the leader is bound to perform ceremonies for the people in exchange for the land. Tax on fruit-producing trees was based on how many trees the person cultivating the tree was responsible for cultivating. Coomaraswamy (1979) states that the craftsmen could refuse the services attached to the land and give up their land, but that usually never happened. Teachers were one of the few civil government jobs that held land in exchange for duty (Sastri 1966: 321).

Every village had a record book that kept track of all the land values and how much everyone was required to pay. The British government that was in control at the time of Buchanan's expeditions would send officials called a *Tahsildar* who would travel to all the districts and villages checking on all the landowners. This official would make sure that everyone was paying what they should and that the village leaders were treating the renters fairly and nobody was dishonest. He would also ensure that the only land being cultivated was documented and not being used without payment. This official was also responsible for making sure the canals were in good working order and, if needed, to make sure they were fixed. This official was also responsible for taking care of any persons breaking the law. He would take note of all the information about a crime, and if he thought that a law was broken, he would then send the information to the government, who would then decide on punishment (Sastri 1966).

Through Buchanan's writings, it is hard to say precisely what the land tax or land tenure system was like before the British took over the government in

India. In some villages, though he notes interviews with locals that tell what the land revenue system was like before 'the invasion', in these communications, they would state that the rent on land was paid not by money, but by a per cent of the crops. Buchanan then goes on to say that the feudal government before the arrival of the British had no laws and, no revenue calling it a 'feudal aristocracy with limited authority.' The only mention of caste relating to land tenure and tax is when Buchanan mentions that the landowners rent rice field, or wet-land, without regard to caste. This entry is only in one village; this could be interpreted as him only recording the regular running of villages. This was something that stood out in this village, so he documented it because it was out of the ordinary (Buchanan 1807: 549).

2.5 Blacksmithing and Smelting Research in South India and Sri Lanka

Ferrous studies in South India and Sri Lanka have in the past gravitated to a few central themes. Many focus on the founding of iron technology and its diffusion (notably Chakrabarti 1992); others spotlight how the arrival of iron technology changed lives in the past. Many studies have concentrated on iron technology, especially smelting and the elements that make up the iron within a specific assemblage to determine if the metal is high-carbon steel. This research has been carried out primarily on smelting sites and not on many actual iron objects found within excavated sites, often due to the lack of abundance of these objects. Many projects focusing on iron technology also centre on the smelting aspects of production and the waste material that is left behind. Luckily for us here, many of these projects will also include some element of blacksmithing research relevant to them, for instance, the Pioneering Metallurgy Project.

The Pioneering Metallurgy Project was a joint project between the University of Exeter and the National Institute of Advanced Studies (NIAS). This project was aimed at identifying and recording metallurgical sites within Northern Telangana in southern India. In 2010 the project surveyed sites in the districts of Karimnagar, Adilabad, Warangal and Nizamabad. Up to 250 locations were recorded, and a substantial amount of material was gathered (Juleff et al. 2011, Juleff et al. 2014).

This project sparked two other research projects within the University of Exeter and the National Institute of Advanced Studies (NIAS). The first was by Brice Girbal, whose aim was to analyse the multitude of waste material collected during the initial surveys of the Pioneering Metallurgy Project. This was done to gain a better understanding of the technologies used within the Telangana area. During the initial surveys, many crucibles were discovered. These crucibles would have been used in the production of high-carbon steels. (Girbal 2017: 33). During this project, these crucibles were studied to understand how they could have been made and how they differed within the region.

Tathagata Neogi conducted the other research that arose from the Pioneering Metallurgy Project. During the Pioneering Metallurgy Project, 11 interviews were conducted with local blacksmiths. These blacksmiths were also observed while working, and sketches of the smithing areas were taken. While interviewing these blacksmiths, it was discovered that the blacksmiths ancestors were smelters in the past. They say that the family had to change from smelting to blacksmithing due to the demand for smelted iron falling. The project also had the opportunity to record the Mammayee festival. Mammayee is the goddess most highly revered by the local people in this area. It is from this base of ethnographic data that Tathagata conducted his research (Neogi 2017).

Similarly, as part of the Samanalawewa Hydroelectric Project in Sri Lanka, Dr. Gill Juleff conducted an impact archaeological survey of an area due for inundation. Through the excavations that resulted from the initial surface surveys, evidence of smelting iron and steel in a large-scale industry was discovered. These dated to the first millennium AD, but what made these findings genuinely remarkable was that they seemed to be using a technology that exploited the monsoon winds to power these furnaces (fig. 4.7) (Juleff 2013: 141). This is a type of smelting iron that is very different from anything that was known.

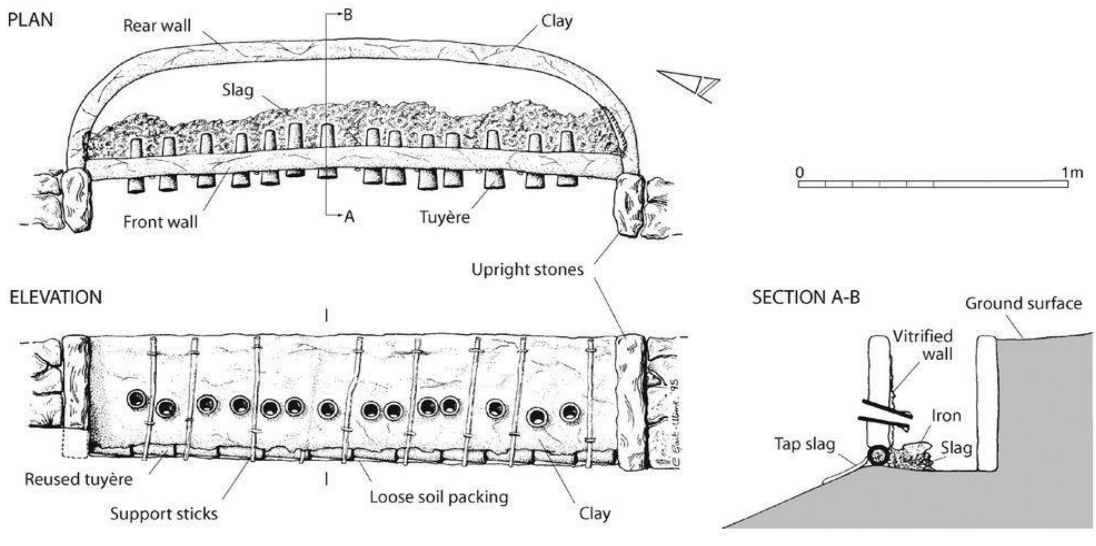


Figure 2.7 Diagram of furnace structure discovered in Sri Lanka (Juleff 2013: 141).

In order to test many hypotheses about these new furnaces, several experiments were carried out involving reconstructed furnaces. More experimental smelts were conducted in 2007, 2008 and again in 2013. What is of great interest to this study is during these surveys, interviews were conducted to assist with understanding the living history of the iron industry in the area. During these interviews, the remnants of a blacksmithing community living in and around the village of Hatanpola was documented, and interviews conducted about the blacksmithing heritage in the village. Surveys and forge work were also recorded in detail. Blacksmiths in this village would also assist with the research by forging one of the blooms that resulted from the experimental smelts. This was also documented (Juleff 1998: 101-14).

A great deal of research has focused around high carbon steel in both Sri Lanka and India. As mentioned above, the wind-powered furnaces discovered by Juleff in Sri Lanka are believed to have been used to produce this type of steel. These studies usually focus on the smelting aspect of this technology, but a few focus on analysing iron objects excavated from sites to ascertain the types of material the objects are forged from to understand this highly regarded steel better.

Many of these studies only conduct chemical analysis when researching iron objects from sites. One such study also included microscopic study to help understand the techniques involved in manufacturing the objects. This project was a doctoral thesis by M. S. Mudhol (1997) with the University of Baroda. In this work, Mudhol analysed 22 fragments that had been excavated from sites in Karnataka and Andhra Pradesh. With these objects, chemical and metallographic studies were carried out to understand not only the smelting technology that went into making the iron but also the objects that were forged from it. This was also an attempt to decipher the skills of the blacksmith who had forged the finished object.

The group of objects selected for study was based on what is believed would have been representative of what would have been used during the megalithic period in South India. Through this study, Mudhol discovered that the smiths who forged the objects studied commonly used a lamination technique in which iron bars would be piled onto one another and then heated to very high temperatures to weld the bars together. Then the object would be forged from the resulting welded part. A few of the objects showed case carburising and quenching, which are a way for the blacksmith to add carbon to the iron to make the resulting object harder in areas that the smith would like to be a bit more resilient such as the blade of a knife. One of the objects also showed signs of being quenched at a very high temperature, and then after the quenching forging was carried out and the iron object was then left to cool in the open air. Also, it is interesting to note that a few of the objects had what Mudhol calls a 'thin coating of rust inhibitors,' these were thin layers of calcium carbonate and ferric oxide, also stating that these objects were less corroded and in better condition that other objects studied without this coating (Mudhol 1997: 160).

As part of the Samanalawewa Hydroelectric Project in Sri Lanka, Dr Gill Juleff conducted an impact archaeological survey of an area due for inundation. Through the excavations that resulted from initial surface surveys, evidence of smelting iron and steel in a large-scale industry was discovered (Juleff 1998). This area was also of interest due to the ties to Ananda K Coomaraswamy. It is from Coomaraswamy's writings that we first learn of the iron-working communities of the Samanalawewa area. Coomaraswamy, in 1902, documented some of the last iron-smelting and steel-making using traditional methods in this area of Sri Lanka (Juleff, Craddock & Malim: 2009).

As part of Juleff's project, a small scale ethnographic study was conducted. This was initially to obtain oral stories about smelting traditions in the area. In conjunction with this, much data was gathered about the blacksmithing history of the area. In all, 14 primary interviews were conducted in an informal setting and surveys of operational smithies were conducted. Along with the interviews of the residents of Hatanpola,

The village of Hatanpola is a small village about 10 km away from the town of Balangoda located within the Sabaragamuwa Province and district of Ratnapura. The village today has a small community of about five families continuing the blacksmithing tradition. These families in the past were traditionally tied to Uggal Aluthnuwara Devalaya or the Aluthnuwara temple, which is less than one kilometre away. The village has a long written and oral history of the blacksmithing traditions and technology and has been renowned for centuries for the skills of its blacksmiths. Blacksmithing is a trade that is usually handed down from father to son in this village, and the smiths have an excellent reputation for the work they do. With the governmental and societal changes within Sri Lanka, the community has needed to adapt to decreasing need for the traditional trade they were born into. This rapid decay of the traditional lifestyle has led to impoverished conditions within many traditional communities. Hatanpola has learned to adapt to the changes and still maintain the blacksmithing traditions that are part of the cultural fabric of this community.

Alutnuwara *devale,* the nearby temple, also provided records which in the past was the largest landowner in the area. These records documented the principles of the *rajakariya*, or the traditional feudal land tenure system that was historically used in the area (Juleff 1998: 102). These documents showed the landshares allocated to the blacksmiths, smelters and charcoal makers of the communities and families with ties to the temple. Within the records, a hierarchy can be seen between the metalworkers based on the location of the communities compared to the temple. In this case, if the worker, the blacksmith, is working and living closer to the temple than, say, the smelter, that would signify that they have superior prominence with the temple. This seems to indicate a higher ranking in the caste system. Through historical writings such a Knox (1818) and Davy (1821), the metal workers and blacksmiths specifically held a reasonably high position within the caste system.

Through the interviews, Juleff discovered that the smiths and smelters would probably have very little interaction as the smelters would have been from a very low caste. If a person needed an object forged, they would have to obtain the iron bloom from the smelter and then have brought that iron to the smith to be forged from the bloom. In this way, the consumer would act as an intermediary between the two trades, and they would also dictate the supply and demand for the two trades for objects that were made outside of the temple's needs (Juleff 1998: 111).

Hatanpola, at the time of Juleff's research, had a total of 14 blacksmiths working in five different smithies. In the totality of the Samanalawea area, 25 blacksmiths were documented during the project. It was noted that four of these blacksmiths came from outside the area and were working then in the town of

Belihul-Oya; otherwise, the smiths had a long hereditary history in the area. This would indicate a robust iron-working community of the area in the past (Juleff 1998: 113). During this research, the smiths in Belihul-Oya had distinguished themselves by gaining electricity within their smithy, which caused them to gain more work forging pruning knives. It is noted that these smiths even had power hammers and electric bellows.

The interviews and smithy surveys suggested that the location of the smithies have not changed for several generations, and most of the time, the blacksmiths family home would be only a short distance from the forge itself. The forges or smithy themselves are usually open on all sides with a coconut thatch roof over the top to keep the rain or sun from the work area. The hearth is a raised platform built up out of mortar and brick. The top of the hearth is made of clay, and the upper surface will be hollowed out or have a concave form to it. One side of the hearth will have a wattle and daub wall that, on the other side, will house the bellows.

At the time of Juleff's work, the smiths used triangular accordion bellows, noting this name or type being styled from Rostoker and Bronson (Juleff 1998: 113). The local name for these types of bellows in Sinhalese is *mynahamma*. These types of bellows are substantial in size, and it was noted that many of them were very old, even outdating some of the smithing structures surrounding them. The bellows were supported by poles that would raise them off the ground, and they were worked by the smith himself using a leather strap attached to the bellows. The bellows will blow air, using a metal pipe, that runs from the bellows through the wall separating the hearth and the bellows and then into a small opening on the hearth that has been created with clay and used to direct the air into the hearth, and in turn, focusing the heat within the forge (Juleff 1998: 113).

Within the main forge space that the blacksmith would use were cut stone water troughs for quenching and an anvil. Juleff states that the smiths would usually use two anvils, one being a cylindrical shape and forged from two or three blooms of iron forge welded together, and the second anvil was a modern European anvil. The first anvil made from the bloom iron was used for forging a raw bloom of iron or scrap into a workable billet. This type of anvil would have been used for this because the anvil is made from iron that is a bit softer and able to give more when being hammered heavily as would be needed when forging blooms into billets. The European anvil would then be used for more detailed work, such as forging a blade (Juleff 1998: 113).

The smith tools were relatively standard, with an array of hammers, tongs, punches and files. A collection of which was gathered by the project in the form of a box of items donated to the group, the contents of which were analysed and inventoried. The bulk of the iron objects forged by the smith was for domestic and agricultural use. Items such as large mattock that are used in paddy cultivation was a popular item to be forged. These items are made only when the customer needs to have one forged new, or the smith will also repair objects made previously. Due to the made to order style of work and the small local population, this does not create much reliable income for the blacksmith and their families (Juleff 1998: 114).

The work the blacksmith carried out technically would be considered basic in the operations they needed to perform in making the tools for the community at that time, but this does not always seem to be the case. During one of the interviews with W.A. Siyadoris, he states that in the past, customers would come with food and stay in the village until their tools were made (Juleff 1998: 353). This would seem to indicate that the village had a good and far-reaching reputation if the customers would travel so far that they would need to stay in the smith's home until the objects being forged were finished. Siyadoris also states that his father made tools that were more intricate in design with brass inlays that people still keep and are passed down from generation to generation (Juleff 1998: 353), indicating that in the past, the blacksmiths of the area would have used their skill in more of a creative way to forge beautiful and functional objects.

The history of the smiths of Hatanpola is tied tightly within the past of the Alutnuwara *devale* (temple). As a group, they consider themselves to be the blacksmiths of the *devale,* and during festivals, they perform special duties, such a drawing a ceremonial chariot. It is unknown if the smith also forges any objects for use within the *devale,* either for ceremonial purposes or essential everyday use within the temple (Juleff 1998: 113). It would not be a far reach to think that these blacksmiths were brought in by the temple and offered a placement or job when the temple buildings were first built. Much like they did in South India. The blacksmiths would be known for their skill and reputation. This would be passed on by word of mouth and would travel to other regions. When a temple was begun, they, of course, would want only the best smiths to build the temple, and so would bring in smiths based on reputation. This place, or job, within the community and temple would from then on be a heredity placement being passed on for generation after generation. In this way, it would not be a reach to think that the smiths living and working in Hatanpola today are the decedents of the original *devale* builders.

Juleff, in exploring two different smelting technologies, the small scale village smelting and the larger west-facing, questions if one of the technologies would have been indigenous to the area and if the other technology might have been from an immigrant community from south India (Juleff 1998: 121). This difference is also made more acute by the differing status within the caste system, not only between the smelters and the blacksmiths but within the blacksmithing community itself. Juleff notes that Coomaraswamy also debated these differences within the craft communities; he believed that the indigenous crafters would have evolved into workers that created the planer and simpler everyday objects. These crafters would have been seen in society as just ordinary workers. Whereas the immigrant crafters would have been the top crafters at the time and would have been utilised in creating more refined, more important objects and, as such, would have held a more esteemed place in society (Coomaraswamy 1956: 62, in Juleff 1998: 122).

2.6 Sri Lanka and South India Connection

The *Mahavamsa,* a non-canonical text written in Pali around the 5th century CE. Pali is considered the sacred language of Theravada Buddhism. The *Mahavamsa* tells the story of the consecration of Prince Vijaya, the first recorded King of Sri Lanka, who reigned from 543 to 505 BCE and originally from North India. In this story, the people of Sri Lanka beseech Vijaya to become the first king of the land. Vijaya agrees upon one condition, only if they can find a maiden of noble birth to be consecrated as queen at the same time. Upon hearing this decision, the people of Sri Lanka send many gifts, such as jewels and maidens of their own, to Madhura, modern-day Madura in southern

India. The King of Madhura agreed to send his daughter to be wedded to Vijaya to become the queen of Sri Lanka. With his daughter, the king sent 100 maidens said to be of differing rank for the ministers of Sri Lanka to marry. The maidens were sent with elephants, horses, wagons, and artisans reported being a thousand families of the eighteen guilds (Geiger and Bode 1912).

Another story of the movement of craftspeople occurs later in the *Mahavamsa.* This is the story of the Bodhi-tree, which occurs in 249 BC. The Bodhi-tree is a type of fig tree under which Siddhartha Gautama, later known as Buddha, is said to have attained enlightenment. In this story, Emperor Asoka wanted to send an expression of his newfound faith, Buddhism, to the island of Sri Lanka. He took a piece of the sacred tree, placed it in a golden vessel, and waited for the tree to take root. When the tree was ready for transport Asoka sent this by ship along with attendants to protect and tend to the sacred tree. It is said that 18 people from royal households were selected along with Brahmans, ministers, traders, and several handicrafts families. Emperor Asoka gave the large group travelling with the Bodhi-tree eight vessels of gold and eight of silver to keep the tree watered (Geiger and Bode 1912).

When the sacred tree arrived, it was met with many celebrations, and King Devanampiyatissa met the ship at the shore and escorted the tree in a grand procession. This tree was planted in the *Mahamegha* garden of Anuradhapura with grand festivities and treated with high prestige and reverence. Although it is known that the tree that exists today at the site in Anuradhapura is not the original Bodhi-tree, but is believed to be one of many that have been replanted in the exact location over the years. To this day, the place of the Bodhi-tree is of great importance, and every year many Buddhists make the pilgrimage to see the sacred tree (Geiger and Bode 1912).

In his book 'The Buddhist Visnu' (2004), Holt proposes that the documented changes in religious tolerance shown through changes in law and political climate prove the migration of people from India. Holt believes that the seeming influence of Hindu deities in the Buddhist religion in Sri Lanka is evidence of people from India moving into Sri Lanka. While his writing does not explicitly cover a journey of craftspeople from India to Sri Lanka or vice versa, it is essential to an understanding of the demographics of the time. Coomaraswamy (1909: ix) notes that Christians, Muslims, and Jews are seen more like strangers and less acceptable to people of the Buddhist faith than a Hindu. This could not be more evident than in the fact that the Buddhist temples would hire Hindus for work even though they did not hold the same religious perspective. This could be seen as validation of the long incorporation of people into the Sri Lankan and Southern Indian society. It is important to note that with the study of inscriptions and religious writing, they only tell the 'upper class' story. As such, these changes would have only been documented when they involved political and religious affairs. This would not record the movement of everyday people and ideas into the area.

Many other writings reference the moving of individuals, specifically artificers from Southern India. Accounts of war with invaders from India seem to begin around 237 B.C., with the Sri Lanka King being from India at different times in history. One of the Kings decided to invade southern India, returning with 1200 captives from India in one story that is of interest. The king is then said to have settled the prisoners throughout Sri Lanka. When the tooth- relic, which is said to be the left canine tooth of Buddha, was brought to Sri Lanka, it arrived with a Brahmin princess who would have travelled with her attendants. The princess's entourage would have probably included her craftsmen and their families. This influx of people from southern India is documented to proceed well into the 18th century. Some of the transported craftsmen would have been mainly brought to work for the king and would be granted land for the work they carried out for him. While the record shows a significant arrival of many craftsmen from southern India, it seems from the artworks that remain that the local craftsmen remained faithful to their original technology and style (Holt 2004).

Holt also notes that trade and commerce were not the only factors in the movement of people back and forth between southern India and Sri Lanka. A portion of the people would also be soldiers, or mercenaries, many from Kerala, making up large parts of Sinhala military power, and at one point said to guard the tooth-relic. The safeguarding of the tooth-relic would have been a vital job due to the belief that the king who holds the relic is the actual king of the Sinhalese, the symbol of the king's power (Holt 2004).

The craftspeople from South India and Sri Lanka would have worked together and traded ideas, but it is worth noting that the native workmanship mainly remained the same and genuinely Sinhalese in design (Coomaraswamy 1979: 62). Another influx of people from the south of India would have been from the marriage alliances between the Kings of Sri Lanka, who are chronicled only to take brides from southern India. This would have created a type of balance within the kingship through marriage alliances. Like many other travellers of royal prestige, these new brides would have travelled with their companions and workers. These marriages would have created a need to help the new arrivals settle in the towns they were moved to. This can be seen in the tolerance for people of the Hindu faith, which most of the new arrivals would have been. This can be regarded in some of the temples built and documentation stating that the king had people of the Hindu faith given land and favours. This would have also created a new dynamic in the politics of the time. The king would also have to keep his new group of inhabitants happy, creating new rules and laws to include his new subjects (Holt 2004).

Juleff (1998: 89) expresses that this movement of people would not have been a single event but a continuing immigration practice over a long time. Traces of this can still be found in the language and believed status, still used in regard to caste. Juleff states that the divide in caste between smelters and blacksmiths could harken back to the arrival of iron workers from south India. During the Late Historical time, it was not uncommon for the king to grant land and privileges to craftspeople who were extraordinarily talented in their trade (Codrington 1909). This would have created the need to stand out; the south Indians, possibly to keep their status and compete with the indigenous workers, could have created stratified jobs within the ironworker's caste based on technological differences, such as smelting or smithing of the iron. This separation could account for the smelters being considered lower caste due to the smiths being the crafters with more interaction with the consumer (Juleff 1998: 121).

This section has shown that religious and historical texts abound for this time and place in history, (i.e. Mahavamsa, Bhagavad Gita and Knox, Buchanan), along with inscriptions that all tell the tale of individuals moving to Sri Lanka from South India. Many ethnographic studies have been done in both areas and later compared and debated to try to establish a link, or not, between the two regions. Minute details about the exchange of religion between the areas have surfaced to discover the link once again between the two regions. Linguistics has been used to explain the ties between the two regions. The origin of the first people in Sri Lanka is a topic that is hotly debated; when did the first people get to Sri Lanka, and from where did they come. Are Sri Lankans just an extension of the Indian people, or are they wholly separate? Archaeology is one of the primary disciplines that could help answer many questions about the trade networks between Sri Lanka and India, one that has sadly been relatively quiet.

2.7 Conclusion

In this chapter, the topic of the Kandyan blacksmith was discussed, starting with understanding the term Kandyan itself, then the location of Kandy, next the socio-political environment during the Kandyan period and the fall of the Kandyan Kingdom. An introduction to the origins and understanding of caste was made to aid in the knowledge of the blacksmiths and their beliefs and way of life. Some of the more prevalent historical written works and an introduction to the authors of these works were made. Lastly, more recent archaeological and ethnographic work was discussed.

Throughout the political transformation and turmoil in Kandy and South India in the Late Historical Period, the villages and towns carried on without much notice or change, enduring as they always have. While other outside countries had interests and agendas of their own regarding trade and exploration, as can be seen in the published commentaries written during this time, these changes would have little effect on the small village farmer. Military engagements and modifications in the hierarchy would create significant differences in palace life, but it would do little to affect the socio-political life of most. Even though varying from region to region, the caste and land tenure system were deeply held structures within both society and theology. The men who documented life during this time might not have always held the greatest intentions in documenting all the information they did, and it is important to recognise this when reading them. Still, they should be acknowledged for the contribution they made. The connections between South India and Kerala have changed significantly. Yet, the importance of the ancient ties between the two areas has remained, making these two regions a distinctive interwoven fabric for this research.

Chapter 3 Methodology

3.1 Introduction

In a recent study (by the current author), for the completion of a master's degree in 2014, the metallurgical analysis of iron objects found at the site of Ban Don Ta Phet was used as a base study for experimental reproduction work (Bonnet 2014). In the original research, it was believed that in forging one of the objects, labelled as a billhook, a right-handed smith first formed a blade edge on the side of metal facing him while holding the iron object in his left hand. Once the blade was finished, it was then thought that the smith turned the iron object around to forge-weld a socket onto the blade area (Bennet 2009: 375).

In Bonnet's study, a blacksmith in Devon, England, was asked to reproduce one of the billhooks based on the metallurgical research and the parameters (blade then socket) set out by Bennet. The blacksmith had a challenging time forging the billhook in the way that was set out; he then formed the billhooks in the opposite direction (socket then blade) and was able to forge the objects with more ease. Bonnet then travelled to Sri Lanka to work with native smiths in the highlands and had them forge the same object without any instruction, and the smith followed the opposite way as well (socket then blade). This could lead one to wonder what is known about processes conducted by ancient smiths using standard metallographic procedures used in a lab. The iron material itself can be understood on the microscopic level. It is known how different processes change and distort the properties of iron. What needs to be understood is how much is a deduction from established blacksmithing practise by the metallurgist conversant with these methods from watching a smith work or through books showing standard blacksmithing processes? How much of this is determined by the lab?

The skills and techniques of past metal smiths are primarily gauged by analysing the microstructures of artefacts using standard metallography. Little to no research has been conducted to test or verify microstructural observations through ethnoarchaeology and experimental forge work. This study will offer a way to establish the veracity of this approach for studying iron objects in particular. It will draw on direct practical engagement with remnant Kerala blacksmithing communities, combined with controlled experimental forge working, deconstruction of techniques and comparative microstructural analysis. How the objects are forged and what makes up the smithing toolkit will also be assessed and how each forging space is utilised. A range of methods will be used, including experimental forge working in a manner that will also assess their future applicability to other regions and periods.

For clarity, this chapter has been separated into five categories; research approach, ethnographic, experimental, and microstructural, followed by a section on ethics. Each section will address in detail the decisions made at each stage of the research. In practice, many of the methods here will overlap and combine with the other sections. As such, the separation here is for ease of understanding. It is also worth mentioning that although the research is presented as separated into different sections, this does not mean to say that these sections represent different phases of the investigation. Many of the various methods were carried out simultaneously.

3.1.1 Selection of Research Area

Many aspects of the primary production of iron, or the smelting process, have been researched in South India and Sri Lanka, leading to finds of a very advanced level of technology. It would not be difficult to imagine that the next step in the production of iron objects would be as sophisticated as the smelting technology. This study will focus on the technology after the primary production of the iron, namely the creation of actual iron objects, to create a greater understanding of the whole picture of the iron industry in these areas. In Sri Lanka, Juleff has stated that research in the Samanalawewa region (fig. 1) can "give a near-complete description of bloomery processes that parallels on several continents and the potential to inform the interpretation of many less complete records" (Juleff et al. 2009).

It could be argued that the picture is not complete until the whole process is included, from raw ore to complete finished product. This full picture would give archaeologists a rare look at the entire iron technology of an area and why it makes this area of Sri Lanka so unique for this study. Another reason to consider is due to the geographical location of the highlands, as this area of Sri Lanka was exposed to outside influence less than any of the other regions of the island. The King of Kandy, who ruled this area of Sri Lanka, did not surrender to the English until 1815, and most of the traditions remained long after this time.

Juleff has said that to understand Sri Lanka truly, one must "first look to India," even calling India the "cultural well-spring of Sri Lanka" (Juleff 1998: 9). If this is true, then to truly create a complete understanding of the blacksmithing technologies of Sri Lanka, it would need to include India. The locations of Central Kerala and the highlands of Sri Lanka were chosen for this study due to the alleged historical ties between the two regions that are said to have traded not just the technology of the particular areas but to have traded and moved the crafters themselves. These trade stories between Sri Lanka and India date to the start of the Sri Lankan monarchy (543 BC) and continue through to the 18th century.

One such story is told in the *Mahavamsa,* a non-canonical text written around the 5th century in Sri Lanka. In this story, the people of Sri Lanka beseech Vijaya to become the first king of the land. Vijaya agrees upon one condition, only if they can find a maiden of noble birth to be consecrated as queen at the same time. In Southern India, the King of Madhura agreed to send his daughter to be wedded to Vijaya to become the queen of Sri Lanka. With his daughter, the king sent 100 maidens, said to be of differing rank, for the ministers of Sri Lanka to marry. The maidens were sent with elephants, horses, wagons, and artisans reported being a thousand families of the eighteen guilds (Geiger and Bode 1912). In his book 'The Buddhist Visnu' (2004), Holt proposes that the documented changes in religious tolerance shown through changes in law and political climate prove the migration of people from India. Holt believes that the seeming influence of Hindu deities in the Buddhist religion in Sri Lanka is evidence of people from India moving into Sri Lanka.

Juleff (1998: 89) expresses that this movement of people would not have been a single event but a continuing practice of immigration over a long period. Traces of this can still be found in the language and believed status, still used regarding caste today. Juleff goes on to state that the divide in caste between smelters and blacksmiths could harken back to the arrival of ironworkers from south India. During the Late Historical time, it was not uncommon for the king to grant land and privileges to craftspeople that were exceptionally talented in their trade (Codrington 1909). This would have created the need to stand out. South Indians could have created stratified jobs within the iron worker's caste based on technological differences, such as between smelting or smithing of the iron, possibly to keep their status and compete with the indigenous workers. This separation could account for the smelters being considered lower caste due to the smiths being the crafters with more interaction with the consumer (Juleff 1998: 121). The connections between South India and Kerala have changed significantly over the years. Still, the importance of the ancient ties between the two areas has remained, making these two regions a distinctive interwoven fabric for this research.

3.2 Research Approach

Throughout this research, several methodological aspects will be key, both in terms of the overall approach and to the interpretation and understanding of data and blacksmithing in general. As such, it is only natural to discuss this methodology before the practical methods that will be used during this research are given in detail. The following section will start with the project's general overall mythology and then move on to more specific methodological aspects dealing with ethnographic and experimental practices.

3.2.1 Forging Links in the Chain

Throughout this study, a holistic approach will be used. Methodologically the best way to explain my process would be through the work of Bruno Latour in his book *Pandora's Hope* (Latour 1999: 24-79). In this book, Latour is interested in how scientists actually conduct research in practice, process the information, and take all the steps that lead to their end results. In the specific study to be discussed, Latour befriends a group of scientists and examines how they take their research from the field and transform it into the written form that results from the fieldwork. In the broadest terms, he considers how we, as researchers, can take the world that we observe and then transfer that into words that we can share.

As Latour explains, the process of research can be best understood as chains that link into each other, with no necessary beginning or end. As science is conducted, these chains can then be added on to at either end and at any time (fig. 3.1). Adding to the chain does not necessarily have to be done by the same research project or by the same persons, nor even having to be in the same

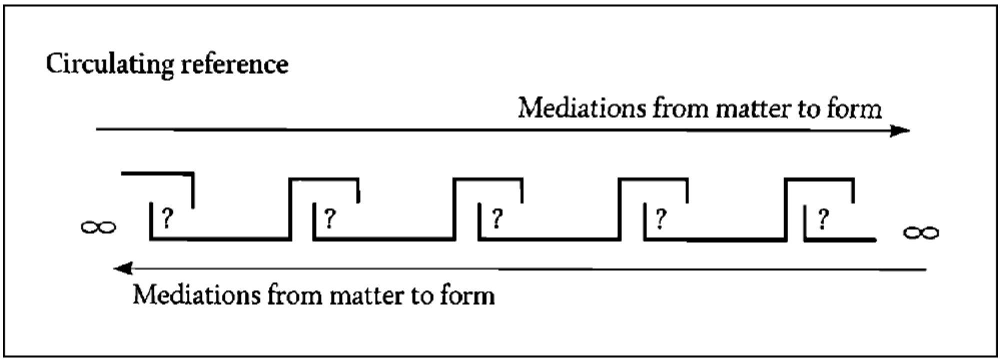


Figure 3.1 Latour's chain of knowledge that shows the space between "form" and "matter" (Latour 1999: 71).

research field. These chains can be filled in with missing information. Latour

(1999: 69) compares the chain to electrical wires; if a part is cut off or missing, then the electricity (or knowledge) cannot be passed to the following link in the chain. This could be explained with the scientific method; when a link is missing or a void is discovered, new hypotheses are made and tested as attempts to fill in the new gaps between these links.

From this, Latour finds that research consists of what he terms "circulating references that are created through transformation between matter and form" (Latour 1999: 71) that is between the object of study, the "matter" being researched, and the form that this research will ultimately take, the written word. He believes that these transformations are necessitated by the inherent gap between the "matter" (object of study) and the "form" (written word). This gap needs to be bridged to successfully present the world on the page. The transformation is what happens to bridge this gap.

Latour states that these transformations "cascade" (Latour 1999: 68) into one another, forming a cyclical pattern where the research will move between the field (the specific, localised, particular situation being investigated) and the constructed world of the text, where the research can be standardised, universalised and disseminated to others. In this understanding of the production of scientific knowledge, these "circulating references" would be whatever is being studied, with the matter being the physical subject and the form being the writing portion of that research. It is in this way, in essence, that these "circulating references" could be described as the chains of knowledge that are created when the world is put into words or the transformation between fieldwork and finished field report. Each transformation is a link in the chain of this knowledge, and each link leads to the next. In this manner, both the research processes themselves and the information being produced by these processes undergoes many changes, transformations and decisions along the way. An essential property of these chains and transformations is that they must be able to travel in both directions. Through the end product (i.e. field report), the ability to travel back to the raw data is vital. In other words, the study must have the ability to be repeated.

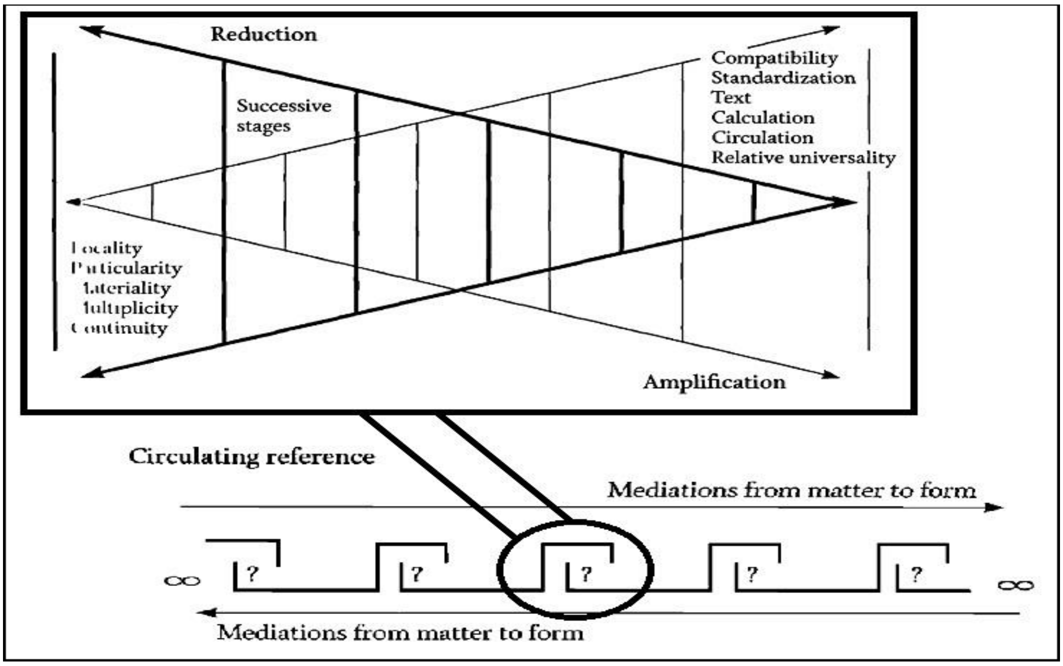


Figure 3.2 The transformations that take place to bring the world to words. With the reduction, or what is lost, and amplifications, or what is gained (after Latour 1999: 71).

When transferring the world into written form, there is a gap that must be bridged. The data from the world goes through what Latour calls transformations of reduction and amplification (fig. 3.2). These transformations fill the space between world and written word. Transformations are the decisions that are made during the research. When new knowledge is acquired, or the world is put into numbers, such as heat readings or blows on an anvil, these transformations reduce the data into text that can then be analysed. It is this dialectic of gain and loss that takes the data and creates patterns of understanding (Latour 1999: 24-79). Each reduction and amplification can be seen as a piece in the bridge being built to cross the space between world and written word.

This research has been set up in a similarly cyclical arrangement. While some of the work will be carried out concurrently, many features cannot come before the others. The ethnographic leads to the experimental, which then leads to the microstructural. These links could even start with initial research, which leads to the ethnographic, experimental, and microstructural, and then ultimately to the end thesis. These different aspects of the research cascade into each other, with the various parts forming the whole picture to be presented. It could be said then that this research will create several links in the chain that will then be added to the overall larger chains of several different subjects, such as archaeology, Asian studies, metallurgy, blacksmithing, and so on.

Finally, it could be argued that such traditionally ethnographic studies do not fall under what is typically considered archaeological science. In this study, the ethnographic research will be conducted and disseminated in the same way that Latour has argued that traditional science is. When taking a holistic approach to a given question, this circulatory process acts to interlink the different research processes together.

3.2.2 Unpacking the Forge

Taskonomy, when working with smiths, can be described as a cluster of tools utilised for a specific task at hand or tools situated in a specific location within the workspace (Dougherty and Keller 1982: 765). This works to create a type of taxonomic understanding of the tools used in the workspace. Instead of creating a typology based on the tool's characteristics, it would be much more valuable to form a "taskonomy" based on the tasks required to produce the object, whether it be tools used during the forging process, which would create a unique taskonomy or cluster of tools utilised in forging each specific item forged and to each smith themselves. The tools in the workspace can then be further organised into another form of taskonomy based on the location of the tool in the workspace. Many tools are located in the forge area based on specific tasks assigned to different stations. These areas represent a conceptual organisation based on the foreseen task and represent the workflow of the smith as they carry out the act of forging (Dougherty and Keller 1982: 766). These conceptual groupings can be vital to the interpretation of archaeological sites and our understanding of metalworking in the past.

Recording how the smith moves within the forge will be significant to interpretation and analysis as well. This part of the study will help form what Ingold (2001: 197) describes as a "taskscape"; that is, the related ensemble of tasks that together constitute the act of forging. Here, this becomes a type of record of how the blacksmith moves through the forge. The study of how the smith dwells within the workspace, also known as dwelling perspective, applies to how tasks are enacted within a landscape. In this study, the landscape under investigation is the forge, and the taskscape is the areas that the smith moves through as he works to create iron tools. Many of these taskscapes are inherited through previous forges the smith could have worked in, and as such, they can be seen as culturally driven (Ingold 2001: 194).

Combining these two approaches, taskology and taskscape, will allow a recreation of sorts of the smith within the forge. With taskology, it is understood that the tasks are embedded within the forged object. With taskscape, the movement within the forge is embedded into the forged object. It is when these are combined that we will, in a sense, take a dead forge, unpack it and bring it to life. In the archaeological context, this will allow the researcher to take a forging site and the objects produced there and put the living blacksmith back to work, at the centre of the investigation. This will place the movement and technology back into the site itself.

3.2.3 Sensory Perception and Blacksmithing

Another strategy to be used to understand blacksmithing technology will be in the form of blacksmith training, to be undertaken by the author. This will further the understanding of smithing skills in a way that verbalisation alone cannot and is a logical next step in the participant-observer method utilised in ethnography. Keller and Keller (1996: 3) explain this approach in their book *Cognition and tool use.* They state that many of the activities involving technology become habitual and routine over time, making it increasingly difficult to verbalise or instruct actions and aspects of smithing that are physically or mentally memorised. As such, an understanding of the subtleties of the technology may be missed by an observer.

Research in the past has tried to interpret the training or learning of craft skills through language studies, believing that knowledge can only be passed using language to express technical concepts (Scott 1989: 237). These concepts, translated into words, would then be decipherable in ancient texts. All that is needed then is to study these texts to unlock the secrets of past skills. The study of texts alone to find details about technological processes would fail to be fruitful due to the lack of detail and, like blacksmiths today, smiths in the past had technical terms that may not translate to what they mean today. These translations make the interpretation of the texts on ancient technological processes difficult as well (Scott 1989: 241). This is not to say that research into technological language found in such documentary sources is not useful, especially when concerning how processes would have fit into everyday society, such as processing ore or making charcoal, situations when the procedures would have forced group interactions.

Part of learning any craft has a side that is difficult to translate into words on a page. In his study mentioned in the introduction above, Latour specifically addresses this problem as it occurs in the sciences (Latour 1999: 70-2). Many crafts that are traditionally taught through an internship style process have much of the knowledge of the craft stored in the individual's memory and learned through experiential training and study, or trial and error (Pfaffenberger 1992: 507). One hotly debated aspect of experimental and material culture theory is the idea of sensory perception. Sensory perception is, as it sounds, a perception of the world through the five senses (Hurcombe 2007: 537). Without this perception, a disconnect between the material being studied and the observer is present. This disconnect limits the researcher in their understanding of the object being studied (Hurcombe 2007: 537). Knowing these restrictions and the properties of the material being studied can be just as important as having an understanding of the socio-economic conditions that they are constructed in (Geselowitz 1993: 235).

In blacksmithing, for example, this could relate to the colour of the iron. An experienced smith will use many of the senses when forging. The colour of the iron plays an important role in knowing when to strike (fig. 3.3). Just the right colour and the iron is plastic, and easy to move, too hot and sparks fly and burn the iron, too cold and the object can be damaged through cracking (Sim 2002: 61). The sense of smell is used not only to tell if the iron is burning, but it can also reveal the composition of the iron, as is the case when working with iron with a high concentration of phosphorus in it.

Figure 3.3 Different colours of iron at different temperatures.

It is common for blacksmiths to learn through trial and error. They do not see mistakes as a failure but as a way of sorting out, in their mind, a way to systematise how an object is made. This includes not only mentally working this through but also physically training the body in which moves to make. After this interpretation process, the mind has memorised the steps that need to be taken, and body memory falls into place. The more the blacksmith makes a specific kind of object, the faster they will become at forging that object, until they can forge the end product quickly with the brain and the body not giving much active thought to the process at all, until it becomes an effortless dance between raw material and creator. Therefore, one cannot learn smithing skills by simply reading a book or watching a video.

The smith can also tell many properties of the iron composition with sound. Just the way the iron sounds when hitting the anvil can tell a smith many things about the composition of the iron. The sound of the fire or the charcoal burning can tell about the temperature of the fire (pers. comm. Dave Budd). With all of these properties, these sensory experiences are not something that can be conveyed purely with words. These are not skills that can be learned with a book or watching another smith. These are only learned through personal experimentation and working with the materials of the craft. These are the types of properties that would have existed to the ancient smiths (Hurcombe 2007: 537). These sensory perceptions would have been taught at a young age and would have become second nature within the smithing communities. Such inherited cultural parameters and frameworks would then be rooted in the technological choices and technological knowledge (Martinón-Torres 2002: 33) of the practitioners. Basic concepts such as what a sickle looks like and what function it serves must be known, along with how the tool is used (Keller and Keller 1993: 126). As such, craft technologies are not only shaped by the social parameters they are situated in but the properties and laws of the materials that shape them (Hurcombe 2007: 53, Heeb and Ottaway 2014: 163).

3.3 Ethnographic Survey of Operational Traditional Blacksmiths of Central Kerala

This part of the research has many different facets. First and foremost is documentation of not only a traditional technology but an ancient way of life that is quickly disappearing. This will involve exploring such things as the use of waist-high hearths versus ground level, bellows designs, the smith's relation to a temple or the use of a family temple, and considering how later colonial influences that might have changed the picture. This might reveal information about closely shared traditions and shared technology of the craftspeople that will lead to a wealth of information about the blacksmithing craft technologies of the two different locations.

Sri Lanka and India have some of the few areas in Asia that still have remnant blacksmithing communities that resemble what could have possibly been found in the 11th and 12th centuries. This ethnographic research will also produce physical iron objects that will then be taken to a lab to be analysed, in a sense giving the opportunity to examine objects that are using the same technology as the objects found within the archaeological record. These remnant communities are changing quickly. Modern society is inexorably encroaching, and with it, the need for handmade objects is fading. Factories that make objects faster and cheaper than a blacksmith are taking over, and the smiths struggle to make a living. The traditional system of hereditary jobs is becoming obsolete due to the next generation not wanting to struggle like their parents, and parents not wanting their children to struggle like them, so they get an education and leave the area to get a job. This is understandable but could mean the end of this way of life.

3.3.1 Finding Smiths, Forging Connections

In Kerala, traditional blacksmiths have in the past only been known to still work in the northern part of the state (pers. comm. Sharada Srinivasan). The location in and around the town of Fort Kochi was chosen to be the location to base the research in due to its central point in the state and in anticipation that new discoveries could be made in and around this region of Kerala.

During fieldwork, the first task was to find blacksmiths willing to participate in the research but that fit into a few parameters. The parameters are set to find traditional smiths that resemble what could have been found in the area during preindustrial times.

These parameters are:

- length of time the smith and his ancestors have been blacksmiths
- if they used modern technology (such as electricity for bellows and angle grinders for polishing and sharpening tools)
- if the smith is associated with any temple or temple rituals, especially if such a temple association could produce a recorded genealogy of a smith's family

Finding smiths was achieved through personal communication with residents in Kerala. Once arriving in Fort Kochi, contact was made with tuk-tuk drivers, the guest stay owners, shop owners, and anyone passing in the street. Though difficult and small at first, these conversations build upon each other and start a dialogue within the villages themselves. Eventually, once they become familiar with the study and its goals, people within the village begin to ask others if they have information. This starts a chain of information that produces results. This approach may seem a bit out of the ordinary at first glance but is no different than what ethnographers have been doing for years. This research style can be very subjective, but it was heavily documented in this study to show how this portion was carried out. It can be challenging to conduct research when no previous documentation exists to start a foundation to begin.

When information on the location of a blacksmith was given, a trip to the site was planned. Upon arrival at the location of the blacksmiths and after introductions are made, a series of questions will be asked of the smith. This questioning will be done in a very informal conversational manner, and an interpreter will be used. The list of the questions that will be asked can be found in Appendix A.1. GPS coordinates will also be documented.

In Kerala, a language barrier existed. The most common language in Kerala is Malayalam, although many people in the more heavily populated areas, such as Fort Kochi, will speak at least a little English. This proved to be enough for the author to find places and have basic needs met. However, when visiting the rural areas, this was not the case, and the use of a translator, who is very proficient in English, became vital. This can sometimes be an issue when attempting to conduct interviews as the translator might put their own ideas into the answers, transliterating rather than translating word for word. Sometimes this can give the answers a different meaning than what the person that is the focus of the study was intending. It was important for interpreters to understand the extreme importance of interpreting everything said, as close to the same meaning that the original speaker intended.

From the first initial contact, the blacksmiths were then chosen for further forging work. Once the smiths to work with were selected, dates to carry out the experimental work were agreed. Along with the experimental work, documentation was made on local folk traditions and oral stories relating to blacksmithing, and relationships to local temples will also be documented. The research was carried out mainly in the form of observation and informal interviews. Formal interviews were conducted with Karuvan Krishnankutty (blacksmith 6) and Chellapan (blacksmith 20). However, they are older and no longer able to work long hours in the forge that other blacksmiths encountered would regularly do; it was decided that a more in-depth interview would be fruitful due to their age and long history working as a smith in their local area. An interview was also conducted with Damodara Sarma, an Oorayma (keeper of the temple) and pujari from the Shri Subramanya Swami Temple, giving a very different perspective of the blacksmiths and their relation to the temples within the area in the past and present. A full transcript of these interviews can be found in appendix A. The information will be documented through extensive fieldnotes, digital photos, videos, and audio recordings. All interviews and conversations will be carried out in the local language and translated to English with the aid of an interpreter.

Out of 19 smiths documented, six were selected for continued research. Detailed information about each smith can be found in appendix A. Blacksmith 13 does not fit into the parameters set due to him using comparatively modern technology in his forge work. He uses electrical bellows and angle grinders. He even has a homemade power hammer that he constructed himself. Blacksmith 13 was selected due to the unique tools that he forges. This blacksmith is a member of a family that owns three elephants that are maintained for temple festivals. He only forges items needed for the upkeep of the elephants, creating items such as chains, toenail cutters and knives for cutting palm leaves. These are tools that were not seen being made at any other location and, for this reason, this blacksmith was asked to forge one of the common implements for him to produce. Any other smith could indeed forge these tools. While this is true, for this study, the need for the smith to be familiar with the forging of the object is important. If the blacksmith is not familiar with the item being made, that could drastically affect the time it takes to forge and the expenditure of the material used in the forging process, such as charcoal and possibly the iron supply itself in the event that a mistake is made and that would require the smith to scrap the object being forged and start over with a new piece of iron to forge. With each iron implement forged by the blacksmiths, such concerns were considered when deciding which blacksmith should forge which object.

In a small village located just outside Kollengode, close to the border with Tamil Nadu, the remnants of a large traditional blacksmithing community were found. A total of 8 smiths were found in this location; these smiths were the most traditional technology observed in Kerala (fig. 2.4). All of the smiths stated that they were related to each other and had ties to the local temple. The temple is just for the blacksmithing community, so this tie between the temples and the blacksmiths offered a unique look into a specialised temple utilised just by a community of this type. It was determined that a significant amount of time would be focused on this community.

Figure 3.4 Blacksmith hut and traditional forge.

3.3.2 Blacksmith Survey

Each time a smith was found or work was carried out with them, a standard form was filled out at the end of the same day, and field notes were taken during the forging work. This will be done as soon as possible to make sure that all the information is still fresh. A blank copy of this standard form can be found in Appendix A.1.

These forms are separated into different sections, the first being basic interview information, such as location, date, time, who is performing the interview, what types of data are being collected (i.e. photo or video numbers), and where it will be stored. The next section focuses on the blacksmith themselves, covering name, age, time as a smith, if they come from a family of smiths, how long they have been smithing if they have temple associations, if they make their own charcoal and finally if they have anyone to pass the trade on to. The last section covers the forge itself and has questions such as size and shape of the anvil if the smith sits or stands during forge or finishing work, bellow type, sources of iron they use to forge and GPS readings for the forge.

These forms were then used to form a database on the blacksmiths in each area. From these forms, comparisons can be made on sources of material, such as the charcoal and iron, what percentage of smiths work in relation to local temples and how long the smith has been working in the area. Maps can also be made, allowing comparisons on the location of where the smiths are found, such as if they are found in clusters, possibly noting an area that could be a remnant craft village, are they located close to temples, or certain agricultural regions. It can also be used to compare things such as anvil shape and size, bellows-type, finishing style (i.e. grinding by hand or angle grinder) and do they work sitting or standing.

3.3.3 Inside the Forge: Smithy Surveys

Some of the forge areas were selected for detailed survey work and documentation. The selection process was based on the age of the forge area. These surveys took place the day of the forging of the objects, and if not, then on a day set by the smith that would not interfere too much with his everyday work. Measurements and distances were taken throughout the work areas. Drawings and photos were also taken. Documentation on the location of tools and the specific areas of the workspace used for different tasks were also noted. Pictures of the tools most commonly utilised by the smiths were documented, along with the local names of the tools.

These measurements cover the whole of the forge work area, starting with measuring the size of the workspace itself. Then measurements of distances from where the smith works to the hearth, bellows, anvil and tools commonly used. If the smith uses a different station or work area for the grinding and sharpening, then the measurements for where the smith works were also measured and notes on the various tools used when performing these tasks. Measurements between the anvil and hearth and other tools within the forge were taken as well. Measurements of the anvil, including details about what it is made of and how it is placed within the forge (i.e. just lying on the floor, partially buried in the ground or in a stump or other form of base), were recorded. Details about the bellows size, materials and how they are made were documented in the same way. Locations of where the materials used during forging and are collected and stored, such as charcoal and iron, were recorded. This data can then be used for many things, such as a recreation of the forge work area if someone wanted to.

All the data is stored on the author's computer and backed-up in a remote online cloud storage program. The interviews were recorded digitally, and along with notes taken, they have been translated and fully transcribed.

3.4 Experimental Iron Object Forging

After carrying out the initial ethnographic research and selecting and establishing a picture of the blacksmithing communities themselves in central Kerala, the next step was to investigate the blacksmiths in more depth and consider the technology. This was done through experimental forging of iron objects. For this, a selection of tools was forged. As they were forged, detailed documentation was taken, and video that later was used to obtain data on the *chaîne opératoire* of each object. Documentation of technological aspects such as heat temperatures and amounts of resources is included. These forging experiments lead to obtaining the iron objects that later were used for analysing in the lab. As discussed in the section above, careful attention to which tools are utilised during the forging of the objects and when these tools were used were noted. This will create a "taskonomy" of the objects produced as described by Dougherty and Keller in their research with modern blacksmiths in the United States (1982).

For the forge technology experiments, several smiths located in central Kerala were consulted. The smiths were selected based on the parameters set out before. Once again, these are: length of time the smith and his ancestors have been blacksmiths for, if they used modern technology, such as electricity for bellows and angle grinder for polishing and sharpening tools, and lastly, if the smith was associated with any temple or temple rituals.

3.4.1 Blind Forging Studies

The first step in the experiments was choosing iron tools that form a representative assemblage that could be found in the archaeological record within the area. Each smith was asked to forge one or two tools each. The smith was asked to forge a tool that most closely matches what he is used to forging regularly or common tools to the area they work in. Once the tool and the smith were matched, the forge work was carried out blind, meaning that the author was not present at the actual time the tools were made. This was due to the nature of the blind study for the analysis part of the research. The strategy was for the author to be in the forge area before the smithing begins to aid in setting up equipment and to perform an informal interview of the smiths before work begins.

During the forging of the object, several different aspects of the work were monitored and documented. Hours of video documentation was recorded. Weights of all the charcoal used and the temperatures of the forge fire during the smithing was documented in field notebooks. Handwritten notes on interactions, such as customer visiting times and what type of work they requested, were documented. After the object was made, all the documentation was sealed up and kept safe by the author until the metals analysis was finished. Since the author was not at the forge during the actual forge work, a trusted and experienced assistant was needed, along with other people who helped during the forging to assist in collecting and documenting data.

Since the forge work was for a blind study for the author, all data specific to the forge work (i.e. digital video and audio, field notebooks and forms) were sealed in folders and kept by the author until the entirety of the metals analysis was finished. After the metal analysis was completed, the video and field notes were then reviewed and checked for consistency and comparison to the results of the microstructural analysis. All video documentation was analysed for data. This was done by documenting the forge times; i.e. how long iron was in the fire compared to work on the anvil, how many blows with the hammer it took to make the objects, The data on the forge layout and measurements, tool names, tool locations, tools used during forge work, techniques deployed and times taken by each task in the forge work, measurements of charcoal weights and measurements of forge fire temperatures between the smiths was compared to discern patterns and differences.

With each iron implement forged by a blacksmith, the *chaîne opératoire* or sequence of tasks was documented. In this way, the forging process can be broken down and studied as a pattern or "recipe" in the making of each individual implement. This can help in the understanding of the processes that go into forging items in the archaeological record and the skills needed for each item. This sequence of tasks starts with how the blacksmith obtains the iron for the forge work and ends with the completed forged item. It does not include any embellishments that may be added to the items, such as decoration commonly seen or even the wooden handles or hafts that would be needed to use the implements. This will ensure that it is only the actual iron work itself that is being studied. This is important as the times spent forging the items can be totalled, and an understanding of the labour hours required for any assemblage could then possibly be extrapolated.

3.5 Micro-Structural Assessment of Experimentally Forged Iron Objects

The primary objective of the microstructural analysis for this research is to discern the potential information that can or cannot be obtained about blacksmithing technology through the methods used in metals analysis. This research was done in hopes that it can later be used as a proxy for archaeological studies of ferrous materials in other regions and time periods. For this purpose, a double-blind study was conducted. Double-blind due to the author not knowing, in the beginning, the data obtained during the initial forging work performed with the blacksmiths, along with the data collected from the microstructural analysis, which will also not be known. To the writer's knowledge, this type of study has never been conducted in conjunction with objects forged with traditional skills and analysed in a blind study to observe if the data matches. This makes a template to follow from previous studies difficult to find. This also impairs the basis for a methodological framework. The following is a detailed methods section for the lab analysis and an explanation for why the procedures were performed in this way.

Archaeometallurgy is the archaeological study of the processes involved in the past production of metals and metal objects. This can range from ore collection to smelting or smithing the finished product and incorporates different metals such as gold, tin, bronze and iron (Bayley and Crossley 2008: 14). For this part of the study, the focus will be on the aspects of this discipline pertaining to the laboratory analysis of iron artefacts. Many different methods are employed to examine iron objects, from basic visual inspection to the use of microscopes and radiography to isotopic and chemical analysis (Bayley and Crossley 2008: 14). The choices of what type of method to be used are based on what types of questions need answering. For this study, the questions relate to the specifics about blacksmithing forging practices or the methods of manufacture that can be ascertained using the most commonly used metals analysis procedures. These analysis procedures are most commonly used to determine or show fabrication techniques when forging are radiography and metallography (Bayley and Crossley 2008: 14).

Metallography uses microscopes to observe small sections of the iron that has been cut from specific places from the objects being studied. This is done using a jeweller saw, with the sample then being placed in a resin medium (Scott

2015: 68). Metallography reveals the different phases that the iron passes through as the object is being made and the objects final structure. These can show forging practices that involve heat treating, like hardening, and what type of material such as iron or steel was used (Bayley and Crossley 2008: 33).

3.5.1 Micro-Structural Analysis – Procedure and Aims

The items used in the microstructural analysis are the iron objects forged in the ethnographic and experimental research from Kerala, objects forged during previous research by the author. Before that, research conducted by Gill Juleff in Sri Lanka discussed in detail in chapter 4. Since the traditional blacksmithing technology in these areas has remained similar for hundreds of years, it could be said that it is approximately what would be found in the archaeological record. These forged objects have been made using the same tools and work areas found in the archaeological record worldwide.

For the blind microstructural analysis, two qualified metals specialists discussed in detail in chapter 7 have been given already prepared sections of the iron tools from the blacksmiths to examine. The specialists will be given the same samples at different times to compare the findings after they are finished. They will know not to discuss any of the results until the end of the analysis. The specialists were given limited information about the tool, such as the edge of cutting implement or section close to the haft. They were then asked to provide as much detail about the blacksmithing technology as possible from the section they were given.

Before the preparation for the analysis, photographs of each object were taken, and detailed documentation of the dimensions of each object were made.

Samples were then removed from portions of the object that would be most likely to show possible forging techniques or stages in the forging process. The samples were then mounted with resin and polished. The samples were then sent to the specialists for analysis. Once the author received the data on the microstructural analysis, comparisons were begun on the data received and the actual data recorded during the forge work in Kerala and Sri Lanka.

This study is not designed to impugn any work that has preceded this research or to question any one particular study. Instead, it is carried out in the hopes of validating the knowledge and understanding of material culture exhumed from archaeological sites and the technology behind that material culture.

3.6 Ethics

Many ethical concerns have arisen during this work. Firstly, the concerns regarding working with the smiths in Kerala. It was vital that permission be granted for all aspects of the research and that all the participants involved were well informed of their part in the study. This can be difficult to obtain in areas where participants may be hesitant to give information to outsiders. The appearance of looking too formal could be a deterrent and could have led the blacksmiths to be suspicious of the study The first hurdle was obtaining ethics approval from the university. The University of Exeter has a board of ethics applications are accepted and the board meets once a month. The procedure takes time and needlessly postpones fieldwork. The first application was denied stating that it would need to be clearer to the research partners upon initial contact what we are doing and to obtain written approval from them from the start. The application was submitted again with the explanation that some of the blacksmiths are very suspicious of outsiders especially when they ask a lot of questions and fill out a lot of paperwork while doing so. It was thought that this would create an issue with finding people to work with as they would not wish to talk to begin with. The second application stated initial meetings would be through informal conversations or introductions through locals and that very little documentation would be taken. The documentation would revolve around the type of forge they worked in and not about the smiths themselves until approval was made. This second application was denied stating that they wished for more up front approval from all involved especially if they would be in video and photos. The stated that in some areas of the world people would not like photos taken due to a concern that their souls might be taken from them during the photo. Strong written permissions were suggested. The denial of the second application shows a large lack of understanding between the research work that the department and university conducts and a misconception of the people in Kerila that is clearly not based in reality. A third application was sent clearly explaining the people that would be worked with and that they are educated and knowledgeable about technology just as much as we are, and that before any video and photo documentation would be conducted initial verbal agreements would be made. Then it was decided that the approval would be obtained through audio and video recordings, but with a basic outline of questions that were followed for each blacksmith and participant. A copy of these questions can be found in appendix A.3. These questions were covered each time the participant was involved with fieldwork.

Chapter 4 Iron Technology

4.1 Introduction

This chapter will begin with a short overview of the technological stages involved in making an iron object. This first section will very basically explain the technological process involved from ore to finished iron object and will not be location-specific. This process will not be described in detail. Still, it is essential for understanding the complex processes involved and the scale of the technology in use to acquire an understanding of the finished product fully.

4.2 Chaîne Opératoire of an Iron Object

This section of the chapter will cover the technical aspects of the ancient iron industry. If one has not seen rock being transformed into metal, or metal being transformed into a usable object, it would be difficult to understand why some cultures in the past have likened this process to sorcery. There is a sort of magic behind this transformative scientific process. Even knowing the science behind the actions, this process is still a magical sight to see. Starting at the beginning with the ore that will turn to metal.

4.2.1 Smelting: Ore to Bloom

Iron is one of the most prominent, most commonly occurring elements in the earth. It is found in almost all mineral classes in differing amounts and can be found across the majority of the world. It is formed by various processes such as sedimentation, weathering and plutonic activity (Lepp 1977: 188). Plutonic activity relates to intrusive igneous rock or rock formed at great depth under the earth's surface and is formed from the cooling of molten magma. Iron is also the fourth most common element found in the earth's crust and is the only element that oxidises when exposed to the surface environment of Earth (Lepp 1977: 1).

The most common minerals used to produce usable metallic iron are hematite (Fe_2O_3) and magnetite (Fe_3O_4). An extensive range of minerals in varying combinations and amounts can be found in iron ores. Due to these minerals' diverse characteristics, there are several different ways that ore can be categorised. The easiest way to classify the ore is by sensory perception, such as colour, texture, smell and taste. The other elements found within the ore can be used for classification, such as phosphorous or sulphur. Ores can also be categorised by other minerals found within their matrix; this matrix or minerals are called gangue. Usually, the gangue has no value and can be made up of minerals such as silica, lime or clay. An ore may fall into just one of the classifications, or like many of the ores, they can be placed into several of them (Bashforth 1964: 3).

Ore would have been first prospected through visual observance of the landscape and studying rock outcrops. When not readily available, easy to find and on the surface viable ore, ore that would produce a good smelted product, could be found, the next step would have been to dig a simple pit. These pits would have been following already known ore sources, starting from the surface and becoming deeper and deeper as the mining continued. This would eventually leave a series of pits along the surface from where the ores had been removed by the miners, forming features that are recognisable to archaeologists today. Most of these pits would have been relatively small in size and would not run very deep to start with; large ore mines were rare. It would not have been until interest in good quality iron grew that large iron mines would become prevalent. Early on, even small shallow mines would only be dug if high quality ore was found, as mines were dangerous, difficult and unpleasant places for people to work and excavate ore from (Sim 2011: 26, Pleiner 2000: 87).

Once the ore was mined, it would need to be processed or prepared for the smelt. Roasting the ore at a low temperature (400-800°C) is thought to aid in this processing and was commonly used in the past (Pleiner 2000: 107). Roasting the ore can help expel any excess water content that might be retained in the material, and if the ore is too difficult to break due to its hardness, roasting will weaken the rock and aid its breakage into smaller pieces (Tylecote 1962:189). Roasting the ore would also make the ore more porous, which would assist the ore in being more responsive to the reduction process of smelting (Pleiner 2000: 107). This roasting of the ore would also cause micro-cracking, which would increase the surface of the ore and therefore increase the surface area for reactions to take place during the smelting process. Once the ore has been roasted, sorted and broken into smaller, easier to handle fragments, the ore is then ready to move to the next step in the process of making iron, smelting.

Smelting iron is usually achieved in two different ways, termed the indirect process and the direct process. The indirect process results in the iron becoming liquid and is used to produce cast iron. The direct process is when the iron is kept in a solid state, and the metal is extracted from the ore when it is not fully liquefied. Another method uses the iron bloom in a container, known as a crucible, and with high carbon, the material melts the iron to form a high carbon steel (Blakelock 2012: 6). For this section, the direct process will be the focus.

Smelting iron emerged as a technology later than the smelting of other metals such as silver or copper. It is speculated that, beyond the technical difficulty involved in the process, this delay in smelting iron was due to the fact that the temperatures needed to be achieved to cause the ore to separate the iron from the by-products are very high. Also, the cost of materials, such as clay and wood, is very high for smelting. Thermal decomposition causes wood to turn into charcoal. This process happens when the wood is slowly burnt with a minimal air supply.

During this process, the water and other substances are removed from the wood, and the remaining result is the charcoal (Pleiner 2000: 115). This is achieved by stacking the wood in tight piles or placing them in a pit like area dug into the ground (fig. 4.1). The wood would then be burned and then enclosed with a layer of dirt or clay. Holes would be made in the top layer for a bit of air to enter the wood-

Figure 4.1 stacking wood in tight piles (top) or placing them in a pit area dug into the ground (bottom) to make charcoal (after Biringuccio (1540) in Pleiner 2000: 120).

burning space. The wood is then left to burn for about 6-10 days (Pleiner 2000: 120). Wood selection for smelting and smithing would be heavily determined by the forge or smelting location and the ease of supply. As such, whether the source was close and wood readily available would be key factors in the selection of smelting and forging locations.

For a furnace to convert ores to bloom and slag and create an environment for this reduction to occur, a few conditions need to be met for it to be fruitful. First, a chamber needs to be made to hold the charges of ore and charcoal. A 'charge' is the term commonly used to describe each load of charcoal and ore placed into the furnace. Next, the material that the furnace was to be built out of needed to be able to handle the high temperatures necessary for the smelt. The furnace would need to have an air source and permit air to flow into and circulate throughout the furnace. Also, a way for the slag to escape or a place for it to collect once it has been separated from the iron would be needed. Lastly, a place for the iron bloom to be removed is required unless the furnace is to be destroyed at the end of use. The bloom removal could be through the top of the furnace, for instance, or through a door built into the furnace, allowing the structure to be reused (Pleiner 2000: 141-142).

Iron oxide itself can be formed at temperatures of around 800°C, but most iron oxide is found within a matrix of other minerals surrounding and within it. These minerals can often require even higher temperatures to separate from the iron (fig. 3.2). So, to produce iron from these ores, this matrix of other material needs to be removed. These unwanted minerals are the by-products of the smelting process, known as 'gangue.' It is what is removed as slag waste (Pleiner 2000: 107).

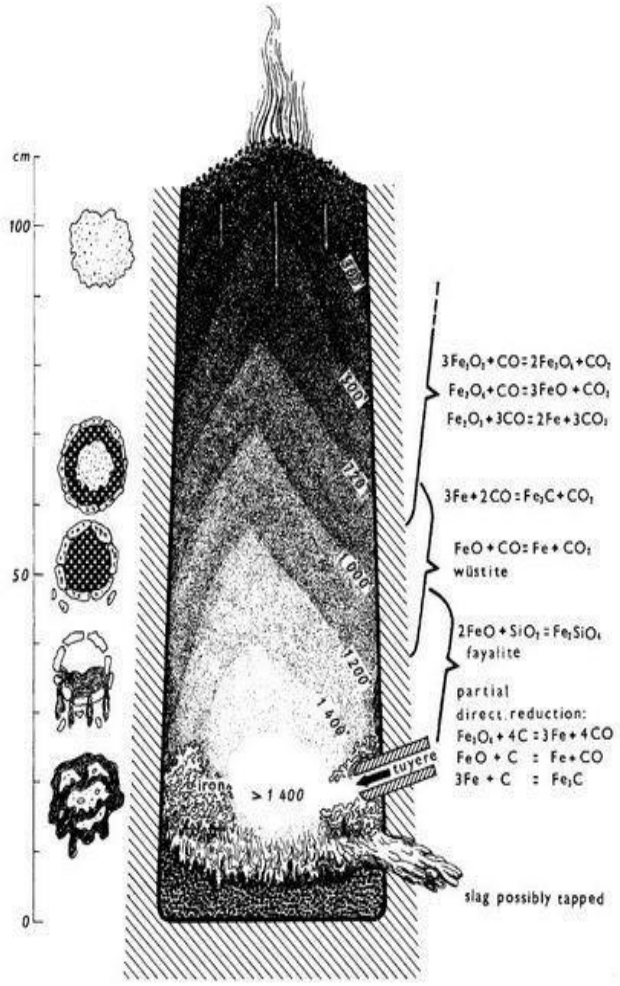


Figure 4.2 Different stages that ore passes from ore to bloom/slag (after Pleiner 2000: 134).

Most slags consist mainly of silica (SiO_2) and iron oxide, known as iron silicates. It is at temperatures around 1150°C that these by-products, or slag, become fluid, and they can be removed from the remaining iron (Tylecote 1962: 183).

To achieve the high temperatures needed for the removal of the iron silicates, an air flow of some kind is required in the furnace. When this air is added, it causes a more significant amount of charcoal to be needed to continue to produce the reducing atmosphere within the furnace. To lower the amount of charcoal used and still retain a reducing atmosphere, the furnace needs to be able to contain heat. Therefore, the furnace needs to be closed off or have a space within the furnace where the air is limited (Tylecote 1962: 184).

Once the slag flows to the bottom of the furnace, it can be 'tapped' or released through holes in the furnace wall to allow the slag to flow out of the furnace and be removed. If the smelt has been successful, the result will be a spongy mass referred to as the bloom. The bloom is then taken and hammered to remove the remaining slag trapped within the iron.

Slag removal is an important factor that must always be considered during the building and use of a furnace for smelting. The slag would need to have a way to be removed from around the bloom. The slag in a furnace flows to the bottom and can be raked out or flow out when tapped through a hole built into the furnace for this purpose. In the case of a slag pit type furnace design, the slag will flow past the bloom to the bottom of the furnace into a shallow pit in the bottom where the slag will pool and then harden (Pleiner 2000: 142). Tapping the slag during a smelt is always a precarious matter. If the slag is tapped too soon, this could result in heat loss, causing the smelt to end too soon before the iron bloom has had sufficient time to form correctly.

With these consistent material requirements in mind, it is not surprising that many furnaces constructed worldwide use similar materials. Most furnaces are built from stone, clay and/or bricks, and slag has been found incorporated as a building material in some furnaces (Pleiner 2000: 141). The inner lining of the furnace is sometimes coated with a fine clay and grog mixture. The air is supplied to the furnace in a variety of ways. The most common would be the use of bellows located towards the lower part of the furnace. There could be one or more sets of bellows used. If the furnace is made high and narrow enough, though, then the furnace will have a natural draught that will result in not needing bellows to be used. Furnaces located on steep slopes or hilltops can use high winds to create the same effect within the furnace and eliminate the need for air to be artificially forced into the furnace through the use of bellows (Pleiner 2000: 141).

4.2.2 Smithing: Bloom to Object

After smelting the ore and producing a bloom, the bloom would need to be refined and more of the remaining slag removed to result in a workable billet or bar of iron metal for the blacksmith to being smithing or forging with. The bloom is a spongy mass of iron with slag inclusions spread throughout (Pleiner 2000: 141). At the onset of working the bloom, the smith needs to work very slowly and not use too much force or heat. Too much force can cause the bloom to shatter, and too much heat can cause it to break apart and possibly even lose iron in the process (Crew 1991: 29). The by-products left behind from processing the bloom at the beginning will resemble smelting slags physically and chemically. As more and more of the slag is removed through hammering, the by-product will become more and more like hammer scale, much like what is found in a blacksmiths forge (Tylecote 1962: 232).

A blacksmith would not be able to work with iron if not for his tools. Only a few essential tools are needed for forging work, and they have not changed much over time. The first and possibly the most critical tool is the actual forge, or hearth, itself. This is what contains the fire that the smith uses to heat the iron. A forge needs an air supply to reach the temperatures required to heat the iron to a workable temperature, which is almost always provided by the use of bellows. The forge and bellows can have many different styles and sizes based on age, location and particular smithing style. The next tool needed would be an anvil or something to place the iron on when hammering. This could be a strong type of rock or metal and can vary considerably in size. All that is required of the anvil in terms of morphology is for it to be large, smooth and strong enough for the smith to use it effectively to hammer upon. For hitting the iron, a hammer is needed and to hold the iron when hot, tongs (Bealer 2009: 47). Many blacksmiths will have more tools than this, and many have more than one variety of each tool, but these four tools provide the most basic requirements that every blacksmith will need.

A collection of atoms, held together by metallic bonds, formed by the sharing of electrons, make up what we call iron and iron alloys, such as steel. These metallic bonds hold the atoms together to form a distinct, repeated crystalline structure. This crystalline structure means that all the atoms, molecules and ions are arranged in a very structured microscopic pattern, creating a type of lattice that extends in all directions. This structure plays a prominent role in how any given metal will react when being forged or worked. For iron to be malleable, it has to become heated to extreme temperatures (1100-1300°C). When heated, the electrons that form the bonds holding the crystalline structure together become excited, and this causes the atoms to jump from bond to bond within the crystalline structure (Scott 1991: 1).

In general, most metals form one of three types of crystalline microstructure; either in a Close-Packed Hexagonal form (CPH), a Face-Centred Cubic form (FCC), or a Body-Centred Cubic form (BCC) (Scott 1991: 1). In relation to blacksmithing and the working of iron and its alloys, it is only the final structural form that this writing will focus on.

Within this BCC structure, the arrangement of the atoms creates a cubic cell structure, where atoms are situated at all the corners of each cell structure, with a single atom locked in place in the centre. Each corner atom is then shared with the adjacent cubes, forming a wider, interlinked three-dimensional cubic structure that makes up the metal in its entirety. This interlinked lattice formation makes metals such as iron so characteristically strong due to this high level of interconnectedness (Scott 1991: 1).

When considering blacksmithing and how the microstructure of iron makes it viable for being forged, it is important to note that it is the potential for plastic deformation, aided in large part by imperfections in the lattice structure described above, that is key. These imperfections in the crystal lattice structure can be expected in any real-world iron piece. Although we can describe an ideal iron piece as a perfect cubic lattice structure, in actuality, any piece of iron material will contain a number of imperfections within this structure. It is these variable imperfections that allow for a great deal of what is termed "slip" (Scott 1991: 3). when the material is worked, this 'slip' is where the atomic cubic structures are able to move across each other within the metal as a whole

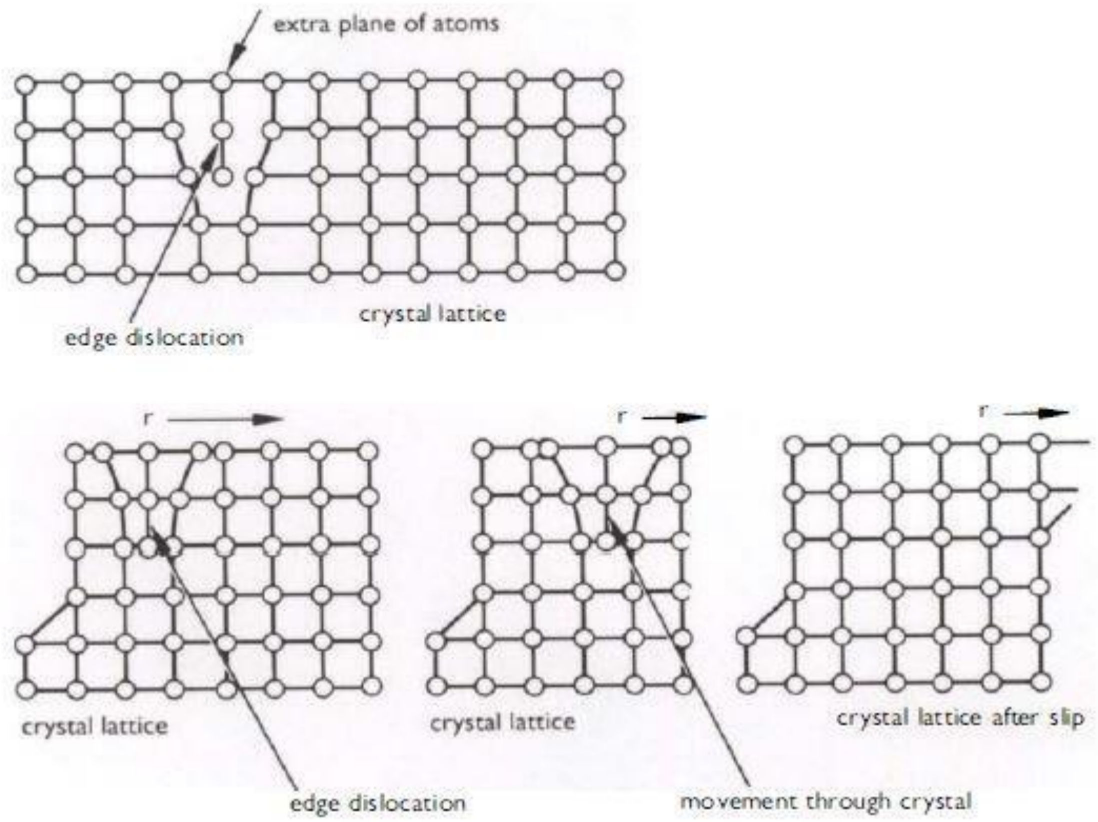


Figure 4.3 Showing how the imperfections and edge dislocations found within a crystal lattice can be used to alter the shape of the metal through the process of 'slip' (after Scott 1991: 27).

(fig. 4.3). This movement gives the metal its potential for elastic deformation and, as such, its ability to be shaped and stretched without compromising its overall hardness and resilience to damage.

The figure above shows in two dimensions how the presence of an edge imperfection can disrupt a crystal lattice. Although this does disrupt the absolute hardness of the material, it is also what creates its ductile strength. It avoids the formation of what would otherwise be a very brittle material.

As we can see in the figure above, the edge dislocation can be moved through the piece during working. What this means is that the form of the iron as a whole can be stretched and have its shape altered through the intentional manipulation of these microstructural imperfections in the iron itself, through this mechanic of 'slip', without compromising the integrity of the overall lattice structure (Scott 1991: 3).

As previously discussed, iron atoms can arrange in a BCC lattice form. As these microscopic lattice structures bond together, they form what is known as 'grains' larger, semi-discreet aggregations of BCCs. During the working of iron, these grains are variously re-shaped, flattened, pushed and stretched out as they are altered through the process of slip. This is initiated by manipulating the existing imperfections and deformations in the material, as well as by creating new imperfections through the working process itself. As this working process continues, eventually, the metal will become too brittle to continue being worked, and the imperfections that allowed for its elastic deformation are effectively used up. It is at this point that a process called annealing is required. This is where the metal is heated to a temperature that will allow for the recrystallisation of the material (generally between 500 and 800 degrees for iron and its steel alloys), effectively resetting the crystalline structure allowing working to begin again (Scott 1991: 7).

For many metals, this process will involve multiple cycles of cold-working and reheating for annealing, but the practice operates slightly differently for iron. As iron cannot be effectively worked cold, these two procedures are amalgamated (onecould say alloyed) into one process, hot-working. This process still uses the same principle of cycling between working and heating, but the iron is reheated consistently to keep it at a workable temperature. Despite this difference in practice, both hot-working and cold-working/annealing metals will produce very similar microstructural results that are perhaps more unique to iron. However, there will still be the continuing presence of microscopic slag particles left over from the initial smelting of the metal itself. In a worked iron object, these particles can be expected to be found stretched out and spread along the length of the piece as a whole. Scott (1991: 7) has termed these "slag stringers" and notes that the presence of such inclusions is an expected and common occurrence in ancient metalwork.

The ability of the metal to resist being damaged depends on the hardness of the metal. Modern machines can be used to determine the hardness of the metals, but most smiths will use a file to test the hardness of the metal they are working. The ability of the iron to resist damage from impact is termed toughness. The harder the metal, the more susceptible it is to impact.

For an object forged by a blacksmith to be durable and to be able to withstand constant use while at the same time retaining its cutting edge, the iron must be intentionally hardened. Hardening can be done through quenching and tempering. Quenching occurs when the steel or iron is rapidly cooled from red-hot heat. This quick cooling causes the structure of the atoms within the iron to become distorted and unstable (Andrews 1992: 120). At this stage, the iron is very hard but also very brittle. The iron is then tempered to alleviate some of this tension from the rapid cooling and aid in the iron becoming less brittle.

Tempering is usually done quickly after hardening; if the piece was left to cool naturally and not tempered, the iron could develop cracks that could potentially render the object useless. Tempering will increase the toughness of the iron. This is done by heating the metal to a specific temperature, one that the smith will determine through observing the colour changes of the metal as it is being heated. Different compositions of the metal and heating the iron to differing temperature will produce differing results. The smith will change these based on what the object being forged will be used for. Once the iron is heated to the desired temperature, it will then be left to cool in the open air (Andrews 1992: 125).

Regarding ancient and historical iron objects, interest in microstructural information is not purely for its own sake, however fascinating it may be. Instead, when considering how an iron object can be formed through the working techniques of a blacksmith (such as hammering, drawing out etc.), it can be highly informative for us as researchers to understand the processes that are at work on a microstructural level. Past blacksmiths would not have known the scientific aspects of the forging process, and many smiths today do not know them. Though, what they do have is a deep, practically orientated understanding of the nature of the materials they work with. Through the use of smell, tactile senses and sight, they can tell more about the physical properties of iron than most microscope users with a non-smith's eye.

4.3 Conclusion

This chapter began with a short overview of the technological stages involved in making an iron object. Although this was a very basic explanation, and due to the universality of many of the physical aspects of iron production, it has not been location-specific, it is hoped that this will aid in understanding all the work, time, skills and materials that are needed to produce just one finished iron object.

Chapter 5 In Search of a Smithy: an ethnographic study of central Kerala's blacksmiths

5.1 Introduction

In 2018 two different fieldwork expeditions took place in Kerala. The first, from February to April, was to seek out blacksmiths in the central area of Kerala. The second, from July to August, was to return to the blacksmiths and work with them to forge iron objects that could be later subjected to microstructural analysis by specialist metallographers. Along with the forging of items, the second expedition also completed measured and drawn surveys of three functioning smithies, one abandoned smithy, and two temples. The temple surveys were of small family temples, one just in the beginning of being constructed, the other has been in use for many generations. We also documented one of the daily Pujas at this old temple, a worship ritual performed in Hindu temples. Also recorded were interviews with two elder blacksmiths who were able to give insights into the blacksmithing villages of the past. Included in this chapter is an interview with a Pujari in the village of Vypin. A Pujari is a Hindu priest that is responsible for the daily rituals within the temple. The temple that the Pujari cares for still has members of the original artisan families working for them today. One of the blacksmiths who worked with the forging activities is connected to this temple. Interviewing the Pujari was an opportunity to see the ties with temple building and how the relationship with the artisan community has changed over the years. All of the surveys and interviews will be the focus of this chapter (full transcripts of all the interviews can be found in appendix A). The forging of the iron objects is the focus of chapter 6.

During the first trip to Kerala, a total of 16 blacksmiths were documented; on the second trip, another five blacksmiths were interviewed, making a total of 21 documented blacksmiths during fieldwork in central Kerala. During the first trip, a specialized blacksmithing village was located just outside the city of Kollengode (fig. 5.1).

Figure 5.1 Location of Kollengode (from Remesh and Manji 2009: 534).

Four blacksmiths were initially recorded, and additional fieldwork added four more, bringing the total in that village to eight. On the return trip, more time was spent in Kollengode to focus on interviews, measured surveys, and forging practises. During fieldwork in Kollengode, the opportunity to record a *puja* at a family temple arose, the results of which are described in section 5.6.

Video and audio recordings of three formal interviews took place, although additional information was gathered through informal discussions with people who were met along the streets; some of these discussions are documented through field notes. Two of the interviews were with elder blacksmiths, one who could no longer work for medical reasons. They both had long histories in the area, and they were valuable sources of information. The third interview was with the Pujari of Sree Subrahmanya Swami Temple, Damodara Sarma, a *Pujari* is a Hindu temple priest who is responsible for the temple rituals, including *puja* or worship. Most *pujaris* are of Brahmin caste. Damodara Sarma, the Pujari of Sree Subrahmanya Swami Temple, allowed me to interview him about the establishment of the temple and the arrival of the skilled workers related to the temple, which is said to have been built around 800 years ago and still has some of the original artisan families associated with the temple working and living within and around the temple complex. These interviews proved to be very useful in understanding the changes that have taken place in the blacksmithing communities in Kerala. The following sections will cover the interviews, surveys and observations made during these visits to the blacksmithing communities in and around central Kerala.

5.2 Approaches to Ethnoarchaeology

In the most general terms, ethnoarchaeology is the ethnographic study of living cultures from an archaeological perspective. Ethnoarchaeology should not be seen as either a single theory or specific method, but rather a type of research strategy. One that embodies a range of approaches to understanding the relationships of material culture to culture as a whole, both in the living context and as it enters the archaeological record, and one that can exploit such understandings in order to inform archaeological concepts and to improve interpretations.

As a broad definition this serves two purposes. Firstly, it highlights the broad range of ethnoarchaeology – both in terms of the investigative methods used and the aims these are applied towards. Secondly it highlights the areas which have received unique, and often quite damning, critiques in recent scholarship – that of its use (or mis-use) of ethnoarchaeology as a research method, that can be used to generate data to aid in understanding archaeological concepts. It is this second focus of critique, of the movement from ethnographic data to concept generation and archaeological applicability, that will be the focus of this section.

David and Kramer (2001: 40-4) provide an adequate example of the limitations of the applicability of ethnographic data to archaeological contexts and concepts when they oppose several different schools of archaeological thought: the processualist, contextualist, and the neo-Darwinian approaches to ethnoarchaeology. Each of these is used as an example to highlight a common trend: first a general rule for the use of ethnographic data is conceived, this is then applied against a consideration of how material culture is connected to cultural and social practices in general, and finally general rules or laws are understood to be generated from these applications that can then be applied, to a greater or lesser extent, to other more traditionally archaeological questions.

For the processualist, the purpose of ethnography is to gather primary data from a number of living cultures that can then be used to derive broader, and ideally universal, cross-cultural laws that can then be applied to understand any particular archaeological site or society. The reverse of this would be the contextualist approach – which instead would argue that, due primarily to the unique social, cultural and ideological functions that objects play in their societies, little can be gained through such direct appeals to cross-cultural unity in human behaviour. Here then ethnography becomes a tool to understand how a particular contemporary group creates social meaning “from the inside” (40) of their culture, and the only generalisable maxims that are possible come through appeals hypothesised processes in human cognition that are seen as the primary drivers of any otherwise culturally unique behaviour. Sitting alongside these two views would be something akin to what they term the neo-Darwinian.

Here an understanding of human society as being broadly determined by the naturalistic evolutionary pressures first identified by Charles Darwin. Ideas about survival of the fittest, reproductive success and calories as a form of ecological and social currency come to the fore (42), and come to define a simple set of goals that societies will ‘naturally’ seek to maximise. David and Kramer also seek to establish their own position in relation to these positions, charting for themselves a middle ground position, accepting of such deterministic, laws-based approaches for certain “primarily economic” (43) areas, while demarking “less constrained” (42) social activities such as pottery decoration as being less useful in cultural comparison.

All of these approaches seek then to define the appropriate use of inductive analogy in ethnoarchaeology, something that is recognised by both David and Kramer and others (cf. Gosselain 2016). But central to this idea of analogy is the link between past archaeological cultures and the contemporary ones that are selected for ethnographic study. This is where, as Gosselain has put it ethnoarchaeology find its “terrible pitfall” (218). Making reference to Bruno Latour’s insightful critique of the development of certain ideals of the Enlightenment (Latour 1993) Gosselain argues that many societies selected for study are done so because they fit a particular researchers idea of what that kind of society should look like, rather than any kind of particularly rigorous comparison. In this way certain contemporary groups have become almost standard bearers for archaeological comparisons (such as the San of the Kalahari as related to ice-age European hunter-gatherers) regardless of any real relationship between the conditions (material, ecological or social) of the contemporary and archaeological populations (219-20).

For this research, the consideration of this body of scholarship has produced a series of questions, problems and intentional reactions. This focus of study has been centred firstly around a particular subset of human behaviours – those focused on blacksmithing itself (that is the traditional production of iron and steel objects) and it's directly related activities. As presented in Chapter 3, rather than seeking to define ultimately universal rules of human behaviour as a goal, this project has begun by looking at the actual process of blacksmithing, and how it has been carried out in places such as Europe, North America, and Sri Lanka.

By doing this it was possible to begin to reveal certain practices that seemed cross-culturally apparent, and those which were culturally independent. An example of this is body posture and movement in a smithy. Whereas it could have been assumed – based on North American and European examples alone - that all smithing must be done standing, with the concurrent implications of this for the shape, construction and layout of smithies, it is through the consideration of South Asian examples from India and Sri Lanka that this is seen to be entirely a false assumption. Indeed, one could have formulated many plausible explanations for why all smithing must be done standing – all related to seemingly invariable rules about necessary body posture, the application of force to hot, malleable metal, the control of heat and the construction and use of bellows. Yet all of these assumptions can also be seen to be utterly fallible, when simple ethnographic evidence form a different culture is taken into account.

This led to the consideration of ethnographic studies of groups that still carry out such activities in a broadly ‘traditional’ way – that is without industrial technology – from many distinct (including North America, Europe, Africa and South Asia) regions around the globe, and then the direct ethnographic observation of such practitioners in South India and Sri Lanka.

The selection of Keller and Keller’s in-depth spatial study of blacksmiths in North America and our own focus on South Asia in particular was not without specific reference to Gosselin’s criticisms as well. When Gosselain speaks of the role of Western Enlightenment ideology in ethnoarchaeology (2016: 218-20), he discusses an intellectual environment which has repeatedly characterised the West as the definition of advancement and progress, and conversely non-Western societies as being, by definition, backwards, undeveloped and (sometimes quite literally) less evolved. An idea that is, undeniable, utterly false.

To avoid this narrative, the intention here was to select areas for study that could offer long standing, and in-depth cultural blacksmithing traditions, that have been preserved and studied both archaeologically and ethnographically. Building on Keller and Keller’s work with North American blacksmiths, and especially their idea of taskonomy and the focus on the use of space within the smithy, ethnographic methods were deployed in South India to generate a large amount of completely new data for analysis, and was intended to form a substantial part of the project from the outset. This focus, on ethnoarchaeology as a core aim and method, rather than an addendum to an otherwise laboratory or library based project, is part of what makes this research unique. But it has also placed a great weight of responsibility on the author to carry out in an ethically correct and culturally sensitive fashion.

It is this last idea that has brought us back to Gosselain's most cutting critique, and the one that inspired the title of the paper referred to here: "to hell with Ethnoarchaeology" (2016).For Gosselain, ethnoarchaeology as it has been practiced has been colonialist, imperial and Orientalist. Beyond even all these failings is something even worse – it has not adequately recorded its data. Gosselains final critique then is that so many studies carried out under the title of ethnoarchaeology have recorded almost nothing other than their final outcomes. There are mentions of interviews, of native specialists ignored by other ethnographers, and even the production of reference collections of tools and other artefacts. With limited records regarding actual interviews, for example, there is little for later scholars to turn to, except either the unconditional acceptance or rejection of theoretical conclusions which today seem hardly justified (224-5). For Gosselain, it is this that is sufficient to jettison the entire product of trying to link ethnographic practice in a broad sense with archaeological questions. The result, for that author at least, is to cede the ground, as it were, to experimental reproduction in the abstract, rather than look for what might remain of 'traditional' production techniques in the 21st century.

But here, such a dramatic capitulation hardly seems justified. Indeed, through careful consideration and planning, meticulous recording, and the presentation of as much data collected as possible, this project has intentionally attempted to preserve as much information regarding traditional skills as could be reasonably achieved, while at the same time subjecting that material to a thorough, cross cultural comparison with a similarly well researched and recorded case study

5.3 Forging Connections: the search for traditional blacksmiths

Finding the smiths was achieved through personal communication with residents in Kerala. From anyone passing in the street to the guest stay owners and museum workers with the author learning some of the local terminologies to aid in this search seeking out anyone and everyone for the information and following leads. Eventually, the people within the village became familiar with the author and became curious and interested in the study. This interest leads the people in the village to begin to seek others for information concerning blacksmiths.

Due to the nature of this type of research, this chapter is written a bit differently than the rest. It is written in a more experiential tone to show the process used in the field used during this research. Most research has other research that has been carried out previously for them to build on. If there is no other research and no previous knowledge, one has to find ways to gain that knowledge. This search or survey to find blacksmiths was conducted the same way that much previous ethnographic research in other areas has been conducted for years. The theory and methodology of this process are discussed in more detail in chapter two.

The search began in Bangalore with deciding where to have the epicentre for the exploration of blacksmiths that would be willing to participate in the research. An area central to Kerala, with valuable links to transport and the possibility of English-speaking people, would be a bonus. This area was desirable as not a lot of information about metalsmiths from this area was known. Due to its central location within Kerala, Kochi had the best potential. Kochi has a long history and reputation as a trade port in South India. Kochi also has a reputation as being highly touristy which would mean good transport and a better possibility for English speakers.

With location sorted out, it was then a decision on where to stay. In India, where an individual is staying can be more than just a place; it is an experience. Carefully deciding where to stay would be vital as this would prove later to be very important when trying to establish relationships with locals. After a long internet search, a local homestay with owners who lived in the area all their lives, run a tourist business, and have a reputation for being very knowledgeable about local neighbourhoods and transportation would be ideal.

The plan at this time was to travel to the homestay and then visit local museums and attempt to find blacksmiths. At this stage, how to find blacksmiths was very unclear. Learning the Malayalam name for a blacksmith, which is കൊല്ലന് or keāllan, pronounced ko-len-a or ko-len, and the word for thank you, which is നന്ദി or nandi would only provide limited feedback, but after all, would prove helpful.

Fresh off the bus from Bangalore, a tuk-tuk was flagged down for the journey to the homestay. On the way to the homestay, through very poor Malayalam, the driver was informed about the exploration in Fort Kochi to find keāllans. He excitedly stated that he knew where one was and proceeded to drive to the location in the heart of Fort Kochi. This smith is described in detail later as blacksmith number 1. After visiting with the smith for some time, it was time to move on. Plans were made with the tuk-tuk driver to travel the next day to some museums and again look for more blacksmiths. At the end of the first day, it seemed that it would be straightforward to quickly find many blacksmiths and document them; this would turn out to be just first-day luck.

The next day, with the same tuk-tuk driver, trips were made to museums to try and find more blacksmiths that were possibly more traditional in the technology they used in practice. It was thought that the people working at the museums would have more information about traditional technologies in the area that they live. Visits were also made to many different shops and retailers, all trying to sell various wares. By the end of the day, not a single smith had been found. Dejectedly returning to the homestay, it seemed the tuk-tuk driver lost interest in the mission. Days passed, alone and still searching and asking as many people as possible about blacksmiths, hopeful that someone would know where to find one - conversing with many people who would talk animatedly with interest and ask many questions, who were very curious about the research and why inquiries concerning blacksmiths were being made, but still no blacksmiths.

Considering a new location after a week and a half with no more blacksmiths found in the hope that better success could happen elsewhere. It started to seem nonsensical to think that a person could just show up in a country that they did not know, did not speak the language of, did not know anyone, and find and meet people for research. Finally, one day after talking with Paul, the owner of the homestay house, there was a lead. He said that they had found a blacksmith close to where his wife's family lived, and that afternoon he would be willing to take me to meet the smith. Paul would make the arrangements for travel and make introductions with the smith himself. Two smiths were documented in Vypin during this trip, and one of the blacksmiths would later participate in further research. After this initial expedition, more trips with Paul were planned to venture out and talk to locals and find more blacksmiths. It is in this way all the blacksmiths in this study were located and documented.

When information on the location of a blacksmith was received, a trip to the site would be made. Upon arrival at the location, after introductions, a series of simple questions would be asked of the smith through an interpreter. These questions were predetermined and on a form that was filled out while in the field. All blacksmiths were asked the same series of questions. This form is found in appendix A.1. Most of the blacksmiths were friendly, eager to help and proud that someone was showing an interest in their job, even if slightly confused as to why. Not everyone wanted to give information, or they were too busy to want to participate. In these cases, information about the forge and its location would be documented with as much information as possible.

During this time, it was discovered that Kerala's tourism website mentioned a town named Kollengode that was known in the past for its blacksmiths (https://www.dtpcpalakkad.com/historic.html). The word Kollengode itself was said to mean the abode of the blacksmiths. If a visit were to proceed, it would take a few hours to reach, and a Temple close by would have festivals at that time of year, which would have many people. The village is close to the border with Tamil Nadu, and it is known for being very hot. After much persistence and lots of discussions, the decision was made to journey to the village and see what could be found. The plan was to leave early in the morning so the traffic would not be too heavy and the day would not be at the hottest. This trip would prove beneficial as several blacksmiths were found, and some of the oldest traditions were still being used and noticeable.

After the initial contact, blacksmiths were then selected for participation in further forging experiments and workplace recording. Along with the experimental work, documentation of local family histories, folk traditions and oral stories relating to blacksmithing were recorded. Relationships to local temples were also documented. A numbering system to keep track of the blacksmiths was created; these numbers are sequential and registered as each blacksmith was first introduced. Out of the 21 blacksmiths in the study, six were selected for the experimental component of the research, two would be formally interviewed, and one temple pujari was also formally interviewed. Detailed information about each smith is given in appendix A, and a table has also been included below in table 5.1. Details on the blacksmiths selected for further research will be provided in the following section.

Table 5.1 *List of blacksmiths and information compiled from first meeting forms.*

Blacksmith	Name	Age	Location	Make Charcoal Used	Bellows Type	Grinding/Sharpening Type	Source of Iron	Sitting While Forging	Sitting While Grinding/Sharpening	Anvil Shape
1	Gabriel	50's	Fort Cochin	No	Electrical	Electrical	Scrap	Yes	No	Square
2	~	~	Vypin	No	Crank	Electrical	Scrap	Yes	No	Square
3	Premanath T.N.	50's	Vypin	No	Double Bellows	Hand	Scrap	Yes	Yes	Square
4	~	Mid-40's	Tirur	No	Electrical	Electrical	Scrap	Yes	Yes	Square
5	Velayudhan K.K.	55	Tirur	No	Yes	Hand	Scrap	Yes	Yes	Square
6	Krishnan Kutty T.P.	72	Tirur	Yes	Crank	Hand	Scrap	Yes	Yes	Square
7	~	~	Thrissur	No	Crank	Electric	~	Yes	No	Square
8	~	50's	Thrissur	No	Double Bellows	Hand	Scrap	Yes	Yes	Square
9	Prabhakaran C.	55	Kollengode	No	Double Bellows	Hand	Scrap	Yes	Yes	Square
10	~	~	Kollengode	~	Electric	Electric	~	~	~	Round

Blacksmith	Name	Age	Location	Make Charcoal Used	Bellows Type	Grinding/Sharpening Type	Source of Iron	Sitting While Forging	Sitting While Grinding/Sharpening	Anvil Shape
11	Subramanian	50’s	Kollengoge	No	Double Bellows	Hand	Scrap	Yes	Yes	Square
12	~	40’s	Kollengode	No	Double Bellows	Hand	Scrap	Yes	Yes	Square
13	Chandran S.	~	Viakom	Yes	Electric	Electric	Scrap	Yes	No	Square
14	~	60’s	Viakom	No	Double Bellows	Hand	Scrap	Yes	Yes	Square
15	~	~	Viakom	~	Double Bellows	Hand	~	Yes	~	Square
16	~	50’s	Viakom	No	Double Bellows	Electric	Scrap	Yes	No	Square
17	Vellappan V.	51	Kollengode	No	Double Bellows	Hand	Scrap	Yes	Yes	Star
18	Murali M.	49	Kollengode	No	Double Bellows	Hand	Scrap	Yes	Yes	Round
19	Kandamuthan C.	61	Kollengode	No	Electric	Hand and Electric	Scrap	Yes	Both	Rectangle
20	Chellapan	72	Kollengode	Both	~	~	~	~	~	~
21	Vanugopal N.P.	63	Tirur	Both	Crank	Hand	Scrap	Yes	Yes	Wester Style

5.4 The Blacksmiths: research partners and blacksmithing specialists

After the initial task of finding blacksmiths, the next stage was to identify those who would be willing to participate in the study and meet a few specific parameters. The parameters were set to find traditional smiths that would resemble what could have been found in the 11th to 12th centuries, which would have been pre-industrial times in this area of India.

These parameters were:

- length of time the smith and his ancestors have been blacksmiths, the longer, the better, looking for smiths who have a long generational blacksmithing tradition
- if they used modern technology (such as electricity for bellows and angle grinders for polishing and sharpening tools), the less modern technology, the better
- if the smith is associated with any temple or temple rituals, especially if such a temple association could produce a recorded genealogy of a smith's family or further information regarding the blacksmithing communities

Details on the blacksmiths specifically selected for the experimental work and that more closely fit within the parameters set above are as follows.

Blacksmith (3): PremanathT.N.

Figure 5.2 Premanath T.N in his forge in Vypin.

Premanath T.N. (fig. 5.2) lives in the area of Vypin, just outside of Fort Kochi. He is associated with the Sree Subrahmanya Swami Temple, the local temple located a short distance down a small road from his forge and home. This smith has a very old double bellow that he says has been in operation for 700 years (replacing parts when they wear out). He does not use electricity at all in his forge work; although he has a power source close by at his home, he sometimes runs a cord for a light to his forge. He says that a lot of the tools he makes are for masonry and woodworking. This smith seemed very busy every time we visited, and he said that he had a steady stream of work. He says that the Sree Subrahmanya Swami Temple owns the land he lives on, and once a year, he forges two different types of knives to present to the temple during the festival. The privilege to forge these objects for the temple was a right passed down to him from his father's father, and so on for about 700 years. Premanath T.N. forged two knives for this research, and a measured survey of his forge area was made (section 5.5a). Interviews about the artisan's relationship to the Sree Subrahmanya Swami Temple were conducted with the Pujari of the temple (section 5.7.2) with full transcripts in appendix A.5.

Blacksmith (5): Velayudhan K.K

Figure 5.3 Velayudhan K.K. holding a ceremonial sword he was repairing.

Velayudhan K.K. is a smith located just outside of Tirur. His forge is set just off the road in front of his family home. This smith had a crank blower for bellows, which also had a bicycle wheel attached to it to aid in the smoothness of the crank. He does not use any electricity for any of his forge work. He is not involved with any local temple but is frequently asked by customers involved in temple festivals to repair or forge swords for the temple festivals (fig. 5.3). This smith also had a small family shrine between his forge and home that he would worship at regularly. For this study, Velayudhan K.K. forged a knife known locally as a Vettu Kathi, an object that he said he forged a lot and was accustomed to making. Also, he had a friend, Mani A. P., sit in to crank the bellows for him while he worked for the forging experiment.

Blacksmith (6) Krishnankutty T.P.

Krishnankutty T.P. is around 85 years old and has been forging in the area of Tirur since he was 15 years of age (fig. 5.4). He comes from a long line of smiths who have all been in the Tirur area. He does not use any electricity for his forge work but does have more modern crank bellows. He specializes in a particular knife from the area, known as the *Malappuram* knife and a particular door lock called *Manichitra Thazhu.* This is what he primarily works on now as he is getting older, and it is becoming more difficult for Krishnankutty T.P. to work long hours in the forge. For this research, Krishnankutty was not asked to forge any objects. Still, a formal interview was conducted and recorded as he was a good source of information about the blacksmithing past of the area. This interview will be discussed further and can be seen in full in the appendix A.7.

Figure 5.4 Krishnankutty T.P. During the interview at his home.

Blacksmith (9): Prabhakaran C.

Prabhakaran C. is around 55 years of age and is located off the main roadway to Kollengode (fig. 5.5). He has a small thatch hut off the road, situated next to a toddy shop. He has no electricity in his hut and uses double bellows that he has a long wooden handle attached to so he can operate on his own. He said that he had been smithing in that location for about 40 years. He is from a long line of smiths and is related to most of the other smiths in and around Kollengode in some way or another. He said that a lot of his work was from sharpening tools and making tools for tree chopping and sickles. Prabhakaran is part of the local blacksmith temple and said that his door was facing towards the temple, so he could see the temple while he worked. Prabhakaran was asked to forge a new style sickle and a knife for chopping trees for this research. A complete survey of his forge was conducted as well.

Figure 5.5 Prabhakaran C. in his forge in Kollengode.

Blacksmith (11): Subramanian

Subramanian located in Kollengode (fig. 5.6). He is around 50 years of age. His forge is a little farther off the road, along a small dirt path behind a few buildings on the main road. This forge is also made of thatch and is the largest of the blacksmith huts we found in Kollengode. He has no electricity in his forge and is part of the local family of blacksmiths. He also makes swords for the family temple and tools for the surrounding tea plantations in the mountains. His forge is about 80 years old, and he had an area set up in his forge just for sharpening tools. Subramanian is also responsible for the puja at the old family temple. For this study, he forged a knife known locally as a *kayatta karude kathi*, and a complete survey of his forge was also conducted (section 5.5).

Figure 5.6 Subramanian working in his forge in Kollengode.

Blacksmith (13): Chandran S.

Figure 5.7 Chandran S. discussing the forging of the object he is working on.

Chandran S. is around 50 years of age and located in the area of Vaikum (fig. 5.7). This smith does not fit into the parameters initially set for blacksmiths due to the comparatively modern technology in his forge. He uses electrical bellows and angle grinders. He even has a homemade power hammer that he constructed himself. He was selected to participate due to the unique tools that he forges. Chandran is a member of a family that owns three elephants that are maintained for temple festivals. He only forges items needed for the elephants' upkeep, creating items such as chains, toenail cutters and knives for cutting palm leaves for elephant food. These are tools that were not seen being made at any other location and, it is for this reason, Chandran was selected for the study while it is true that other smiths could forge these tools. For this study, the need for the smith to be familiar with the forging of the object was essential. If the blacksmith is not familiar with the item, it could affect the time it takes to forge and the expenditure of the material used in the forging process, such as charcoal and possibly the iron supply.

Blacksmith (17): Vellappan V.

Figure 5.8 Vellappan V. in his forge located on the edge of a rice paddy in Kollengode.

Vellappan V. is located in the village of Kollengode (fig. 5.8) and is 51 years old. His forge is situated in a thatched hut at the very edge of a rice paddy. Vellappan was not planned to work initially due to him being located during the second visit to the area. Unlike the other smiths that were asked to participate in the forging experiments in Kollengode, Vellappan's forge was not found on the main road, but the forge was established around the houses of the smiths. He was also part of the large family of smiths in the area and came from a long line of blacksmiths. He was born in the village and has been smithing since the age of 16. He had a double bellow in his forge and did not have any electricity. For the research, he forged an old-style sickle. His forge was not surveyed as the location of his forge was only five years old.

Blacksmith (20): Chellapan

Figure 5.9 Challapan during an interview at his home.

Chellapan is located in the village of Kollengode and is 72 years old (fig. 5.9). He was born in the village and is part of a blacksmithing family in the area. He has been retired from smithing for about five years due to illness and could not forge any objects for the study, but he was willing to sit for a more formal interview about the blacksmithing community of the area (section 5.7). He also had his forge still located next to his house, which was abandoned due to non-use and was very run down; the walls and roof were collapsing. He started smithing at the age of 15 and is from a long line of blacksmiths. The full interview will be discussed later, and transcripts will be found in the appendix A.6.

5.5 Kollengode: the discovery and description of a blacksmithing village

Elavanchery is a small village just southwest of the town of Kollengode but is still considered part of the city of Kollengode by most locals, and they use both names for the location. Elavanchery is a short distance off the main roadway (SH58) between the city centre of Kollengode and Nenmara. With mountains surrounding the area, when the rains come it looks like silver threads adorning the hills, and it is not difficult to comprehend why Kerala is called God's own country. The village has an almost magical effect with the feeling that one has stepped back in time while still being connected to the present with the road links, located in the Palakkad district of the South Indian state of Kerala. The village is 97 meters above sea level and is nestled within the southern part of what is known as the Palghat Gap.

The Palghat Gap, also known as the Palakkad Gap, is a low mountain pass located within the western ghats. The western ghats is a mountain range that runs north to south essentially cutting the south Indian peninsula in half shutting out easy access over land between what is now Kerala and modern Tamil Nadu.

The Palghat gap is thought to have played an important part in ancient trade by opening access between Kerala and Tamil Nadu. Jean Deloche in his article, *Roman Trade Routes in South India*, (2010), Deloche makes a case stressing how the importance of this trade route between east and west peninsular India may have been over-looked. Deloche writes in great detail about the perils of sailing a ship through the Mannar channel between the

Coromandel Coast, or southwestern seaboard, and Sri Lanka. Sighting sand bars, coral reefs, monsoon winds, storms and even the threat of pirates (Deloche 2010: 36).

The main problem though of sailing between India and Sri Lanka seems to have been shallow waters. With ships loaded down with wares this would not be passable and the need to unload goods into smaller vessels to lighten the load would be needed. Then once on the other side of the channel and into the Bay of Bengal they would reload the ship. This would take up much time especially if other ships were traveling through at the time and sailors had to wait to pass (Deloche 2010: 43). If a ship decided they did not wish to chance sailing through the channel between Indian and Sri Lanka, then they could easily sail around Sri Lanka, but again this would take up valuable time.

The other option to get good from the Arabian sea to the Bay of Bengal would be over land and through the Palghat Gap. Deloche argues that in ancient times this would have been the safest, easiest and shortest route (43) this would be the logical way to transport what would have been precious goods that would have held high value.

It is no wonder then that in an area such as this thriving crafting communities would have once been situated. It is obvious that the blacksmithing community in and around Kollengode in the past was much larger and this is why a separate section is needed to discuss the area and importance of the blacksmiths of Kollengode.

Elavanchery seems to be the remnants of a large traditional blacksmithing community. Eight smiths in total have been documented in this area, and it was said that this is a small number compared to the recent past. Three of the forges surveyed and three of the smiths who participated in the study were from this location. One of these surveys was a rundown forge area no longer functioning, but it was the oldest forge seen in Kerala. These smiths use the most traditional technology observed in Kerala, and the forge buildings themselves are constructed of wood posts and palm thatch.

Figure 5.10 Typical forge hut made from palm fronds in Kollengode. Note charcoal drying in the sun.

Most of the forges have no source of electricity close to them, and during this study, generators had to be brought in to help document the work they did. Many of the forges are constructed out of wood posts covered by palm fronds (fig. 5.10). The highly flammable construction material of the buildings does cause issues with fire; one smith said he had to rebuild his forge three times recently due to it burning down. The traditional way of building the forge area is not the safest. More modern materials keep the structure from burning down; some of the smiths within the town prefer the traditional building and continue with this.

The blacksmithing community in Kollengode also had two family temples. One is an old temple that was said, by the blacksmiths, to have been there since their grandfathers' grandfather could remember and a new one that was in the process of being built. It is not uncommon to see small family temples throughout Kerala. Still, the blacksmith temples in Kollengode are a bit larger, and both offer daily pujas in the morning and evening. These temples were surveyed, and a puja was recorded and documented at the older family temple. It is also interesting to note that there are other artisan communities within the area, including potters and carpenters, and each of these had its family temples.

This area has changed a lot due to a major road being built and bringing in more traffic. As work for the smiths declined, they adapted to the need for more work by moving their forges closer to the road. Traditionally, a smith's forge was located in close proximity to the family home, which we still see in other areas of Kerala. Kollengode was the only place where the forge being away from home was observed.

5.6 Measured Surveys and Ground Plans

During fieldwork, four forge surveys were completed, with three of them carried out in Kollengode. Also, two temple surveys were conducted in Kollengode. The findings for these surveys will be covered in this section. All the details of the surveys can be found in appendix A and what follows is a summary of the information gathered. A discussion of the findings can be found in chapter 7.

5.6.1 The Forges

The forge surveys included the layout and measurements within the forge area, but also the smith would be asked to select the tools they used most often or daily, and these were photographed, and the local names for the tools were documented. A survey of all the tools within the forge area would have been a significant undertaking and did not fit into the scope of this research, although this would be a worthy future task. One of these surveys was at a rundown forge that no longer was functional, but it was the oldest forge seen during the fieldwork in Kerala. This rundown forge is the only survey where no forge work was carried out with the smith as the smith is retired due to old age. Most of the forges were similar and differed slightly in the bellows used, either with or without electricity. Almost all of them worked sitting down the whole time, and the layout of each forge differed, but one thing they all had in common was a space located somewhere within the forge area dedicated to a deity, most often with photos and offerings. Upon opening the forge for the day, most of the smiths would make an offering of incense or candle burning or say a prayer for the start of the workday.

(a) Blacksmith 3 Forge - Vypin

The first forge survey that will be discussed is the only one that was located outside of Kollengode. This blacksmith and his forge are situated a short distance outside of Kochi, in a small village called Vypin. The blacksmith that runs the forge is Premanath T.N., and the decision was made to survey his forge due to the contacts with the temple he resided next to and the long record of his family smithing in the same spot. Due to the longevity of this association, it is thought that this could give an idea of the layout of past forges of the area. Premanath is known as blacksmith (3) in the field records, and he forged objects one and two. Premanath's forge is located directly alongside one of the main roads within the village of Vypin. The road leads only to the Sree Subrahmanya Swami Temple that he is associated with. The forge is located in front of several of his family's homes. The road is reasonably busy during the day, and he has installed a tarpaulin attached to wood posts to keep the noise and dust out of his work area but still has a small section of the tarpaulin open like a window, so he can see out onto the road from where he sits as he works (fig. 5.11).

Figure 5.11 Where Premanath sits and works with all his tools close to hand. Note tarpaulins with gap so the smith can see the road as he works.

Inside the forge, he had two anvils which he said when he placed them in the ground, he buried them about a foot deep. It was a round shape to start with, but now after years of use is an odd shape. The other anvil is buried about half a foot underground and is a square shape. The two anvils are placed next to each other and directly in front of the forge hearth. He has a small wooden stool that is very low to the floor that he sits on while he works, and all of his tools are usually within reach of where he is seated. A small wooden pallet like structure with a vice attached so it can be moved around the forge is also a dominant feature.

Figure 5.12 Measuring the double bellows in the forge during survey.

The bellows are double bellows, and they are attached to two posts buried into the ground to stabilize the bellows as they are pumped (fig. 5.12). They are operated via a long wooden pole with a string attached to the back of the bellows, and the other end reaches the other side of the hearth close to where the anvils are located. The wooden pole for the bellows can pivot so it can be worked sitting on either side of the anvils. As with most blacksmith forges in Kerala, he also has ample seating for people to come and chat or wait while they have objects made or repairs done to items they have brought to be fixed.

Vypin Forge

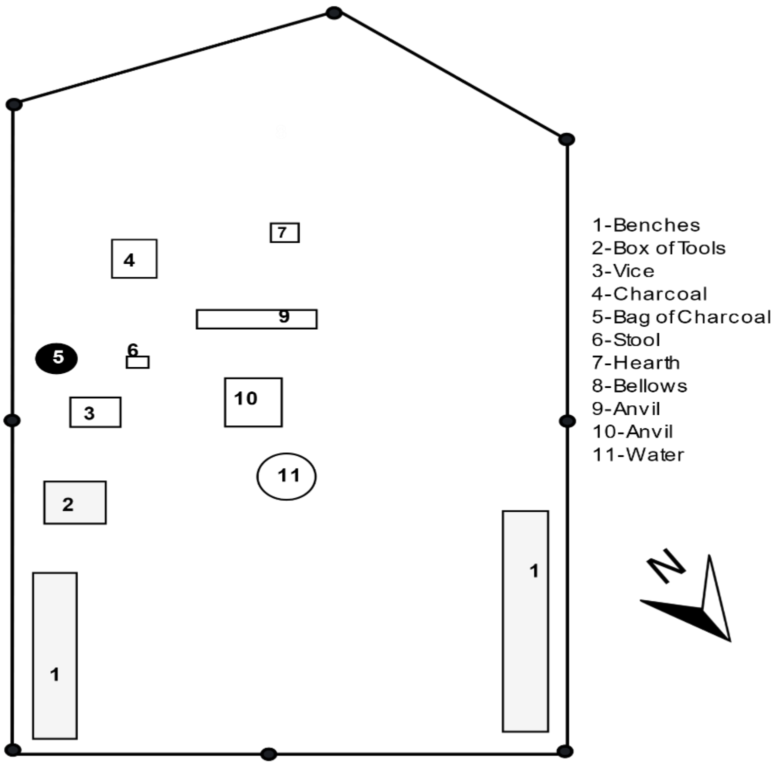


Figure 5.13 Vipin Forge Survey Ground Plan.

*The solid lines are where the 'walls' are located. The walls consist of waist high tarpaulins with iron rods in the ground to secure then to.

We asked Premanath to bring us the tools he used most often while working in his forge and the list and photos that follow is what he provided for us with local terminology for each object in italics. English is used for some names as no local name is used.

Table 5.2 Tools most commonly used while forging according to Premanath.

List of Tools Most Used in the Forge with Local Names			
Koodam		*Achu Irumbu*	
Hammer		*Vettu Irumbu*	
Muttika		*Achu Irumbu*	
Chuttika		*Chintheru*	
Kodil		*Pasha Kol*	
Rough *Aram*		*Pothu Kombu*	

Smooth *Aram*	

In table 5.1, the *Pasha Kol,* in English, a brush, is what Premanath dips into water to cool the iron as needed when working it. The last picture is of what he calls *Pothu Kombu* and is part of a ram's horn. Premanath uses this to burn on the outside of the iron to give it shine and finish the item off. The words in English are words that do not have a different local name. The local names are provided in italics.

Premanath also added the bellows, anvil and his stool which we did not remove from his forging area for photos, which can be seen in table 5.2. Since Premanath's forge has two anvils, images for both are provided. Pictures of those with the local dialect name for each are as follows. Premanath was the only smith to include objects that generally would be considered main items found within the forge, listed in the table below with local names.

Table 5.3 Extra tools added by Premanath.

Extra Tools used in the Forge			
Ula (bellows)		*Ada Kallu* (anvil)	
Ada Kallu (anvil)		*Korandi* *Palaka* (blacksmith stool)	

(b) Blacksmith 11 Forge - Kollengode

This forge is located down a small path off the main road to Kollengode. The forge is owned by Subramanian, who is listed as blacksmith (11) and forged object number eight. Subramanian's forge is the largest out of all the forges we studied and is constructed of wood posts and palm thatch.

Figure 5.14 Subramanian’s large palm hut forge in Kollengode.

The forge layout is rectangular, with the hearth on the opposite side of the door. Of all the forges, Subramanian's was the cleanest, having storage boxes that he kept most of his tools inside and wooden boxes serving as extra seating for customers to sit on. Even with the storage boxes, he still would sit on a small stool to do all of his forge work and would have all of the required tools within reach of his sitting spot as he worked.

Figure 5.15 Subramanian working in his forge.

He had two different workspaces in the forge area, one for the actual hot forge work at the hearth and another closer to the door, which was said was there due to seeing better in the sun by the door. This area was used for grinding and sharpening, and he had another stool that he used for this area and sometimes would place a small mat under the work area. His anvil is a large square block and looks as if it was removed from a large lorry. He had a new set of double bellows with a wooden stick with a chain attached to them and had a chain on the other end for Subramanian to easily reach when he worked. Even though he had new bellows, he kept the old ones leaning against the wall next to the new ones. When asked why he still had the bellows, he stated that they were very old, and he did not want to get rid of them.

The day to start the experimental forge work had been prearranged with Subramanian. On the day he was not feeling well, due to this, it was decided he would only forge one item for the study. When asked about his illness, Subramanian said that he was having problems with his lungs and breathing. He noted that it was a common ailment within the blacksmithing community around him. He stated that it was from all of the smoke they breath in, in the small closed-in spaces.

The ground plan to follow is Subramanian's smithy. As with all of the smiths, we asked Subramanian to bring us the tools he used most often while working in his forge and a chart with photos and names follow the ground plan.

1- Bench
2- Box of Tools
3 & 4- Water Buckets
5- Bag of Charcoal
6- Lose Charcoal
7- Bellows
8- Old Bellows
9- Stool
10- Hearth
11- Anvil
12- Scrap Iron
13- Bench
14- Box of Tools
15- Bucket of Water
16- Mat
17- Stool

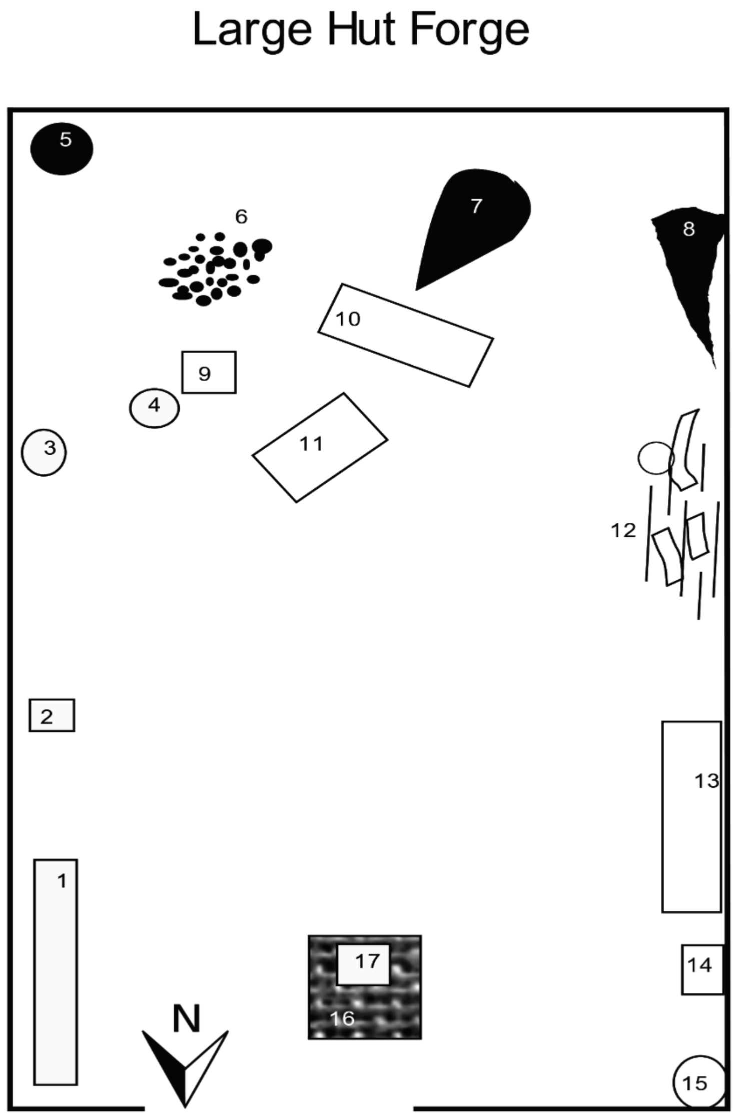
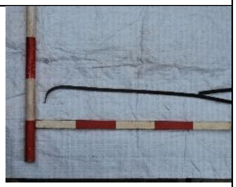
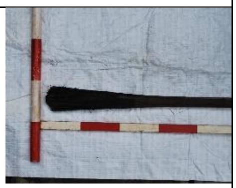
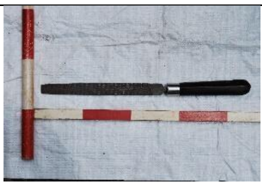
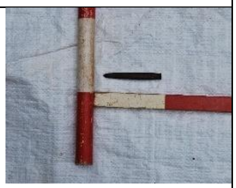
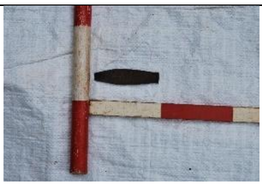
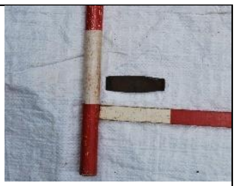
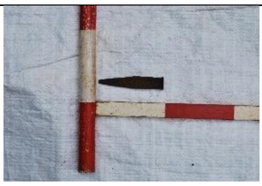


Figure 5.16 Ground plan for large hut forge in Kollengode.

*The solid line is where the walls are and the gap in the walls is where the door is.

Table 5.4 Tools most used in Subramanian’s forge.

List of Tools Most Used in the Forge with Local Names			
Koodam		*Kodil*	
Muttika		*Kolumbu*	
Chuttika		Scale	
Chuttika		*Axo* Blade	
Kodil		*Chavara Kol*	
Aram		Center Punch	

Washer Cutter		*Vettu Irumbu*	
Vettu Irumbu			

(c) Blacksmith 9 Forge - Kollengode

This forge was the first that was found in the Kollengode area during fieldwork. The forge itself is a small hut directly off the main roadway. This forge belongs to Prabhakaran C., also referred to as blacksmith (9) and forged objects four and seven.

Figure 5.17 Prabhakaran's palm hut forge by the main road in Kollengode with charcoal drying after a storm.

The forge is built out of wood and palm thatch, and the roof slightly inclines towards the back of the building away from the door, causing the ceiling in the front to be somewhat higher than the back (fig. 5.17). This building is one of only two buildings located at this part of the road, the other building right next to the forge is a toddy shop.

Figure 5.18 Prabhakaran sitting in his forge. Notice the barrier between were visitors sit and the work space.

Prabhakaran was the only smith that had a distinct separation between the forging area and an area where customers would sit with wooden barriers up on both sides of the forge to separate the two areas (fig. 5.18). The work area is minimal and cramped with bags of charcoal and scrap pieces of iron. Prabhakaran also proudly stated that his door and work area is situated facing the family temple, so he can see this as he is working.

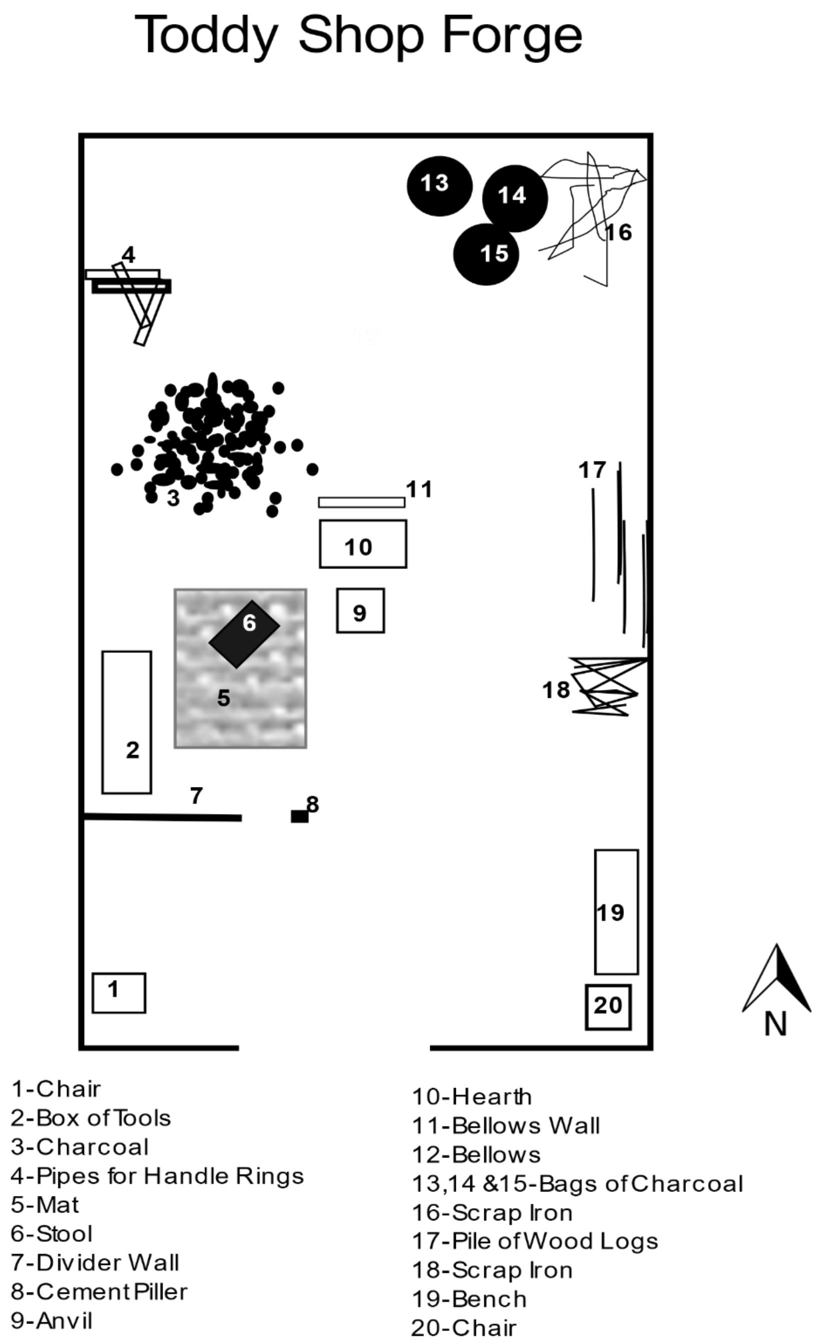
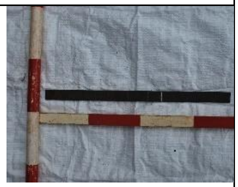
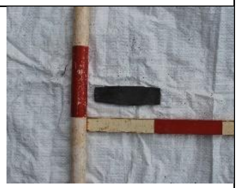
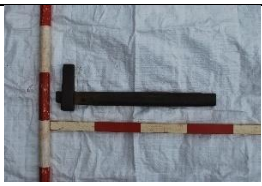
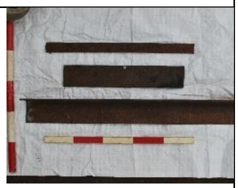


Figure 5.19 Toddy Shop Forge Ground Survey.

When asked to bring us the tools he used most often while working in his forge Prabhakaran was the only smith to include charcoal and the scrap iron he works within the assortment of items. The list and photos of the items he provided for us with local terminology for each object follow.

Table 5.5 Tools most used in Prabhakaran's forge.

List of Tools Most Used in the Forge with Local Names			
Koodam		*Alavu Kol*	
Kodil		*Vettu Irumbu*	
Muttika		*Axo* Blade	
Chuttika		*Koduval*	
Chuttika		*Leaf, Patta, Langle*	
Muttika		*Valayam*	

Aram		*Mara Kari*	

(d) Blacksmith 20 Forge - Kollengode

This smithy survey is different from the others as this was a forge that had been abandoned three years prior by the smith due to failing health. The owner of this forge is Chellapan, who is also referred to as blacksmith (20). Chellapan did not do any forge work with us but was interviewed. This will be covered later in this section. The forge itself was located next to Chellapan family home and next to the new family temple. He stated that he did not explicitly close the forge but that he just shut the doors and did not go back to work. When asked about the missing tools used in the forge, he stated he did not know what happened to them and that someone must have taken them.

Figure 5.20 The remains of Chellapan's forge.

Chellapan's smithy today is not much to look at (fig. 5.19), once built with two concrete beams, bamboo poles and palm thatch. Now the door is gone, and most of the thatch has fallen away, leaving a shell of a forge. The bellows have been carefully covered, and the anvil remains along with the stool that he sat on while working for many years.

Unlike the other surveys, this forge could not be recorded entirely due to the state of the building. The survey was conducted so that comparisons could be made as Chellapan had not changed anything and tried to preserve the location of the items located in the forge. Also, Chellapan has a long history of blacksmithing in Kollengode, so it was thought that his forge would be representative of forges in the past.

Figure 5.21 Chellapan sitting on his porch surrounded by photos of his younger years.

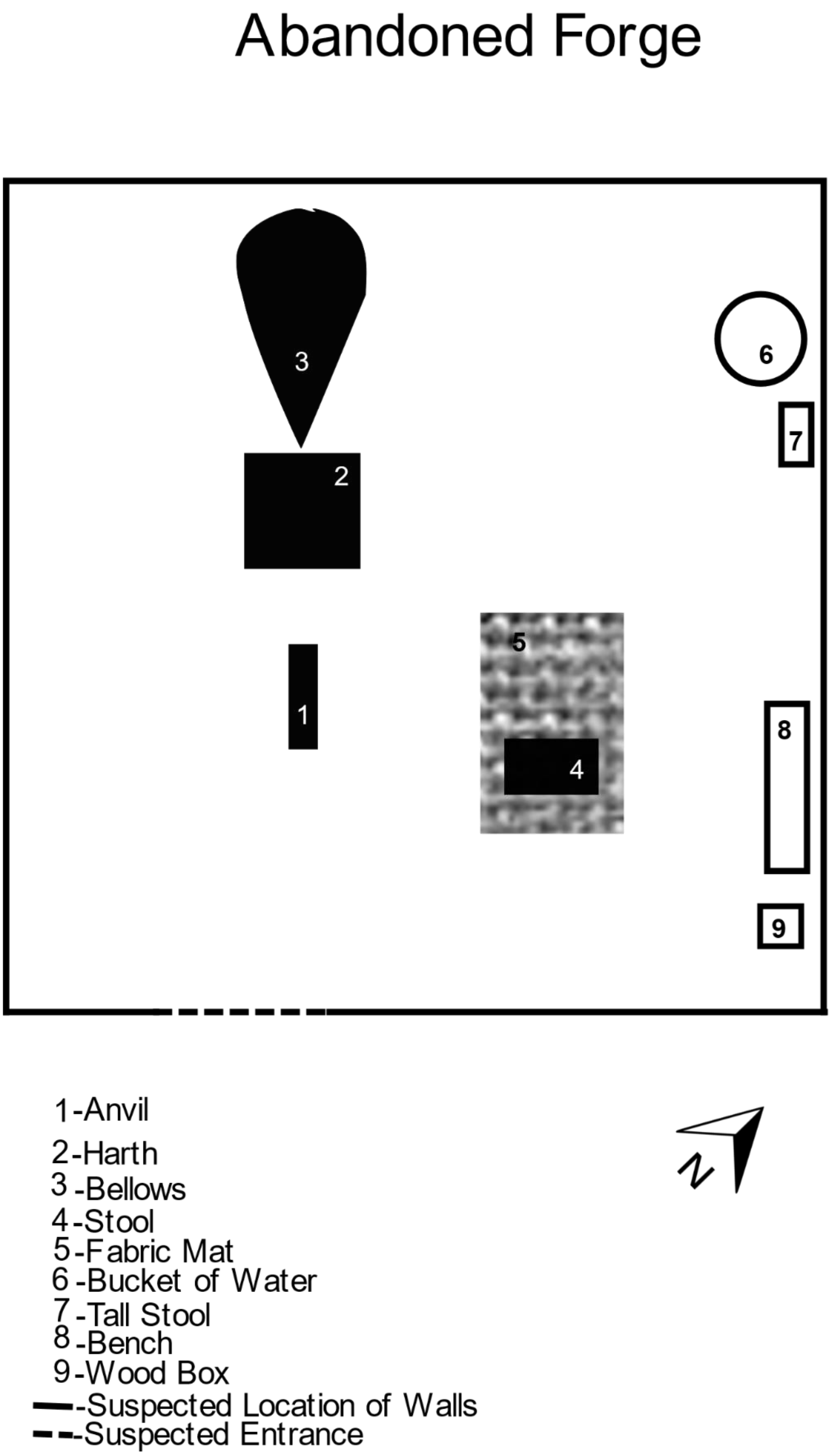


Figure 5.22 Abandoned forge ground survey map.

5.6.1 The Temples

In Kollengode there is no denying the connection between smith and temple. Many of the smithing families were responsible for the upkeep and care of the family temple, and as in the case of Subramanian, blacksmith (10), he was even responsible for conducting the puja for the temple, morning and night. Prabhakaran C., blacksmith (9) another smith located in Kollengode was unable to work for a few days due to him going on a pilgrimage to another temple, which he took very seriously. The everyday life in Kollengode, as in many parts of India, was surrounding the running of the temple, and of faith through action of everyday life. Many of these workers would have been brought to the area just for the temple building, so it is not uncommon to find remnant crafting communities in and around large temple complexes. These crafters have a long history in the area just like the temple.

During fieldwork in Kollengode, we were given the opportunity to survey two-family temples, one old, the other in the process of being built. This part of the study includes being able to document the layouts of the two temples and record the different deities and offerings being made to them. The aim was to understand this practice in small villages and offer an account or small snapshot of the importance of daily religious life in this area of Kerla.

New Family Temple (Temple 1)

The newer blacksmith temple in Kollengode is being is still in the process of being built (fig. 5.23), and the deities are housed in a temporary building. It was decided that it might be a good chance to compare the two temples, so we also surveyed this location and documented the deities. This temple had three smithies in very close proximity, and distances to these in the study of the temple is included. The deities associated with family temple one were Murkan, Parmashaury and Mahavashnu.

Figure 5.23 Family temple 1 lit up at night with candles.

These temples have been in use for many generations, so the term family is a broad term. The temples started as being for one family unit, and as the family grew, so did the people associated with the temple. All the blacksmiths in this area say they are all part of the same family that started the original temple.

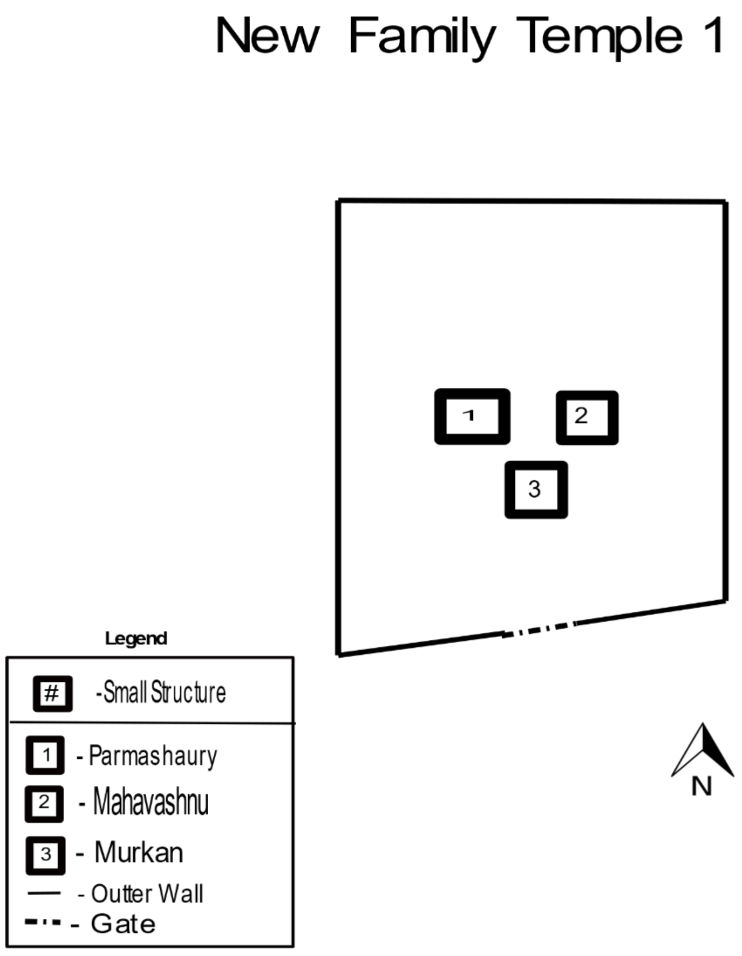


Figure 5.24 Family temple 1 ground survey map.

Old Family Temple (Temple 2)

While visiting the oldest family temple and talking to the caretakers, we were granted permission to survey the temple and record the evening puja that afternoon. While conducting the survey, it was discovered that a woman is buried at the location. Thambatty Muthi is the woman's name. It is not known how long Thambatty has been buried at the site, but most people said for a very long time, or shortly after, the blacksmiths moved to the village. They say Thambatty was responsible for building the temple and was buried at the temple as the locals venerated her before her death. Now people of the village come to pray to her, and she is part of the daily prayers carried out in the temple. Next to where Thambatty is buried is a small shrine (fig. 5.25) dedicated to a male friend of hers who is said to have assisted her in building and maintaining the temple.

Figure 5.25 Shrine to Thambatty's friend.

The main deities of the temple were noted, and the puja was recorded that evening which will be covered later in this section. There were no smithies located at this time around this family temple, but they did say that in the past, there would have been many. When the area began to grow, the smiths needed more room, so the new temple is located on the other side of the area. When the main road connecting the more significant towns was constructed, the smiths start to move their smithy's closer to the main road to gain more work. The deities associated with the old family temple (spellings were provided by the people who attend the temple) are Kanta Karnan (a version of Kanda Karnan), Goddess Loka Parmeshwari, Bogarswamy, Shanieshwaran (Shiva) and Nagaraja (Serpent King).

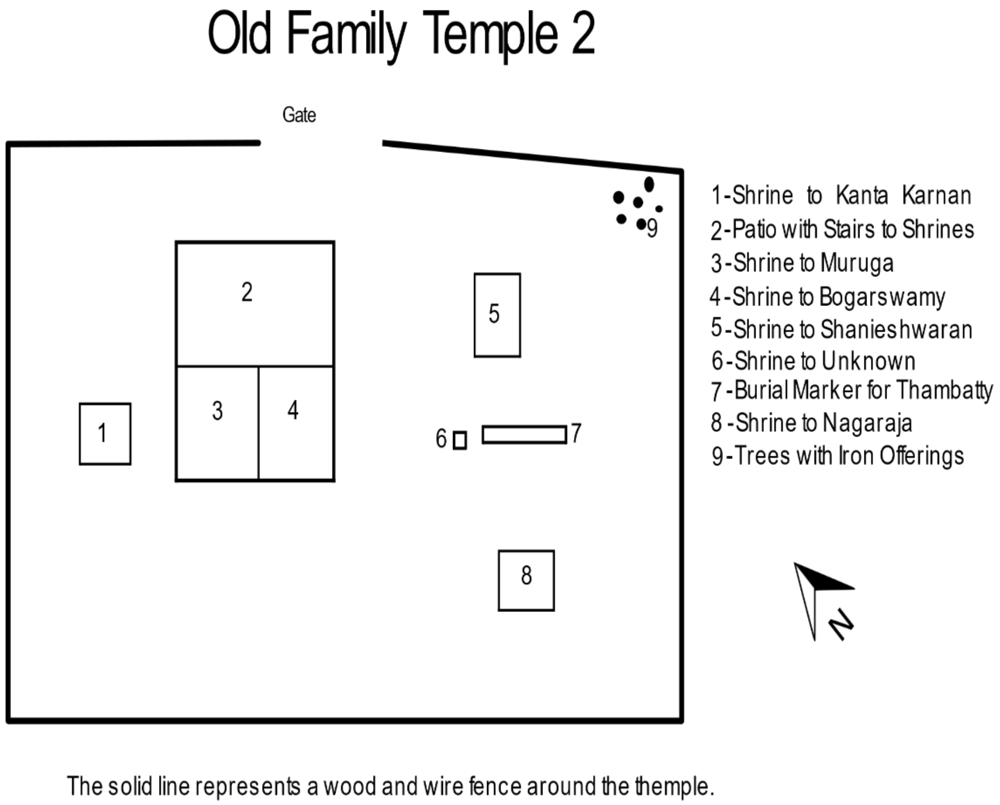


Figure 5.26 Old family temple 2 ground survey map.

5.7 Puja: worship in Kollengode

While we were surveying the old temple, we were also permitted to document and record the family Puja. The puja is usually lead by Subramanian, or blacksmith (11), but he was ill on this day, so he sent his son to come and conduct the puja. His son said that this honour fell to him because he is the eldest son and next to inherit the rights to perform the puja in his father's absence. Full notes on the technical aspects of the puja can be found in appendix A.14.

Figure 5.27 Pujari ringing the bell to signal the beginning of the temple prayers.

The puja started with the pujari ringing the bell (fig. 5.27) outside the main temple shrine to Murugg, followed by opening the doors to first the shrine to

Figure 5.28 Cleaning of the shrines.

Murugg then the shrine dedicated to Bogarswamy. He then cleaned the two shrines (fig. 5.28) clearing the old offerings and wiping the shrine down with a cloth.

Figure 5.29 The oil lamp where Thambatty Muthi is buried being filled and lit.

He then moved to the shrine of Nagaraja, Shanieshwaran and lastly, Kanta Karnan. Once they were all cleared of all old offerings and cleaned, he then went to the shrine where Thambatty Muthi was buried and lit oil lamps (fig. 5.29) and incense at her shrine and the small one located next to her that is believed to be of a male friend of Thambatty. He then

Figure 5.30 Incense being lit at the shrines.

entered the shrine of Murugg and lit oil lamps and incense and did the same in the order he cleaned them. After Murugg, Bogarswamy, Nagaraja, Shanieshwaran and Kanta Karnan at each lighting oil lamps and incense (fig. 5.30). He then stopped at each, saying prayers in the same order that he had cleaned and lit the lamps and incense.

Figure 5.31 Saying prayers at the main shrines.

Before he stepped out of the temple area, he placed the distinctive white mark on his forehead. After, when asked about the order, he chose to clean, place offerings, and pray at each shrine and why he kept the same order each time. He stated that is just the order that they have always done it in and the order that they pray in. When we were there, only one of the other family members came to pray after the puja (fig. 5.31). She followed the same order except that she added prayers to Thambatty Muthi after Murugg and Bogarswamy. She also added the white mark to her forehead and took some of the chalk and rubbed this on her lower right leg (fig. 5.32). No one else came to pray while

Figure 5.32 Following the same pattern as the Pujari offering prayers to each shrine.

we were there. This could have been due to shyness as many of the people that were in attendance watching us as we worked. An in-depth discussion about the actions and meanings of the small family puja will follow in chapter eight.

5.8 Interviews: shared knowledge from blacksmiths and a Pujari

This section will deal with the formal interviews conducted during fieldwork. Two were with elderly blacksmiths, both of whom had long family ties to the blacksmithing community they are residing within. Through them, a picture of the past and the changes each region has gone through can be better understood. A formal interview with a Pujari of a temple in Vypin is also presented to understand the connection between the blacksmithing community, the relationships with the temples, and the society that they live within. Full transcripts of all interviews can be found in appendix A.

5.8.1 Blacksmiths

Chellapan of Kollengode

The first interview conducted was with Chellapan in Kollengode (fig. 5.33). Chellapan is 72 years old and is recorded as blacksmith (20). He was born in the village and lived most of his life there, although he did leave for work in Tamil Nadu for a few years. He says that his father and grandfather, as far back as any family member can remember, his family have lived in the village, and they have all been blacksmiths. He has been blacksmithing since the age of 16 and learned his skills from his uncle and other male members of his family. He stated that his father was also a blacksmith and typically would have taught him, but his father fell ill with Hansen's disease when Chellapan was young. He says that one of the significant changes in blacksmithing from when he was young to now is that the iron scrap they received was in large pieces only in the past. Still, now they can buy the pieces in all different sizes and do not have to spend large amounts of time getting the size down to begin working on an object to be forged. Chellapan built his forge, which is located next to his home, in 1971 (fig. 5.34). He said that the

Figure 5.33 Chellapan at his home during the interview.

Figure 5.34 Chellapan when he was younger.

most common objects he forged were the *mullu kothu* or estate knife and the *kada* para, a tool used to dig sand or big holes to plant trees. He said that there were more tea and coffee estates in the area in the past, and they would come to him to forge the knives for the plantations. He states that he cannot remember when bloom iron was used, not even in his father's time. They have always bought scrap iron from the iron sellers. He also states that blacksmithing was more of a communal job in the past and there would have been groups all working together in the forge, where now it is more isolated with only one smith working in a forge. He has always been paid in cash for his forge work, but he remembers his father was paid in rice for the tools he made. Chellapan said he had not been working for the last 3 to 4 years due to becoming ill; this causes him much sadness as he misses the work. He remembers fondly the past work he did in his forge and said they used to sing songs from the dramas he acted in at the local temple. He said one of the favourite songs they would sing was from the drama Raja Harishandra, and he sang some of the songs during the interview before having to stop due to becoming overcome with emotion.

Krishnankutty T.P of Tirur

Figure 5.35 Krishnankutty answering questions during the interview.

The next blacksmith interview was with Krishnankutty T.P (fig. 5.35), who is 72 and lives in Tirur, which is located in the Malappuram district. Krishnankutty is also recorded as blacksmith 6. He was born in the city of Tirur, and he comes from a family of blacksmiths. His forge was to the side of the home he lives in, where he has been for about 12 years. When arriving at Krishnankutty's house, it was filled with his family, sons, daughters and grandchildren, which gave the feel of attending a family gathering, starting with everyone gathering in chairs on the front porch talking and ending with groups photos (fig. 5.36).

Figure 5.36 Krishnankutty's family and the researchers chatting on the porch after the interview.

Krishnankutty stated that he learned the blacksmithing trade from his father and has been working as a smith since the age of 15. His father started him working on handles for fish and vegetable knives and making these knives were some of his first memories in the forge. Krishnankutty attended school up until year seven. Then he went to work with his father, helping him in his forge; being the firstborn with six younger siblings, he needed help.

At 15, when he began working as a smith on his own, the most common objects he would make were carpenters chisels, big tools for cutting stones, coconut climbers' knives, goldsmiths' knives and tongs used by bronze smiths. Today he mostly makes a knife known as the Malappuram knife. When asked what his favourite item to make is, he laughed with a look of, what an absurd question, the said "all of the objects that I make are favourite to me" with a mischievous grin. He then went on to say that the

Malappuram knife and an ornamental lock called a *manichitra thazhu* were now the items he mostly made because he was fond of making them.

When asked about how blacksmithing has changed over the years, he stated that he is the only traditional blacksmith in the area, although there are a few who work with modern tools. He said the most significant change in blacksmithing from when he was young is the tools used in forging work, stating that they had to make big tools by hitting everything themselves in the past. Now they have power hammers. Also, modern machines for grinding and drilling but he still uses old tools and methods. He said that he is one of the few to still use a drill known locally as a *valikunna vaar* (bow drill) to make holes in iron instead of using a modern drill (figure 67). Krishnankutty believes that smithing work was less solitary in the past, stating that they would have two or three people working in one forge at a time. One person would be responsible for the scrap, and one person would

Figure 5.37 Discussing the Malapuram knife during the interview.

work the bellows, and one would do the forging. Today usually, only one smith does all of the work in the forge. He did say that the pay today is better than in the past and that he can get better prices for the items he makes.

Krishnankutty is known locally as the specialist in making what is called the Malapuram knife (fig. 5.37). This knife was used in the past by the local Muslim community, and they would have particular belts that would have a pocket just for this knife to be held in. They would use the blades to cut beetel nuts. Legend of the area states that the wounds inflicted by the knife are more lethal and difficult to heal; they believed that this was due to the metals used in the traditional knife and the craftsmanship of the knife.

Therefore, the Malappuram knife is as challenging to buy as it is to make, and the waiting list to have one made can be long. The blade itself is made from solid vehicle springs and takes about seven days to complete. The knife's handle used to be made from deer horn, but that is illegal now, so the handles are made using rosewood, and they have brass engravings.

When first meeting Krishnankutty, he told a story about a king, a cup and water. He was asked to retell the account during the interview so it could be documented. He said, "The story is that the king asked the carpenter, the blacksmith, the goldsmith, the cobbler and the bronzesmith to make a cup. The carpenter made a cup from wood, the blacksmith made a cup from iron, the goldsmith made a golden cup, the cobbler made a cup from leather, and the bronzesmith made a bronze cup. They were then asked to fill water in the cups they made. After a few days, when the cups were checked, it was found that the leather cup was full of worms. The king then discarded the cobbler clan from the community, and from then on, the cobbler clan is considered to be a lower clan. But now it has all changed."

When asked if he would like to add anything else or had anything else to say, he replied that the new generation was not interested in maintaining the blacksmithing traditions. He stated there were too many hardships and that the pay was too low. This is when the sons became very interested in the conversation and said they see it differently. They remember as a child being encouraged not to try to work in the forge and being told to leave and go to study. They were told to work at school and get a better job. They did not see it as not wanting to carry on family traditions, not liking the job of smiting or not making a lot of money. They see it as being successful in how their parents wanted and taught them how to be and strive to be. They then said that one of the grandchildren has recently shown an interest in the work that Krishnankutty did and that he wanted to learn the trade. So, he will be working with his grandfather, learning the skills that are part of his long line of heritage and

Figure 5.38: Krishnankutty and his family

inheritance. The grandson who is learning the family trade can be seen in (fig. 5.38), directly to the left of Krishnankutty.

Lastly, when asked if he could remember any songs or special celebrations for or involving blacksmiths, he said he did not remember any special celebrations but that they celebrated Onam and Vishnu. Stating that "we used to drink toddy and enjoy."

5.8.2 The Pujari

Premanath T.N. (blacksmith 3) was one of the only blacksmiths studied who still had connections with a large temple complex. His family is said to have worked for the temple for over 600 years. It was decided to interview someone within the temple about their ties to this family and get a little more information about this link between artisans and temples. The temple's office was contacted, and information exchanged, and later that evening, the news that the pujari himself would be willing to give an interview the following day.

Figure 5.39 Pujari Damodara Sarma's family home location in relation to the temple, as seen using Google Maps (Google, 2021a).

Arriving the next morning at the temple, we were greeted by a worker and shown the way to the pujari's home, which is just outside the temple walls (fig. 5.39), in a very old traditional Keralan wooden house that was said to be a few hundred years old. An informal meeting was held inside the home with his family and lots of tea. It was then decided to move onto the porch in the sun to conduct the formal interview.

Figure 5.40 Damodara Sarma sitting on his porch during the interview.

The pujari’s name is Damodara Sarma (fig. 5.40). He is 70 years old, and his official title held in the temple is that of *Oorayma,* which means the owner of the temple. Although the government of Cochin took over the temple in 1905, he still holds this title. The name of the temple is the Sree Subrahmanya Swami Temple, and it is located in Vypin. It is estimated that 2000 families currently worship with them, and they employ 25 people full time. Damodara Sarma said that his duties within the temple were opening the temple, lighting the lamps and taking the diety for the procession around the *Sreekovil* or the sanctum santorum. His family have been the 'owners' of the temple since the temple began around 800 years ago. Although the temple initially was smaller than is seen today. The present temple was constructed 200 years ago.

When giving the history of the temple's founding, he said, "It is believed that the statue of our deity made of stone was originally in Thiruchendur in Tamil Nadu. The statue got damaged, and it was thrown into the sea. The stone statue floated in the sea and reached this place. The statue was installed here, and the temple was erected. The story says that five arrows were shot in different directions, and the arrow which stuck here could not be removed, so the temple was constructed here."

When asked about the main deities and background information on them, Damodara Sarma explained that the temple's presiding deity is Lord Subramanya, also known as Lord Shanmuga or Lord Muruga. Lord Muruga is Lord Shiva's son. Also, Subramanya means a person with complete knowledge of all the Vedas. Mythologically he is the son of Shiva and Parvathy.

It is believed that the Universe had *Devas* and *Asuras* or Gods and Demons. An *Asura* called Tarakasura prayed to Lord Bhrama for immortality and had this wish granted with a condition. That he would only die if a child below six years old kills him. Lord Muruga, when he was under six years old, killed Tarakasura. The philosophical meaning is that by knowledge, one can defeat evil powers. Ignorance can be overcome only by knowledge. In the Hindu religion, every deity has a philosophical background.

Figure 5.41 Location of Premanath's forge in relation to the temple, as seen using Google Maps (Google, 2021b).

When asked about the artisans and how they became tied to the temple, he stated they were brought in from the beginning of construction. Land would be given to the workers by the administrators so that they could live close by to help with the development (fig. 5.41). He said that masons, carpenters, blacksmiths, bronze smiths, goldsmiths and sculptors would have all been used to help build the temple and the items needed within. He also added that the temple would also have washermen and soldiers to protect the people and the temple. The payment made to the artisans would be in land and rice, no coins or money.

Figure 5.42 Nazhi, edangazhi and para vessels from the temple. Nazhi is on the left, edangazhi is in the middle and para is on the far right.

Figure 5.43 Close-up of the details on the para vessel.

They would be paid depending on their job, and rice would be measured in vessels called *nazhi, edangazhi* and *para* (fig. 5.42). To explain the differences in the size of these vessels, he stated that four *nazhi* made an *edangazhi* and ten *edangazhi* made one *para*.

Figure 5.44 Close-up of the details on the para vessel.

Clear as mud. The para vessel had metal details added to the outside of the vessel (fig. 5.43 & 5.44).

Damodara Sarma did not know how many artisans formerly worked for the temple, but today only two work for the temple; the blacksmith Premanath and a carpenter, and that today they are paid in modern money.

5.9 Conclusion

This chapter covered the ethnographic aspects of fieldwork expeditions used to seek out blacksmiths in the central area of Kerala and ask them to forge iron objects to use for further microstructural analysis in a laboratory. During this time, surveys of three functioning smithies and one abandoned forge were carried out, two surveys of temples completed, and a puja documented. Interviews were conducted with two elder blacksmiths who gave insights into the blacksmithing villages of the past. An interview with a Pujari in the village of Vypin was also documented. The temple that the pujari cares for still has members of the original artisan families working for them today. One of the blacksmiths who worked within the forging experiments is connected to this temple. The interview with the pujari was an opportunity to see these ties with temple buildings and how the relationship with the artisan community has changed over the years. All of the surveys and interviews will be the focus of this chapter. The forging of the iron objects will be the focus of chapter 6.

Chapter 6 Forging of Iron Objects

6.1 Introduction

This chapter covers the technical step-by-step methods used to forge the iron objects that were subsequently subject to metals analysis. For each forged object, videos were made to document the process from which detailed notes were taken pertaining to the different steps, such as heat treating, sharpening and polishing, hammer strikes and time in the forge fire. Heat readings, photographs and written notes were taken throughout the forging process. This chapter will give the final values for the various processes. The raw data and notes can be found in appendix B. Each section has a short, written description, an overview chart with the final data, a heat recording chart, local names for tools used with photos, and details of the final finished forged object. For this section, the term forge time translates to the cycle of heating and hammering the iron.

6.2 Object 1VS3 and 2VS3 forged by blacksmith 3

Premanath T.N. (blacksmith 3) was the smith for two objects for this research. This smith is the only one who forged both objects simultaneously because he wanted to conserve materials and time. This means that he forged one object then the next before sharpening and finishing the first. So, with each stage of the process, he completed both objects before moving on to the next step of the process. In this section the processes for object 1VS3 and 2VS3 are presented due to the way the smith forged both. This is not to say that the information for both of the objects cannot be separated to understand each object on its own.

Figure 6.1 Starting piece of scrap (left). Cutting unwanted pieces off the object (right).

Forging description for object 1VS3:

The smith starts with a section of scrap (fig. 6.1), placing it in the fire before commencing the process of heating and hitting with the hammer. He begins by shaping out the handle, then moves to the blade section. The smith uses a chisel to cut away excess iron (fig. 6.1) as he works and goes over the whole object making sure everything is straight and even. Before finishing with forging and moving on to sharpening and finishing, he heats the iron, takes a piece of bull horn and rubs it on the blade section of the object, and the smith does this twice, stating that it makes the iron mild (fig. 6.2).

Figure 6.2 Using bull horn to make the iron mild (left). Using the frayed stick soaked in water for heat-treating (right).

He then moves on to sharpening the object using a file and a rock placed on the ground to prop the object against while filling and using a vice set on the ground for a short time. Once finished with the filing, the smith begins the heat treatment by placing the object into the fire and getting the fire hot. The object is then removed from the fire and quickly plunged into a pile of dirt in the ground; the smith then moves the blade section of the object back and forth under the soil. The smith then dips the sharp area of the blade into the water and then quickly runs a file over the sharpened section. He then takes the object and slowly moves it just above the fire and takes a stick with a frayed soaked in water and uses it to get the blades section wet (fig. 6.2). He then repeats the process one more time, places the object across the water bowl to cool, and states that the object is finished.

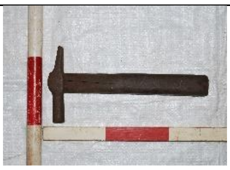
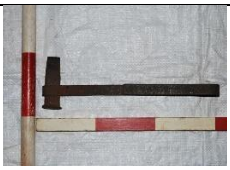
Overview:

Table 6.1 Data summary for object 1VS3.

Summary	
Total time iron was in fire	37m 36s
Work time outside of fire	21m 33s
Time spent heat treating	06m 52s
Total forge time	1h 01m 58s
Total finishing and sharpening time	26m 24s
Total time spent on object	1h 28m 22s
Total hammer strikes	836
File Strokes	1654

Tools Utilized:

Table 6.2 Tool used in forging object 1VS3.

Tools Used Forging Object 1VS3 with Local Names			
Koodam		*Kodil*	
Cheriya Koodam		*Aram*	
Muttika		Smooth *Aram*	
Chuttika		*Thozha Kol*	
Vettu Irumbu		*Chiratta Kari*	

Details of final object: (fig. 6.3)

Local Name of Object: Kathi

Labelled as: 1VS3

Forged by: Premanath T.N. (BS-3)

Location of Forge: Vypin

Date Forged: 22/08/2017

Weight: 316.3g

Dimensions:

1) 33.5cm 2) 4.3cm 3) 5.3cm 4) 1.3cm 5) 10.5cm

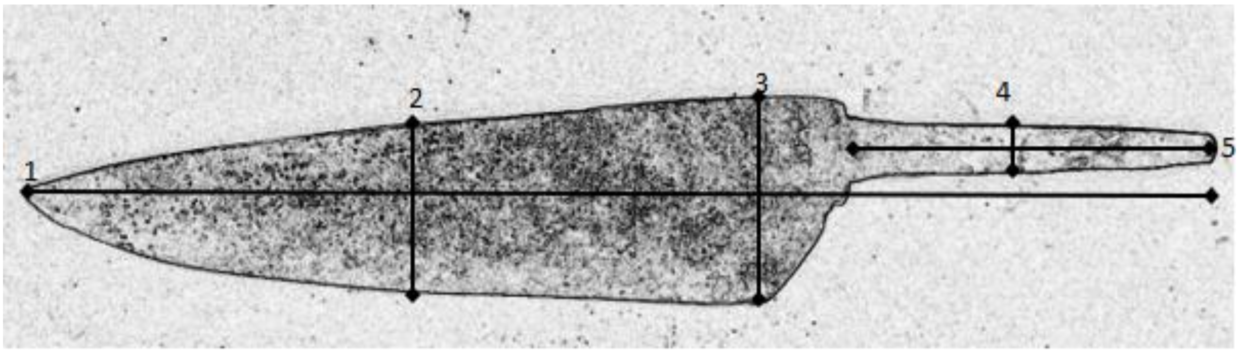


Figure 6.3 Measurements for object 1VS3.

Forging description for object 2VS3:

Premanath started with a new piece of scrap and placed it in the fire. The smith begins the heating and hammering cycle to forge out the object starting with shaping the handle then the blade next (fig. 6.4), cutting away excess pieces of iron as he goes. The smith repeats this process several times before heating the object and then rubs a bull horn up and down the object while still hot.

Figure 6.4 Shaping and spreading the blade section (left) and sharpening the blade with a hand file (right).

The smith now moves on to the sharpening and polishing. The smith uses a rock on the ground to prop the object on while filing (fig. 6.4); he also uses a vice to hold the object during filing. Once finished with the filing, the smith moves on to the heat treating. He begins heating the forge and places the object into the fire. He heats the object to high heat, then plunges the object into loose dirt and moves the object back and forth under the soil (fig. 6.5).

Figure 6.5 Burying the object in the dirt during heat treating (left) and moving object just over the fire during heat treating (right).

He then dips the sharpened blade into water and runs a file quickly over the sharpened area. The smith then slowly moves the object just over the fire, moving it back and forth, heating it (fig. 6.5). He then takes a stick with a frayed end dipped into water and uses it to cool the blade section of the object. He completes this process twice before placing the object over the water bowl to cool and saying he is finished.

Overview:

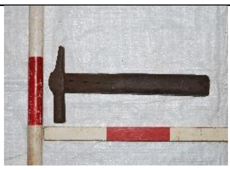
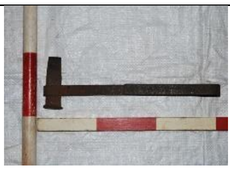
Table 6.3 Data summary for object 2VS3.

Summary	
Total time iron was in fire	17m 45s
Work time outside of fire	21m 28s
Time spent heat treating	02m 53s
Total forge time	37m 54s
Total finishing and sharpening time	22m 08s
Total time spent on object	1h 02 m 55 s
Total hammer strikes	685
File Strokes	1386

Tools Utilized:

Table 6.4 Tools used in forging of object 2VS3.

Tools Used Forging Object 2VS3 with Local Names			
Koodam		*Kodil*	
Cheriya Koodam		*Aram*	
Muttika		Smooth *Aram*	

Chuttika		*Thozha Kol*	
Vettu Irumbu		Scale	

Details of final object: (fig. 6.6)

Local Name of Object: Chiratta Kari/ Cheriya Kathi

Labelled as: 2VS3

Forged by: Premnath T.N. (BS 3)

Location: Vypin

Date Forged: 22/08/2017

Weight: 215.6g

Dimensions:

1) 20.7cm 2) 2.7cm 3) 3.3cm 4) 1cm 5) 4.5cm

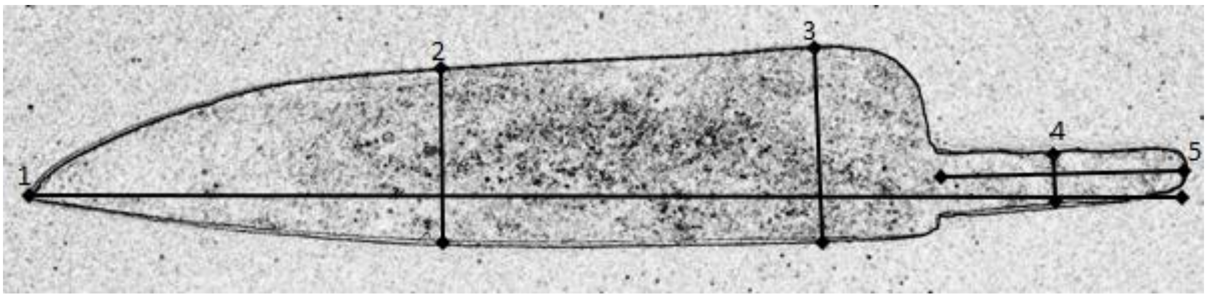


Figure 6.6 Measurements for object 2VS3.

Heat Reading:

Due to the smith forging both items at the same time, the heat readings were recorded together. The highest reading for the forging of 1VS3 is 689.8 Celsius, with temperatures remaining between 450 and 689.8 throughout forging. The highest for the heat treating is 710.9 Celsius. The highest reading for the forging 2VS3 is 795.8 Celsius, with temperatures remaining between 550 and 795.8 throughout forging. The highest for the heat treating is 710.9 Celsius.

6.3 Object 3VS13 forged by blacksmith 13

Forging description:

Chandran S. (blacksmith 13) was the smith for this object. He is the only smith who started forging with the scrap in a preform (already in the shape of a knife). The smith begins with cutting a piece of iron off the preform handle using an angle grinder. He then commenced the forging by putting the iron into the fire and starting the cycle of heating and hammering the object into shape. When finished with the forging, the smith uses a wooden block and an angle grinder to polish, or grind, the object and sharpen the blade. He also cuts two small pieces off of the object, again using the angle grinder. He periodically dunks the object into water while working with the angle grinder on it.

Figure 6.7 Using iron tool and hammer to shape tang (left). Rubbing a wooden block on the object to make the iron mild (right).

The smith returns to forging the object and places it back into the fire. He uses another iron tool to shape the tang of the object by placing the item being forged into a hole on the other iron object and then hammering the object down onto the object being forged (fig. 6.7). The smith continues with the heat and hammer cycle ending with him rubbing a block of wood on the object, which he claims will make the iron mild (fig. 6.7). Then he plunges the object into water. After using the angle grinder and then a hammer to remove a section of the object, he goes back to heating and hammering the object. The smith uses the tool to shape the tang again (fig. 6.7) then plunges the iron into water.

Figure 6.8 Using the angle grinder to polish and sharpen (left) and using a hand file to check heat treating (right).

The smith places the iron back into the fire and uses the wood board to rub all over the object, and place the object to the side of the anvil to cool. The smith then moves to a standing vice, places the object into the vice, and uses the angle grinder to polish and sharpen the object. He removes the object from the vice and uses tongs to hold it, using the other hand to use the angle grinder and continues to work (fig. 6.8). He then places the object into the fire and then plunges the object into the dirt on the ground, and moves the object back and forth, keeping it under the soil. He then dips the sharp section of the blade into water. The smith then takes a file, files the object, and then places it back into the fire (fig. 6.8). He hammers and files the object a few more times, then plunges the object into water before placing it on the anvil and says he is finished.

Overview:

Table 6.5 Data summary for object 3VS13.

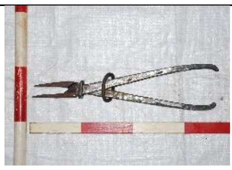
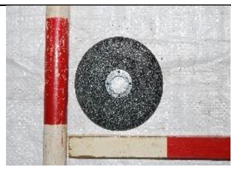
Summary	
Total time iron was in fire	35 m 03 s
Work time outside of fire	51 m 50 s
Time spent heat treating	02 m 58 s
Total forge time	1 h 04 m 55 s
Total finishing and sharpening time	08 m 33 s
Total time spent on object	1 h 27 m 27 s
Total hammer strikes	959
File Strokes	42

Heat Reading:

The thermocouple used did not record temperatures higher than 1400 Celsius; this smith went over that temperature several times. The average forging temperature was between 1100 to 1400 Celsius, with the highest heat-treating temperature of 1023 Celsius.

Tools Utilized:

Table 6.6 Tools used in forging object 3VS13.

Tools Used Forging Object 3VS13 with Local Names			
Valiya Hammer		*Chozha Kol*	
Cheriya Hammer		Angle-grinder	
Kodil		Cutting Blade	
Aram			

Details of final object:

Local Name of Object: Kollengode Kathi

Labelled as: 3VS13

Forged by: Chandran S. (BS-13)

Location: Vaikum

Date Forged: 20/08/2017

Weight: 365.1g

Dimensions:

1) 6cm 2) 6.5cm 3) 23.7cm 4) 2.5cm 5) 6.3cm 6) 2.1cm 7) 8.1cm

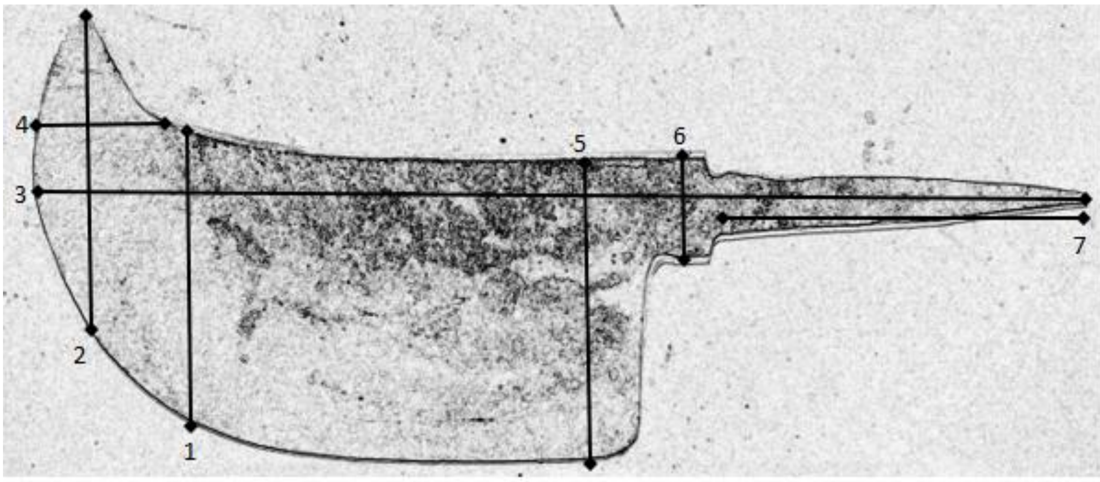


Figure 6.9 Measurements for object 3VS13.

6.4 Object 4KS9 forged by blacksmith 9

Forging description:

Prabhakaran C. (blacksmith 9) begins with a piece of scrap, adding it to the fire to start the forging, heating and hammering. The smith forges the blade section of the object first (fig. 6.10). He uses a chisel to cut off unwanted pieces of iron twice while forging. He works quickly and efficiently, focusing on what he is doing. He uses the large hammer as an anvil to forge a bend into the object (fig. 6.10). He then moves on to the sharpening and filing using a hand file and again using the large hammer as a base to lean the object against while working.

Figure 6.10 Shaping the tip (left). Using the large hammer as an anvil and shaping a bend in the sickle (right).

The smith uses a chisel and small hammer to make small fine marks all along the sharp section of the blade (fig. 6.11). He makes over 500 marks on the blade edge; when finished, he runs both sides of the blade along the

Figure 6.11 Using a small chisel and hammer to make small marks along the blade.

anvil once. He then goes back to filing and sharpening before moving on to the heat treating. He puts the object into the fire, removes the object, takes a file and runs it along the sharp part of the blade. He then puts the whole object inside the water bucket, takes the file, and runs it up and down the sharp part of the blade. He then places the object back into the fire and uses a hammer to finish off the object's shape until he is happy with how it looks and says he is finished.

Overview:

Table 6.7 Data summary for object 4KS9.

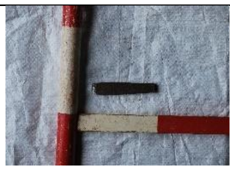
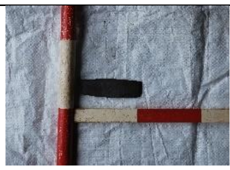
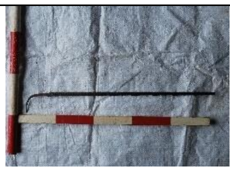
Summary	
Total time iron was in fire	24m 19s
Work time outside of fire	15m 46s
Time spent heat treating	04m 41s
Total forge time	37m 31s
Total finishing and sharpening time	21m 43s
Total time spent on object	59m 36s
Total hammer strikes	1747
File Strokes	739

Heat Reading:

The temperatures while forging started high, with the highest temperature recorded at 1201 Celsius, then staying between 700 to 800 Celsius for the remaining forging time. The highest heat-treating temperature was 705.3 Celsius.

Tools Utilized:

Table 6.8 Tools used in the forging of object 4KS9.

Tools Used Forging Object 4KS9 with Local Names			
Koodam		Scale	
Muttika		*Cheriya Uli*	
Chuttika		*Vettu Irumbu*	
Kodil		*Chvala Kolu*	
Aram		*Kolambu*	

Details of final object: (fig. 6.12)

Local Name of Object: Koythu Arival

Labelled as: 4KS9

Forged by: Prabhakaran C. (BS-9)

Location: Kollengode

Date Forged: 19/08/2017

Weight: 208.7g

Dimensions:

1) 9.5cm 2) 34cm 3) 2.3cm 4) 4cm 5) 3.4cm 6) 1.4cm 7) 10.3cm

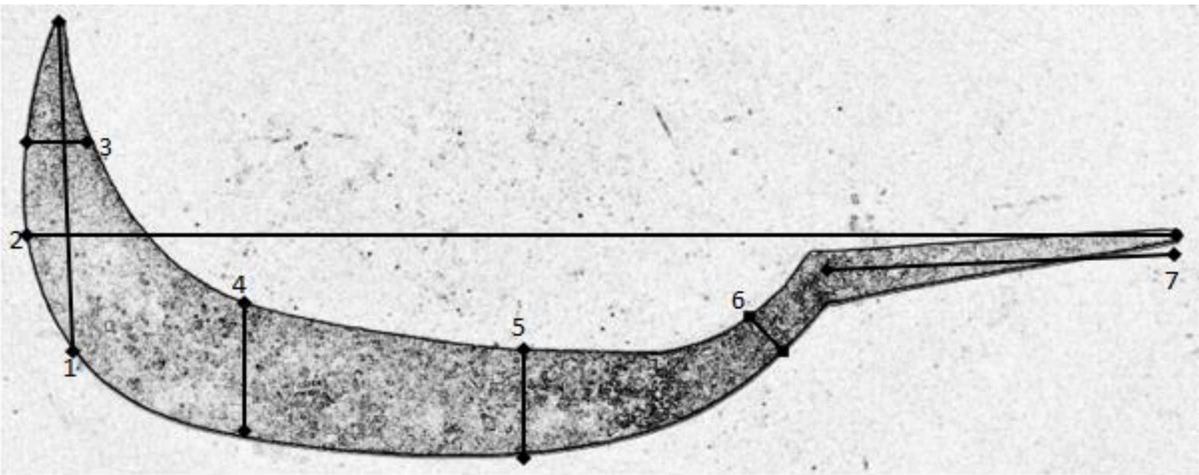


Figure 6.12 Measurements for object 4KS9.

6.5 Object 5TS5 forged by blacksmith 5

Forging description:

Velayudhan K.K(blacksmith 5) is the only smith that had someone working with him while forging. He had assistance running the bellows from Mani A.P. The smith places the scrap in the fire to begin the heating and hammering. He starts by forging the blade section of the object first. The smith uses a chisel to cut away a piece of the iron once during this process. The smith then places a small piece of iron with two holes in it on the anvil and uses a punch to make holes in the object's handle (fig. 6.13). He then sets the object to the side to cool before he begins the sharpening and polishing. Once the object has cooled down, the smith then begins to hammer the iron while it is still cold. He then places two hammers on the ground to prop the object on to start sharpening and polishing.

Figure 6.13 Dipping the blade into water during heat treating (left) and using a punch to make a hole in the handle (right).

The smith then moves on to the heat-treating by reheating the fire; he waits until it is hot and then places the object into the fire, moving the object around directing the heat to the sharpened section of the blade. He removes the object from the fire and submerges the sharpened area of the blade into water (fig. 6.13). He dips the blade in 3 times, then takes a file and runs it over the sharp section of the blade. He then takes a stick of wood that was in the water and rubs the stick on the blade. He then lays the object just over the forge fire and uses the stick to cool the sharp section of the blade again. The smith then holds the object over the fire then fully submerges it into water. He removes the object, looking it over, and begins to sharpen and polish the object more. He carefully inspects the object making minor adjustments, and then sets the object on the anvil and says it is finished.

Overview:

Table 6.9 Data summary for object 5TS5.

Summary	
Total time iron was in fire	09 m 10 s
Work time outside of fire	28 m 58 s
Time spent heat treating	04 m 16 s
Total forge time	51 m 40 s
Total finishing and sharpening time	26 m 12 s
Total time spent on object	1 h 22 m 08 s

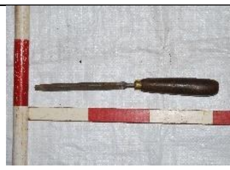
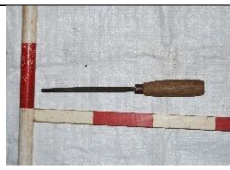
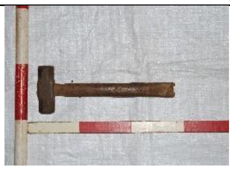
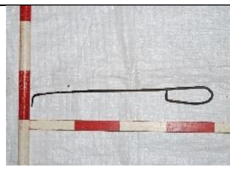
Total hammer strikes	1815
Strikes with iron implement	51
Total Strikes	1866
File Strokes	1742

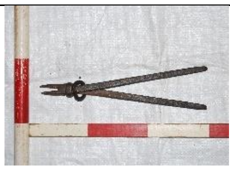
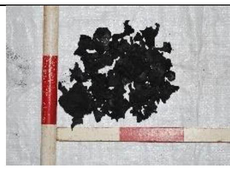
Heat Reading:

The temperatures while forging this object remained between 720 and 829 Celsius, with the highest temperature recorded being 829.9 Celsius. The highest heat-treating temperature was 636.9 Celsius.

Tools Utilized:

Table 6.10 Tools used in forging object 5TS5.

Tools Used Forging Object 5TS5 with Local Names			
Chuttika		*Thricona* *Aram*	
Square *Chuttika*		*Cheriya* *Aram*	
Cheriya *Chuttika*		*Thondi*	

Cheriya Square *Chuttika*		Punch	
Kodil		Iron piece with holes	
Cheriya *Kodil*		*Vettu* *Irumbu*	
Aram		*Chirata* *Kari*	

Details of final object: (fig. 6.14)

Local Name of Object: Vettu Kathi

Labelled as: 5TS5

Forged by: Velayudhan K.K (BS-5)/ Mani A.P. (bellows)

Location: Tirur

Date Forged: 23/08/2017

Weight: 212.4g

Dimensions:

1) 25.2cm 2) 5.7cm 3) 5.3cm 4) 2.8cm 5) 6.3cm

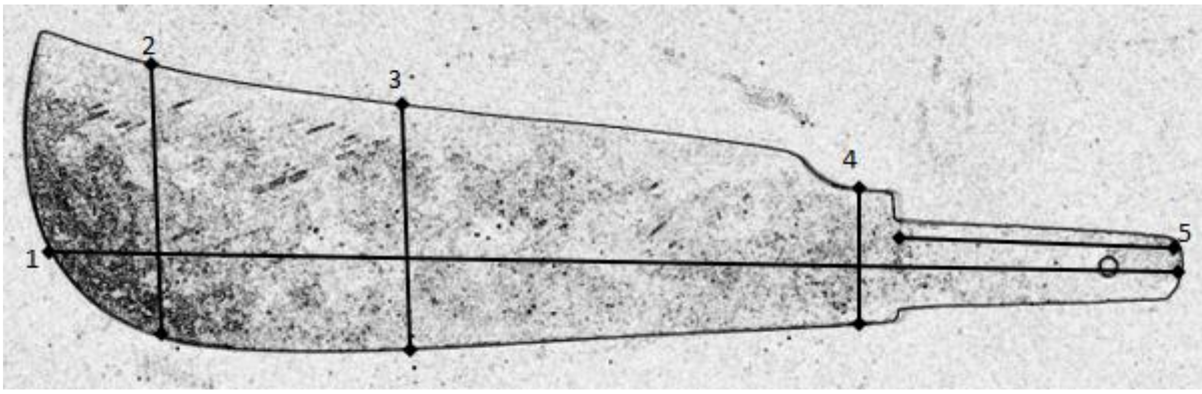


Figure 6.14 Measurements for object 5TS5.

6.6 Object 6KS17 forged by blacksmith 17

Forging description:

The smith for the forging of 6KS17 was Vellappan V. He began work on the object by lighting the fire in the forge using way, then adding a piece of scrap to the fire and then alternating back and forth hammering and heating the object. The smith started with forging the tip (fig. 6.15), then moved on to creating the curve in the blade section and finally moving on to forge the handle. He then set a large hammer on the ground to prop the object on to begin sharpening and polishing (fig. 6.15). When finished with the filing, he moves on to the heat treating by putting the iron back into the fire. When he takes the iron out he then quickly plunges the object into water. He then removes the object from the water and runs a file over it.


Figure 6.15 Forging the tip of the blade (left), sharpening the blade (right).

He then states that he is going to make holes in the handle and picks up a punch. He places the object onto the anvil and uses the punch, hitting it with the hammer and turning the object over to hit the other side of the object with the punch to create two holes in the handle (fig. 6.16). He then inspects the object checking for straightness and hitting it with a hammer again. He then hands the object over and says he is finished.

Figure 6.16 Using a punch to create holes in the handle.

Overview:

Table 6.11 Data summary for object 6KS17.

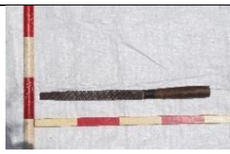
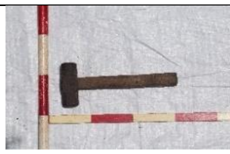
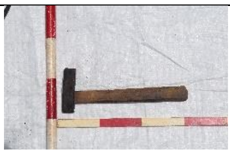
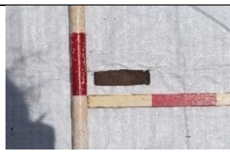
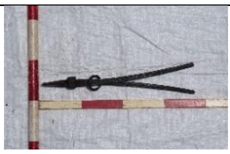
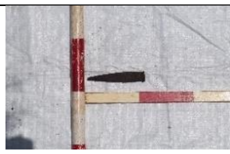
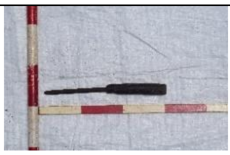
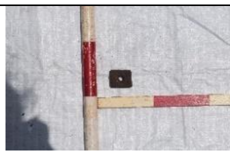
Summary	
Total time iron was in fire	17m 37s
Work time outside of fire	15m 54s
Time spent heat treating	01m 40s
Total forge time	33m 31s
Total finishing and sharpening time	08m 55s
Total time spent on object	50m 36s
Total hammer strikes	1083
File Strokes	702

Heat Reading:

The highest temperature recorded for the forging of the object exceeded the maximum temperature that the thermocouple could record. The highest temperature recorded was +1400 Celsius. The temperatures for the object were high, between 1150 to +1400 Celsius for the first section of forging. Then the temperatures drop a little for the second half to between 900 to 1080 Celsius. The highest temperature for the heat treatment was 888.0 Celsius.

Tools Utilized:

Table 6.12 Tools used in forging object 6KS17.

Tools Used Forging Object 6KS17 with Local Names			
Koodam		Rough *Aram*	
Muttika		*Chuttika*	
Chuttika		*Vettu Irumbu*	
Kodil		Punch	
Smooth *Aram*		*Churul*	

Details of final object: (fig. 6.17)

Local Name of Object: Arival

Labelled as: 6KS17

Forged by: Vellappan V. (BS-17)

Location: Kollengode

Date Forged: 18/08/2017

Weight: 185.8g

Dimensions:

1) 23.5cm 2) 2.9cm 3) 3.8cm 4) 3.4cm 5) 8.7cm

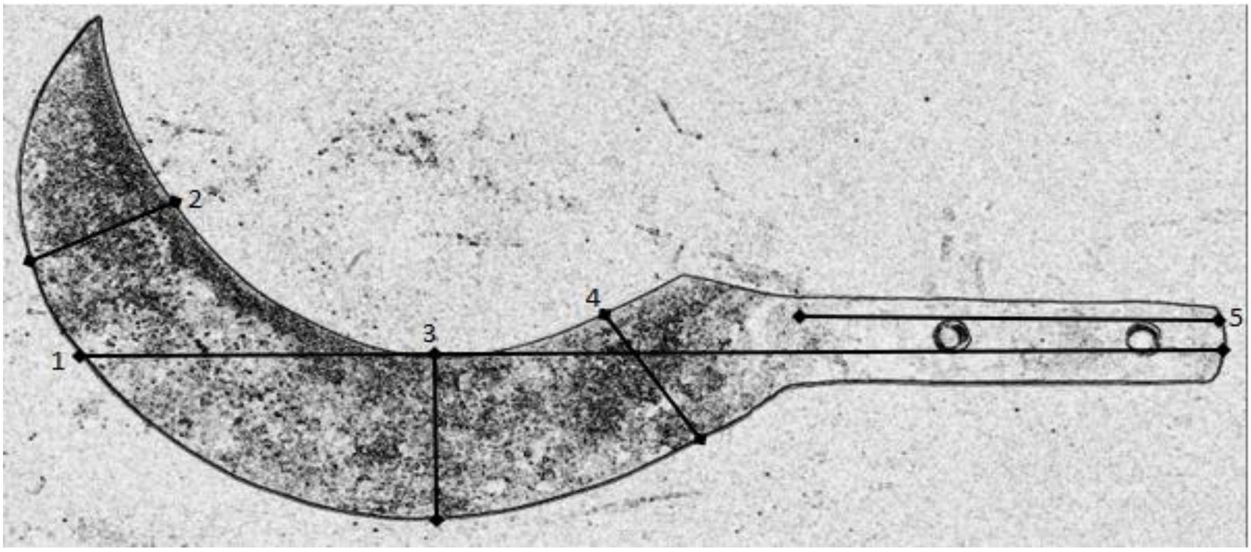


Figure 6.17 Measurements for object 6KS17.

6.7 Object 7KS9 forged by blacksmith 9

Forging description:

The smith forging this object was Prabhakaran C. or blacksmith 9. He begins with a piece of scrap and adds it to the fire to start hammering and heating the object. He first forges the blade section of the object then focuses on the handle using the large hammer several times (fig. 6.18). The smith uses a chisel and hammer to remove pieces of the object nine times during the forging process.

Figure 6.18 Preparing to use the large hammer during forging (left) and using the large hammer to forge the handle (left).

He then moves on to filing and sharpening (fig. 6.19). The smith then picks up a circular piece of iron with a hole inside it and places it on the anvil; he then uses a punch to make three holes in the handle (fig. 6.19). The smith then begins heat treating by placing the object back into the fire. He removes the object, takes a large piece of rock salt dipped in water, and rubs it all over the sharpened section of the blade.

Figure 6.19 Sharpening the blade (left). Punching holes in the handle (right).

He then places the object back into the fire and lets the fire get hot. Then he removes the object and plunges it into water. He looks over the object, makes a few adjustments with the hammer, and sets the finished object down, saying he is finished.

Overview:

Table 6.13 Data summary for object 7KS9.

Summary	
Total time iron was in fire	39m 21s
Work time outside of fire	19m 23s
Time spent heat treating	05m 46s
Total forge time	58m 44s
Total finishing and sharpening time	12m 51s
Total time spent on object	01h 16m 40s
Total hammer strikes	1371
File Strokes	1238

Heat Reading:

The highest temperature recorded during the forging of 7KS9 was 1372 Celsius. The temperature stayed between 620 to 1260 Celsius during forging. The highest recorded temperature during heat treatment was 1270 Celsius.

Tools Utilized:

Table 6.14 Tools used in the forging of object 7KS9.

Tools Used Forging Object 7KS9 with Local Names			
Koodam		*Vettu Irumbu*	
Muttika		*Kolambu*	
Chuttika		*Chavala Kolu*	
Kodil		Punch	
Scale		*Churul*	
Aram			

Details of final object: (fig. 6.20)

Local Name of Object: Kavath

Labelled as: 7KS9

Forged by: Prabhakaran C. (BS-9)

Location: Kollengode

Date Forged: 19/08/2017

Weight: 509.6g

Dimensions:

1) 48cm 2) 4cm 3) 4.3cm 4) 4cm 5) 21cm

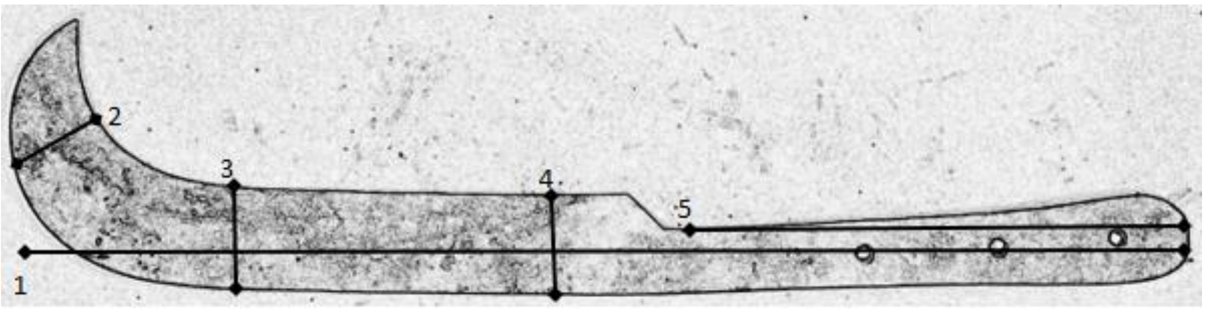


Figure 6.20 Measurements for object 7KS9.

6.8 Object 8KS11 forged by blacksmith 11

Forging description:

Subramanian was the smith that forged 8KS11. He began with a piece of scrap and placed it in the fire to start the hammer and heat cycle of forging. He forges the blade section of the object first then forges the tang (fig. 6.21). He uses the chisel and a hammer twice to cut off unwanted portions of the object. The smith then begins the sharpening and polishing. For this, he moves towards the door of his hut and uses a stone to prop the object on (fig. 6.22).

Figure 6.21 Drawing out the tang while forging (left). Creating the curve in the handle (right).

He then moves on to heat treating the object. He puts the object into the fire; when he removes it, he takes a rag soaked in water and dabs it up and down the sharpened section of the blade. He then puts the object back into the fire, and when he removes it, he plunges the whole object into water. He then takes a bamboo brush and runs it all over the object. The smith then places the object just over the fire and moves the object around, directing the heat to different areas. He removes the object from the fire and runs a file across the sharpened section. He inspects the object and uses a hammer to make some adjustments before he says it is finished.

Figure 6.22 Hand filing and sharpening.

Overview:

Table 6.15 Data summary for object 8KS11.

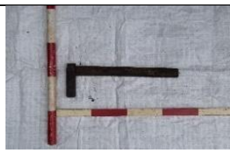
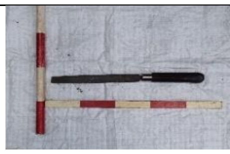
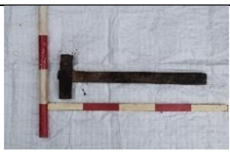
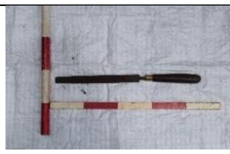
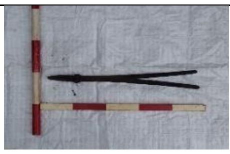
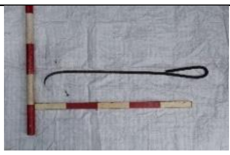
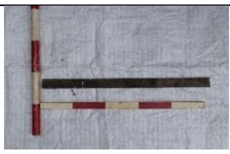
Summary	
Total time iron was in fire	47m 05s
Work time outside of fire	37m 11s
Time spent heat treating	05m 10s
Total forge time	01h 24m 16s
Total finishing and sharpening time	47m 50s
Total time spent on object	01h 47m 18s
Total hammer strikes	1363
File Strokes	1791

Heat Reading:

The heat readings for this object are every minute instead of every second like the rest of the objects forged; this was due to an error with the thermocouple but did not affect the actual heat readings themselves. The highest recorded temperature during forging was 1326 Celsius, and the highest heat-treating temperature was 692.8 Celsius.

Tools Utilized:

Table 6.16 Tools used in forging object 8KS11.

Tools Used Forging Object 8KS11 with Local Names			
Koodam		*Chuttika*	
Muttika		Rough File	
Muttika		Smooth File	
Kodil		*Uli*	
Kolumbu		*Rail Palayam*	
Scale		*Mara thadi*	

Details of final object:

Local Name of Object: Thengu Kayatta Karude Kathi

Labelled as: 8KS11

Forged by: Subramanian (BS#11)

Location: Kollengode

Date Forged: 17/08/2017

Weight: 364.3g

Dimensions:

1) 27cm 2) 12.6cm 3) 7.3cm 4) 9.8cm 5) 45.8cm

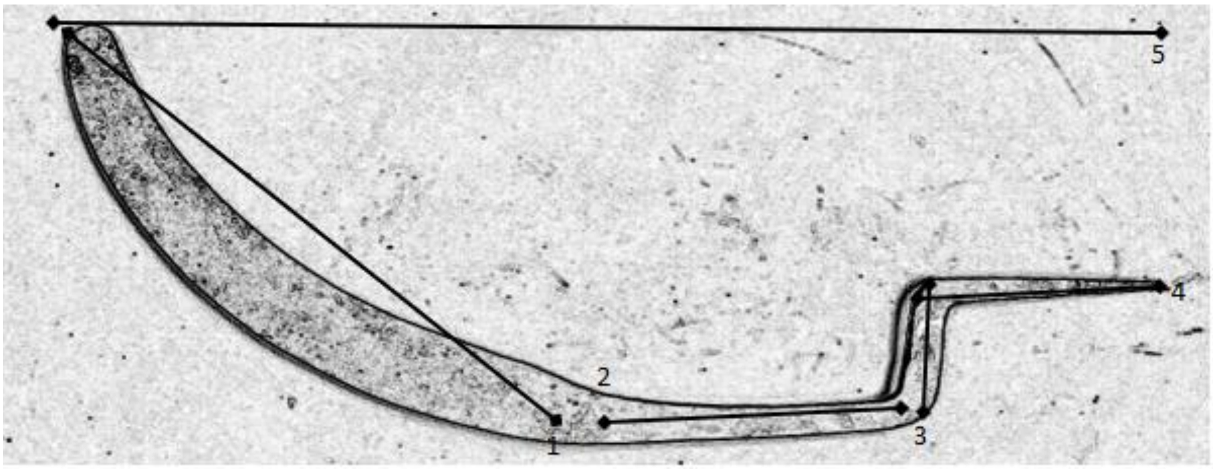


Figure 6.23 Measurements for object 8KS11.

Chapter 7 Micro-structural Analysis

7.1 Introduction

This chapter will provide the information on the means used to prepare the iron samples for the metals specialists. Background information about the specialists and the lab findings they had relating to the blacksmithing of the objects in chapter 6. This chapter will only give the analysis findings that were able to find information pertaining to the blacksmithing technology. The complete object analysis findings can be found in appendix C.

7.2 Metals Specialists

For the metals analysis it was important to find professionals who have a long history and reputations of good standing in the field of metallurgy. It was important for this study to find metallurgists who had a good, long standing reputations within the archaeometallurgy field. It was thought that if standards within the industry were going to be tested and questioned that the results should be from people who really knew iron metallurgy well. In this way it would give the research more clout and give less opportunity for criticism. Initially it was thought that the author would work alongside with the metallurgist specialists while they conducted all lab work. This way the specialist could also teach how they conduct lab work. However, this was unable to happen due to covid restrictions and time constrains within the research time frame. Therefore it was decided that the specialist would conduct the lab work on their own and submit their results to the author. This section will give a brief background of each of the metallurgists.

7.2.1 Brian Gilmour

Dr Brian Gilmour graduated from the University College London's Institute of Archaeology. Since then he has worked for the Royal Armouries and the Tower of London where he was the archaeo-metallurgical researcher. He has collaborated on many academic research projects and publications. He has written widely on ferrous technology of many different locations throughout the world. Dr Gilmour, in association with Dr Peter Northover, wrote many reports and research papers, most notably, Historic England's *Archaeomertallurgy- Guidelines for Best Practice.* Dr Gilmour has also worked for the Research Laboratory for Archaeology and the History of Art, at the University of Oxford for many years.

7.2.2 David Scott

Dr David Scott holds a B.S. in chemistry from the University of Reading and a B.A. in archaeological conservation from the University College London's Institute of Archaeology. He continued his studies with the University College London's Institute of Archaeology and obtained his PhD in ancient metallurgy and shortly after begin teaching at the same university.

In 1987, Scott moved to the United States to take up a job in Malibu California as head of the research laboratory at the J. Paul Getty Museum. In 2003 he left the museum to begin the establish a conservation training program at the University of California in Los Angeles. Department of Art History, UCLA, Los Angeles, and Founding Director, UCLA/Getty Conservation Programme in Archaeological and Ethnographic Materials. He has written over a 100 peer-reviewed papers and many books, including a series on ancient metals that can be considered the seminal work in the field of metallurgical studies.

7.3 Sample Preparation and Lab Analysis Findings

All of the samples that were prepared for this research were cut using a standard Titan tile cutter with a diamond saw and using water to keep the cutting from heating up the iron object. If the iron gets too hot during cutting this can change the molecular structure of the iron samples and render them useless for research. This process is therefore time consuming .

Once the iron pieces were cut they were cold mounted using Buehler EpoThin 2 resin and hardener. They would be mounted the same day they were cut, when possible, then left overnight to set, or cure. Cold mounting in this way aids in preserving the metals microstructural integrity and edge preservation. It also helps with easy of handling. After the resin has set the next step was grinding and polishing.

The grinding was done by hand using different grit levels of sand paper, starting with a course grit and eventually ending with very fine grit paper. It is also important to use a to liquid aid with the grinding, again to keep the metal from getting hot. Once the grinding was finished the sample was polished, this was done with the aid of a polishing machine. A polishing cloth and monocrystalline suspension liquid were used for this process as well.

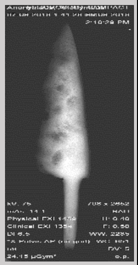
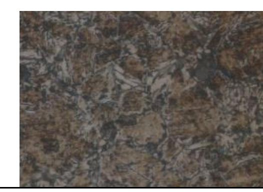
7.3.1 Researcher 1 Findings

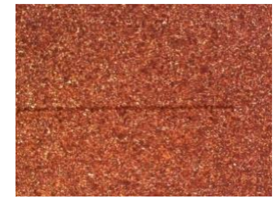
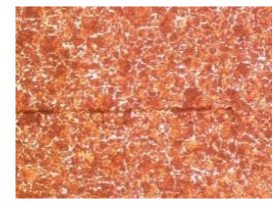
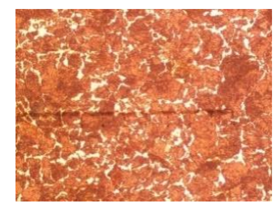
This section will discuss the lab analysis from researcher number 1. It will only discuss objects that were selected to compare with field data. The full list of findings is located in appendix C.

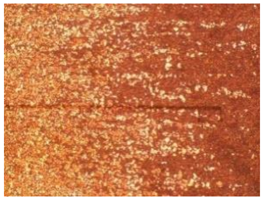
Researcher 1 is the only researcher that was able to complete analysis on all of the samples and sent micrographs for many of the samples. Table 7.1 will give all the details of each object and a short summary will follow.

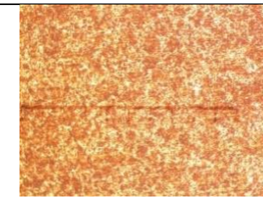
*Details that were not shared with the metals specialists are shaded in grey

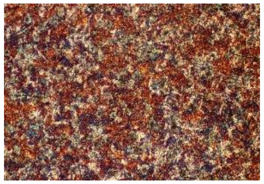
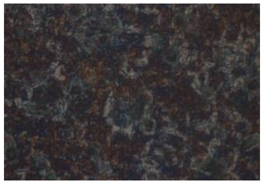
Table 7.1 Researcher 1 analysis findings relating to smithing technology.

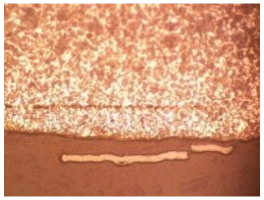
Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description	Image and Magnification	Micrograph
1VS3	Medium Knife			1VS3-1KB		The cutting tip looks like it is not quenched but just rather fine pearlite. The structure further back from this is a very uniform pearlite and ferrite microstructure with more about 0.5% carbon content. It is a good modern steel. Seems to have some directionality to the structure along the length of the section.	1VS3-1KB X 10	
							1VS3-1KB X 20	
							1VS3-1KB X 40	
							1VS3-1KB X 100	

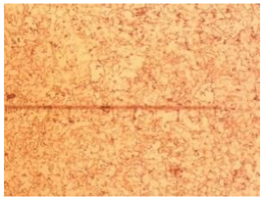
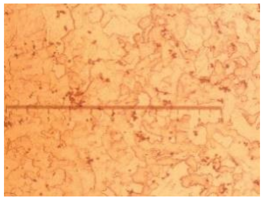
Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description	Image and Magnification	Micrograph
				1VS3-2KB		Fine pearlitic microstructure. Small grain size. Typical modern steel. Carbon content about 0-6-0.7%. The exterior can be seen to be a little decarburized from working or forging while the interior etches to a fine pearlitic structure with about 0.7% carbon content.	1VS3-2KB X 10	
							1VS3-2KB X 20	
							1VS3-2KB X 40	
							1VS3-2KB X 100	

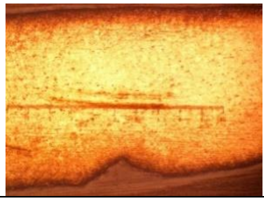
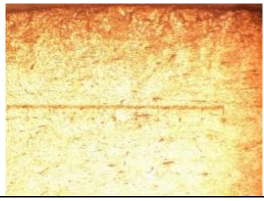
Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description	Image and Magnification	Micrograph
3VS13	Elephant Knife			3VS13-1KB		Very fine structured eutectoid steel blade. Practically 0.8% carbon.	3VS13-1KB X 20	
							3VS13-1KB X 40	
				3VS13-2		Differential structure with the cutting tip being apparently unquenched here (?)...while the rest of the structure is fine ferrite and pearlite. The structure in part may be quenched to produce very fine	3VS13-2 X 20	

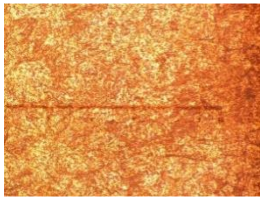
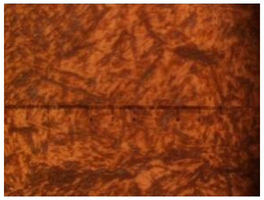
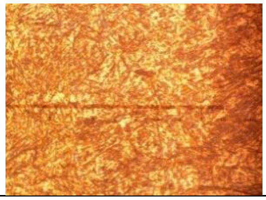
Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description	Image and Magnification	Micrograph
						pearlite microstructure. Directionality is evident in the way the ribbons of the unquenched part of the structure meets up the very fine-grained structure.	3VS13-2 X 40	
							3VS13-2 X 100	
				3VS13-3KB		The low magnification view shows a partially heat-treated edge with blue-etching possible martensite or very fine pearlite.	3VS13-3KB X 10	
							3VS13-3KB X 20	

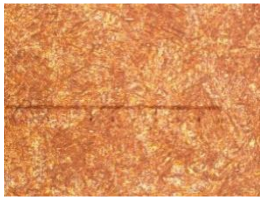
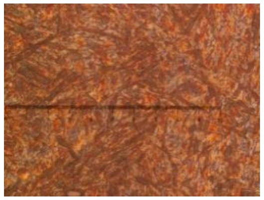
Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description	Image and Magnification	Micrograph
						Higher magnification shows patches of pearlite surrounded by lower carbon areas. At the areas between the different constituents, the areas look as if they have variable carbon content, but not especially high.	3VS13-3KB X 40	
							3VS13-3KB X 100	

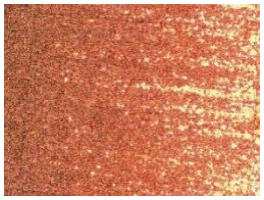
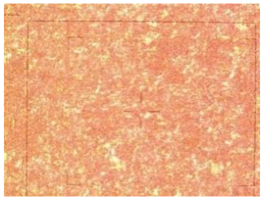
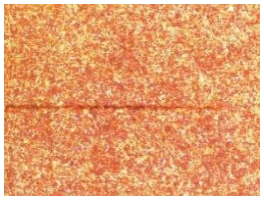
Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description	Image and Magnification	Micrograph
				3VS13-4KB		A decarburized surface zone is quite thick here. The interior is practically a eutectoid steel. The carbon content drops off a lot to the outer surface here, becoming principally ferrite.	3VS13-4KB X 20	
							3VS13-4KB X 40	

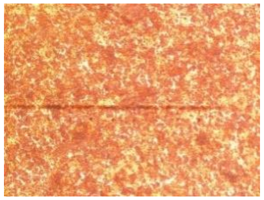
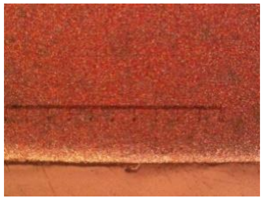
Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description	Image and Magnification	Micrograph
4KS9	Large Sickle			4KS9-1KB		Very fine-textured eutectoid steel.	4KS9-1KB X 10	
							4KS9-1KB X 20	
							4KS9-1KB X 40	
							4KS9-1KB X 100	

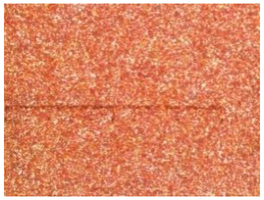
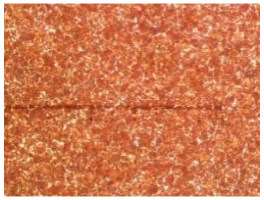
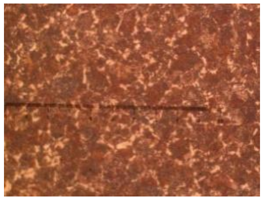
Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description	Image and Magnification	Micrograph
				4KS9-2KB		On etching this sample, the edges have etched quicker than the interior, and looks as if it has a higher carbon content than the interior. The microstructure at high magnification looks acicular as if the material has been heat-treated to some extent. But there is no martensite. Fine acicular pearlitic microstructure.	4KS9-2KB X 10	
							4KS9-2KB X 20	
							4KS9-2KB X 40	
							4KS9-2KB X 100	
							4KS9-2KB X 400	

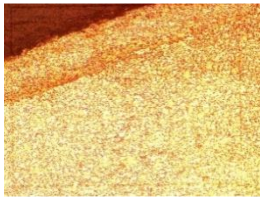
Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description	Image and Magnification	Micrograph
				4KS9-3KB		This sample is of a fine pearlitic steel with about 0.6-0.7% carbon in fine microstructure which looks very uniform throughout as a fine mixture of ferrite and pearlite.	4KS9-3KB X 10	
							4KS9-3KB X 200	
							4KS9-3KB X 1000	
							4KS9-3KB X 2040	

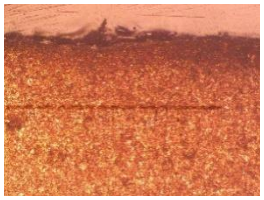
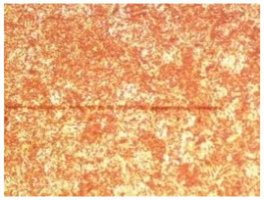
Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description	Image and Magnification	Micrograph
				4KS9-4KB		Almost a eutectoid steel. At x100 the steel has an acicular texture. At x20 the steel has a fine eutectoid microstructure, very even grains, very fine modern steel structure.	4KS9-4KB X 10	
							4KS9-4KB X 20	
							4KS9-4KB X 40	
							4KS9-4KB X 100	

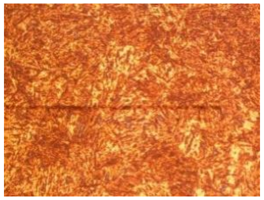
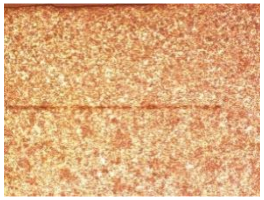
Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description	Image and Magnification	Micrograph
5TS5	Medium Flat Knife			5TS5-1KB		This sample looks as if heat-treated with exceptionally fine dark etching pearlitic structure and meeting up with a transitional zone of possibly high carbon steel. Certainly, these components have been heat-treated to create this microstructure.	5TS5-1KB X 10	
							5TS5-1KB X 20	
							5TS5-1KB X 40	
							5TS5-2KB X 20	

Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description	Image and Magnification	Micrograph
				5TS5-2KB		Fine, slightly coarser microstructure that 4KS9-3KB, has a slight directionality and a fine pearlitic microstructure with larger areas of pearlite which, like many of the samples here cannot be resolved using the eyepiece camera.	5TS5-2KB X 40	
							5TS5-2KB X 100	
							5TS5-3KB X 10	

Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description	Image and Magnification	Micrograph
				5TS5-3KB		Some decarburization along the edge of the sample. The interior is a fine pearlitic steel with about 0,6% carbon content.	5TS5-3KB X 20	
							5TS5-3KB X 40	
							5TS5-3KB X 100	

Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description	Image and Magnification	Micrograph
6KS17	Medium Sickle			6KS17-1KB		Good cutting edge produced with the welding on of an external strip around the core of the lower carbon steel. At higher magnification the join between these two areas can be clearly seen. Like all of these samples so far the microstructure is unlike ancient examples, totally clean and no slag content. The external layer of the blade does not look too different from the underlying steel but has	6KS17-1KB X 10	
							6KS17-1KB X 20	

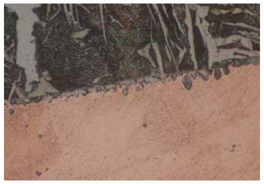
Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description	Image and Magnification	Micrograph
						a slightly higher carbon content. Towards the butt end, the slightly higher carbon content component moves around the back to some extent suggesting that this piece has been made by the welding together of two slightly different carbon steels, the outer edge one being perhaps 0.65% and the internal 0.5% carbon.	6KS17-2KB X 10	
				6KS17-2KB		Fine eutectoid steel with very even grain structure.	6KS17-2KB X 20	

Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description	Image and Magnification	Micrograph
							6KS17-2KB X 40	
							6KS17-3KB X 20	
				6KS17-3KB		Lower carbon steel with about 0.3% carbon content, otherwise similar to other examples here.	No Data	No Data

Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description	Image and Magnification	Micrograph
				6KS17-4		Different from most other samples, this one is principally ferrite. At high magnification, a little slag can be seen together with a trace of carbide. Very close to being a pure wrought iron of ferrite.	No Data	No Data

Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description	Image and Magnification	Micrograph
SL2	Medium “billhook” with Brazed Copper Socket			SL2-1		At low magnification, some decarburization has occurred on one edge, there is a lamination or banded structure of ferrite and pearlite which looks to be unrelated to the direction of working of a point or blade edge. At higher magnification, the ribbons of ferrite can be seen to have some directionality, with fine eutectoid infill. Carbon content about 0.4%. No slag content and no quenching.	No Data	No Data

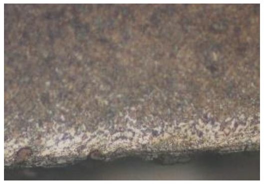
Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description	Image and Magnification	Micrograph
				SL2-2		At low magnification a straited appearance can be seen running diagonally across the blade. No quenching and no slag present. At higher magnification, the structure can be seen to include a great deal of blocky ferrite with pearlite infill, carbon content about O.3 – 0.4%.	No Data	No Data

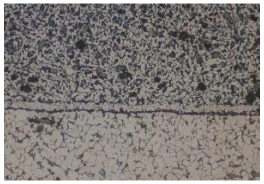
Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description	Image and Magnification	Micrograph
				SL2-3		Good brazed copper surface with no excessive diffusion of iron into the copper. The steel is a lower carbon steel with about 0.5-0.6% carbon and dark etching very fine pearlite. The grain size is noticeably larger than SL3-2 OR SSLS-1. Not quenched.	SL2-4 X 20	
				SL2-4		Brazed copper central strip in join with iron. Dendrites of iron are visible in the copper. Steel is	SL2-4 X 40	

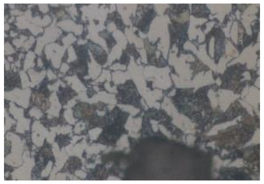
Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description	Image and Magnification	Micrograph
						very dark etching with ferrite at former austenite grain boundaries. Some diffusion of iron into the copper along the join. Partially widmanstatten microstructure with about 0.6% carbon. Perhaps quickly cooled.	SL3-1 X 20	

Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description	Image and Magnification	Micrograph
SL3	Medium “billhook”			SL3-1		Homogeneous carbon steel. No slag. Very even grained. At high magnification can see ferrite at grain boundaries with fine pearlite infill. Carbon content about 0.7%. No quenching.	SL3-1 X 40	

Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description	Image and Magnification	Micrograph
				SL3-2		Good quality carbon steel with less than 0.8% carbon, the carbon content is about 0.7%. No slag content. At X100 the pearlite spacing can be seen in some areas. Clean hypoeutectoid steel. No quenching.	No Data	No Data
				SL3-3		Clean hypoeutectoid steel with no slag content. Carbon content about 0.6 – 0.7% carbon.	No Data	No Data

Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description	Image and Magnification	Micrograph
				SL3-4		Good hypoeutectoid steel.	G3-38 X 100	
				GJ-38		At low magnification this looks like a eutectoid steel which has probably been heat-treated. The structure consists of a mass of interlocking needles, martensitic in effect. Probably 0.8% carbon steel quenched.	GJR-312 X 10	

Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description	Image and Magnification	Micrograph
				GJR-312		A classic sword or blade with a high carbon steel central core. Towards the cutting edge this section goes down to a high-carbon edge and one low-carbon side, while in the central region the high-carbon steel strip is sandwiched between the two low-carbon sides. The outer, low-carbon outer surfaces are typical wrought iron with slag stringers, has no carbon content and is very soft. There appears	GJR-312 X 20	

Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description	Image and Magnification	Micrograph
				GJR-312		to have been some diffusion from the higher carbon central strip as a little pearlite can be seen in the area of the weld. There is a weld line passing along the join which may be sue to some segregation during the heating and joining of the components. The inner steel core etches very fast towards the cutting edge showing that it has been heat treated in this area and has a martensitic	GJR-312 X 100	

Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description	Image and Magnification	Micrograph
				GJR-312		aspect. Further back from this edge, ferrite begins to appear in this core and the carbon content is about 0.5 – 0.6%. So in the manufacture, a wrought iron with typical slag content has been welded to a medium carbon steel central strip, with very little slag content, showing that the fabrication technology of these two components is quite different.		

Observations on Analysis

Objects from Kerala

1VS3

Sample one states that is was not quenched. The pearlite is an indication that the object was cooled slowly as opposed to a fast quench. It does not mention quenching on the second sample but researcher 1 does seem to know that the first sample is from a blade.

3VS13

Sample two states that part of the sample is not quenched, but that some of the sample looks possibly to be quenched. Sample three is partially heat treated. Both samples are from different parts of the blade.

4KS9

Sample two is heat treated but shows no martensite, meaning that is possibly heat treated without quenching. The other samples say either fine eutectoid steel or almost eutectoid steel.

5TS5

Sample one that is from the blade is ‘certainly heat treated’. The other two samples really do not say much and they are not from the blade.

6KS17

Sample one states that a strip has been welded onto a core of lower carbon steel to produce a good cutting edge. The join of the two pieces can been seen clearly at higher magnification. Samples two and three are similar to each other. Sample four is not like any of the others and looks to be wrought iron. (see Scott: 31 for possible more info in future)

Objects from Sri Lanka

SL2

Sample one, two and three all say that the object is not quenched, but on sample four it states that the object was perhaps cooled quickly.

SL3

Sample one and two both say no quenching.

Juleff's Samples From Sri Lanka

GJ-38

Says that the sample has been heat-treated and quenched.

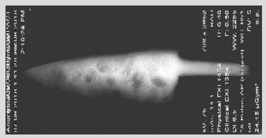
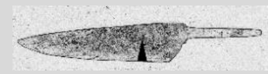
GJR-312

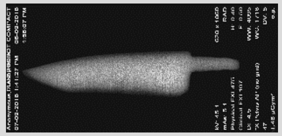
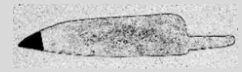
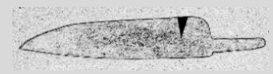
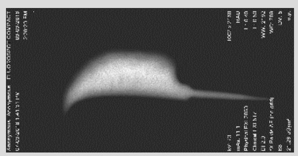
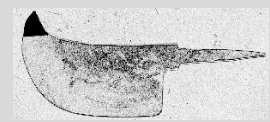
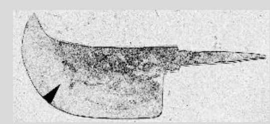
The sample has a high carbon steel central core with two low carbon sides. Sample has a weld line passing through that has some segregation from when the two components were joined. The sample was heat-treated. Also states that the low carbon side strips have typical slag and that the middle strip has very little slag, which shows that the two components have different fabrication technology.

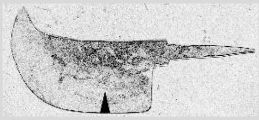
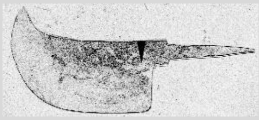
Researcher 2 Findings

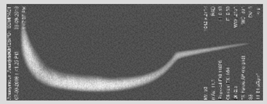
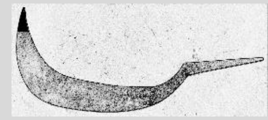
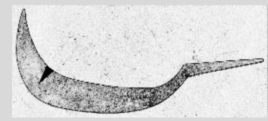
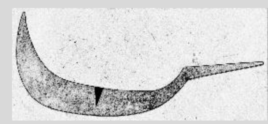
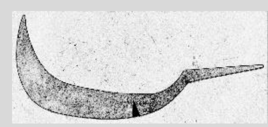
*Details that were not shared with the metals specialists are shaded in grey

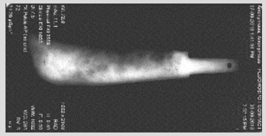
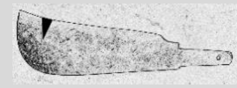
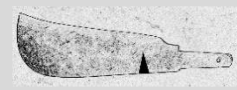
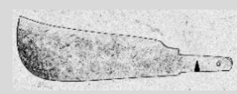
Table 7.2 Researcher 2 analysis findings relating to smithing technology.

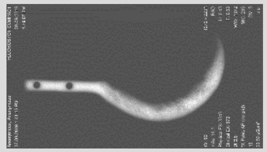
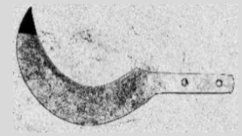
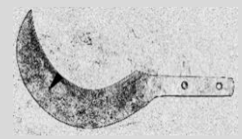
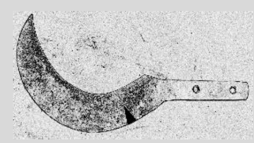
Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description
1VS3	Medium Knife			1VS3-1KB		Tip martensitic it progressively gives way to very fine grain, homogeneous (equiaxed) mainly (unresolved) pearlitic microstructure; (?Phosphorus) banded macrostructure.
				1VS3-2KB		Homogenous fine-grain medium to high carbon steel: unresolvable fine grain pearlite and ferrite - possibly fast air cooled.

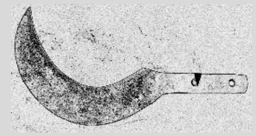
Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description
2VS3	Small Knife			2VS3-1KB		At tip - heat-treated structure: ultra fine grain medium carbon steel with partly spheroidised pearlite; away from tip showing as a high carbon steel - small-med grain ferrite/pearlite.
				2VS3-2		Homogeneous, partially spheroidised very fine grain hypoeutectoid steel quenched, martensitic structure at tip.
3VS13	Elephant Knife			3VS13-1KB		Ultra fine grain, nearly eutectoid steel, unquenched, irresolvable pearlite.
				3VS13-2		(a) Tip - fine grain (quenched and lightly) tempered martensitic structure, (b) centre - partly martensitic/partly bainite or radial pearlite: partly quenched structure; (c) furthest from tip - unresolved fine

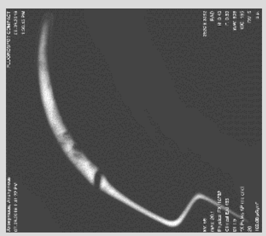
Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description
						grain pearlite plus ferrite - unaffected by quenching. Edge only quenched. Rest of high carbon steel blade probably protected by a clay paste during heating/quenching process.
				3VS13-3KB		(a) Edge: Intermediate martensite/'troostite' (radial pearlite) at tip, ?very lightly quenched; (b) body shows homogeneous, fine grain ~eutectoid, unresolvable pearlite + MnS inclusions.
				3VS13-4KB		V fine grain, high carbon steel, just hypo-eutectoid.

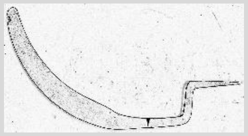
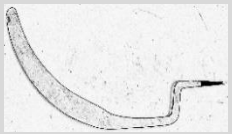
Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description
4KS9	Large Sickle			4KS9-1KB		Uniform very fine quenched martensitic structure probably indicative of high carbon steel.
				4KS9-2KB		Uniform, coarse slow etching martensitic microstructure; as-quenched? Medium to high carbon steel structure with some small probable MnS inclusions.
				4KS9-3KB		All of blade (in) section slow etching, coarse , as (fully) quenched microstructure: Slow etched but fast quenching indicative of a high carbon steel.
				4KS9-4KB		Uniform fine martensitic structure - dark (faster) etching - probably quenched and lightly tempered.

Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description
5TS5	Medium Flat Knife			5TS5-1KB		(a) Tip: Banded macro-structure and very fast/dark etching partly tempered martensitic micro-structure. (b) Body: Uniform partly spheroidised microstructure.
				5TS5-2KB		Generally homogeneous, fine grain medium carbon steel (with flaw) consisting of fine grain ferrite plus pearlite.
				5TS5-3KB		Ultra fine grain, high carbon steel, unquenched, ferrite plus pearlite.

Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description
6KS17	Medium Sickle			6KS17-1KB		Mostly homogeneous, fine grain low carbon iron, mainly ferrite with some pearlite plus a scattering of v small MnS inclusions = 'mild steel.'
				6KS17-2KB		All quenched structure across section: (a) tip with coarse, slow etched (fast quenched) martensite; (b) body faster/darker etched (slower quenched), podd partly auto-tempered +MnS incl's.
				6KS17-3KB		Uniform, very fine grain low to medium carbon steel showing as ferrite plus martensite, with some prob MnS inclusions.

Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description
				6KS17-4		Mostly homogeneous, ultra fine grain low carbon iron, some tendency towards widmanstatten distribution, some very small, prob MnS inclusions (therefore = 'mild steel').
7KS9	Plantation Knife			7KS9-1KB		(a) Tip, partially transformed/incompletely quenched martensitic structure; (b) Body - homogeneous, fine grain low carbon steel with (?phosphorus) banded macrostructure.
				7KS9-2KB		Fine horizontal - P - banded macrostructure; at higher mag'n fine grain low carbon iron plus occasional MnS inclusions: modern 'mild steel' Banded microstructure suggests this is a 'piled' (folded and forge-welded back together several times, resulting in phosphorus

Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description
						enrichment (indistinct pale bands at the welds.)
				7KS9-3KB		Banded diffuse macro-structure: ?remnant effect of modern 'rolling' process; micro-structure: mostly fine grain low carbon iron, some widmatstatten dispersion, plus MnS inclusions.
8KS11	Large Knife to hold over shoulder			8KS11 - 1		Uniform ultra fine grain low carbon iron.
				8KS11 – 2KB		(a) Tip: slow etching fine martensitic structure - quenched but not tempered; (b) body fine to med grain (unresolved) pearlite plus ferrite.

Object	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description
				8KS11 – 3KB		Uniform, ultra fine grain medium carbon steel, not quenched.
				8KS11 – 4KB		Fine to medium grain steel stucture, partially widmanstatten.
Juleff's Samples	Knife forged out of bloomery iron from Juleff's experiments	No Data	No Data	GJ-39		Fine martensitic microstructure: not intentionally tempered but possibly slightly auto-tempered - ?cooled slowly.

Observations on Analysis

Objects from Kerala

1VS3

Sample two is the important one to investigate for this study as it says that the objects was fast air cooled.

2VS3

Sample one states that it was heat treated and sample two is thought to have been quenched.

3VS13

Sample one is unquenched. Sample two has a long analysis stating that the tip, or cutting edge, was quenched and lightly tempered. The analysis then goes on to say that the middle of sample two was partially quenched. Then sample two's middle section is not affected by quenching. The analysis for sample two then goes on to state that the edge of the blade was the only section to be quenched, and that the rest of the blade could possibly have been covered in a clay paste during heating and quenching. Sample three was slightly quenched.

4KS9

All four samples state that they have been quenched, adding that sample four was probably lightly tempered. The fourth sample was the only sample that was removed from the back of the blade of the object.

5TS5

Sample one states that it is partially tempered and sample 3 says that it is unquenched.

6KS17

Sample two stated that the whole of the sample has been quenched and that the tip quenched fast and the middle section quenched slow.

7KS9

Sample one's analysis states that it is incompletely quenched. Sample two shows a banded microstructure that suggests that the iron has been forge welded in layers several times. Sample two is from a portion of the long handle.

8KS11

Sample two's analysis states that the sample was quenched but not tempered and sample three was not quenched. Both sample two and three are from the blade section of the object.

Juleff's Samples From Sri Lanka

GJ-39

The analysis on this sample states that the object was not intentionally tempered but possibly cooled slowly.

7.4 Conclusion

This chapter began with the preparation that the sample undertook before being sent to the metallurgists. Then an introduction to the specialists that conducted the lab analysis research for this study. The section then covered the findings of the lab analysis from both of the researchers.

The researchers were able to pick identifying markers that indicate blacksmithing skills within the samples. Most of the variance between what was found in the lab and what actually happened in the field involved quenching. With sample 6KS17-1 and sample GJR-312, comparisons can be made between two samples that were interpreted to have been forge welded during production.

With Sample GJR-312, the researcher was correct in that the knife did have a section of scrap metal welded into the blade. The scrap was welded onto a forged section of bloom iron. With sample 6KS17-1, the story is a bit different. The researcher states that this sample also had a welded section of higher carbon steel welded into a blade of lower carbon iron. This is not what happened in the field. The researcher even says that the weld is seen in the micrograph, and a very distinct line can be seen.

For 3VS3 the researcher states that the edge of the sample was the only part to be quenched and that the rest of the blade was probably protected by a clay paste during the heating and quenching process. This, again, was not the process that was observed during fieldwork. The smith heated the edge of the blade and then dipped only the blade's edge into water. He then heated the blade again and plunged the whole blade into water.

This section only discusses the results of the analysis that are pertinent to this study. The full lab findings from both researchers can be found in appendix C. This chapter gave the lab findings only and did not give any interpretation or comparisons to the actual smithing technology to make the objects. This will be discussed in chapter 8.

Chapter 8 Discussion and Conclusion

8.1 Introduction

This chapter will discuss this research within the context of the theoretical parameters outlined before the study was conducted. It will analyse the usefulness of these theories and how they assisted, or not, during the research and analysis. The lab analysis and forge work findings are then compared and discussed. Finally, the limitations of the study are addressed, and future research is proposed.

8.2 Ethnographic

The ethnographic component of this research was conducted in Kerala, South India. Initial research proved to be difficult due to a lack of previous knowledge of blacksmiths in central Kerala. The approach utilised was typical of other ethnographic studies in that the author lived in the community, depending on word of mouth from the people within that community. Eventually, many informants would provide information that would lead the author to traditional smiths operating within the community. The research was also conducted online, with the Kerala tourism site providing a fruitful location in the village of Kollengode. This process is discussed more fully in chapters one, two and five.

As opposed to library research, this research style is essential as it gives the researcher an experiential insight that cannot be gained through books or second-hand experience. For this study, it allowed many smiths to be located and documented, some more traditional than others. Eventually, this word of mouth approach helped to find very traditional smiths and an old community of artisans in Kollengode. This approach led to the author finding not just translators, drivers and blacksmiths but led to finding research partners that were an invaluable part of the study.

This type of ethnographic research is very much like being thrown into the fire, meaning one learns very quickly what will work and will not work. Going into the study, it was thought that an assemblage within a museum could be found to conduct research on. Even if not to lab test on, an assemblage that the smiths could recreate for the later lab analysis. Museums proved not to be a very good source to utilise. That is not to say that they were not friendly and helpful in their own way; it is challenging in India to gain access to museum items for anyone.

It also quickly became apparent that with some smiths, one could not just walk up and expect to be able to observe and ask questions, especially without a good translator who understands the research very well. Many of the more traditional smiths do not like people, especially outsiders, asking questions and observing what they are doing for various reasons; with some smiths, formal introductions needed to be made through a person familiar to the smith and that they trusted.

Without this slow, informal research style, many nuances could have been missed, and preconceived notions would not have been lost. Before arriving in Kerala, it was assumed that the traditions of the blacksmiths were rapidly on the decline, and if actions were not taken quickly to document this way of life, the knowledge would be lost. After spending time with the smiths and their families, this is no longer thought. Many of the older smiths were quick to point out that no one would carry on the tradition of smithing in their family after they were no longer living. They mostly would say that the younger generation no longer had an interest in blacksmithing work, that they all wanted to go off and make more money and do other things. It was only through speaking with the children of the smiths that another story began to emerge. The children say that when they would show interest in the forge area and what the father was working on, the father would tell them to study and get an education and not end up working in the same way.

This way of thinking is beginning to change within the smithing families. They are looking to training the younger generation within the family. Even if the people in the family do not keep smithing as a job, it is beginning to be seen as necessary for the children to know the skills involved and keep the tradition alive within the family. This is their heritage, and they want to make sure that their family keeps this knowledge alive.

This was also demonstrated through an informal discussion with Premanath T.N (blacksmith 3) in Vypin. After surveying his forge, his family and others were informally talking. It was commented that Premanath was considered highly educated and that he had a good job when a death led to the family no longer having anyone to carry on the tradition of smithing. This was when he decided to leave his career and return to his family home to be the family smith working with the temple. He felt that the long-standing tradition of smithing and ties to the temple were too important.

Through this informal discussion, one can learn things that would not be apparent to someone just showing up to a forge to watch a smith work for a few hours. Things such as one smith trading his old bellows for a newer leaf blower and then changing it back to the old bellows due to not liking the ‘new’ technology. Or one of the smiths preferring a metal structure instead of the thatch huts due to his forge burning down several times. Other smiths chose the thatch, even with the dangers, due to the tradition that that building style has in the area. One smith preferred to have a crank with a bicycle wheel attached to his bellows because he felt it gave a more consistent airflow to the fire.

Without the time spent making these connections and friendships, it is doubtful that some of the conversations would have taken place, diminishing the flow of knowledge and limiting the understanding of the technology and the smiths themselves. Without this initial groundwork, this research would not have been possible.

In chapter two, the idea of taskonomy (Dougherty and Keller, 1982) was discussed. Taskonomy is the tasks required to produce an object and the tools utilised within a workspace that are both used to create an object. Even though Dougherty and Keller conceptualised their ideas on taskonomy with American blacksmiths, this concept proved to be equally applicable to Kerala and is a valuable aid in understanding blacksmithing technology. By employing this idea, detailed information was documented for each object forged, the tools utilised in making them, and comparisons can be made on differing task times.

Also discussed in chapter 2 is the concept of taskscape, which is how the smith moves within the work scape while performing tasks. This worked well as a tool to understanding how the smith utilises the forge space. Many of the smiths would organise their workspace based on the tasks that they would be performing. If they had a more extensive work area, these task spaces were very distinct. In the case of a smaller work area, this separated task space becomes a bit muddled. Most of the smiths kept all the tools needed while forging within arm's reach from where they would sit during forging.

If the work area was a bit larger, the smith would usually have a separate place where they would sit on another stool and file and sharpen the object. This area would have every tool needed for this task located within arm's reach from where he would sit. Then the smith would move back to the forging area to heat treat and do any finishing touches. If the smiths were limited on space, then everything that he would need to complete all tasks would be within arm's reach from where he sat. Most would turn away from the hearth when sharpening the object, then turn back to heat treat and finish off anything that needed to be fixed before completing the object.

It is important to note that the size of the smithy did not equate to the amount of production or output of objects and tool repair. This smithy size also did not affect the number of persons working within a forging area. For example, the smithy in Vypin had a workspace that, upon initial appearances, would only accommodate one smith. Still, two smiths were observed working in the area simultaneously on opposite sides of the anvils with a bellows handle that swivelled for both to use.

This style of smithy could lead to misinterpretation within the archaeological record. Some would see a small area with a good size anvil and most likely would think that the small space would only be for one smith with a minimal amount of product being produced and vice versa with a large area being possibly for several smiths and having a large amount of product being produced. This was not the case with the smiths in Kerala, and no relation between the size of the area being worked in to the amount of product being produced. The forge-scape is an area that is culturally driven in that most of the forges looked the same and had the same basic setup with some basic variations, but mostly and understanding that this is how they are set up.

These two approaches, taskology and taskscape, formed part of the foundation of the approach to the research in the field for this study, and they proved to be fruitful in producing a lot of good data. With these approaches, a type of recreation of the smith working in the forge is possible. This is a way to unpack a dead forge and bring it back to life. Recreating the movement and technology of the smith in the smithy. Again, when placing the smith back into the forge, care should be taken to not place a western smith or even a modern smith into every forging site found. Smiths in western and modern society work in spaces that are different, but also the relation between smith and material is different. The smiths that were observed in Kerala had what seemed like a visceral interaction with the material and object being worked on. They would use their feet to help hold tools or hold the object being created. When working with different tools, they would use the whole body, such as the large hammers, they would stand and use their whole weight along with the weight of the hammer, and when using a file, they would move with the movement of the filing in a flowing motion, almost like a dance. This type of interaction with the tools and objects is not something that this author has seen in modern blacksmiths.

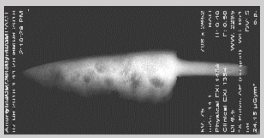
8.3 Lab Analysis

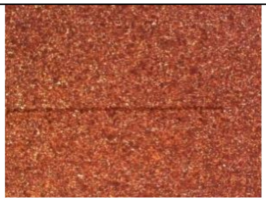
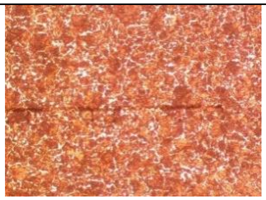
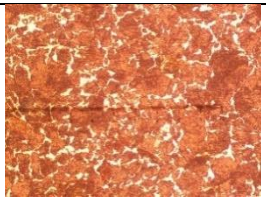
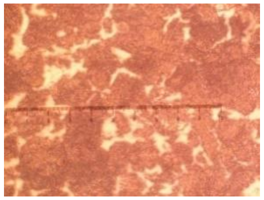
This section will discuss the lab analysis and compare this with the findings from the fieldwork. Researcher 1 was able to complete the analysis for all of the samples and provide micrographs. Researcher 2 completed analysis on half of the samples; both of the researchers' findings are discussed below.

8.3.1 Kerala

*Details that were not shared with the metals specialists are shaded in grey

Table 8.1 Researcher 1 lab analysis of object 1VS3.

Object 1VS3 From Kerala							
Description	X-Ray	Photo	Sample Number	Sample Location	Sample Description	Image Magnification	Micrograph
Medium Knife			1VS3-1KB		The cutting tip looks like it is not quenched but just rather fine pearlite. The structure further back from this is a very uniform pearlite and ferrite microstructure with more about 0.5% carbon content. It is a good modern steel. Seems to have some directionality to the	X-10	
						X-20	
						X-40	

					structure along the length of the section.	X-100	
			1VS3-2KB		Fine pearlitic microstructure. Small grain size. Typical modern steel. Carbon content about 0-6-0.7%. The exterior can be seen to be a little decarburised from working or forging while the interior etches to a fine pearlitic structure with about 0.7% carbon content.	X-10	
						X-20	
						X-40	
						X-100	

Researcher 1 found that sample one was not quenched, and sample two did not find any structures that indicated the production technology used by the smith. Researcher 2 did not find any production indications in sample one but stated that sample two was fast air-cooled.

The smith for object 1VS3 was blacksmith three in Vypin. He used part of a bull horn when forging the object and rubbed the horn on the blade to “make the iron mild” to give it a shine and finished look. The smith then sharpened the edge and then proceeded to put the iron back into the fire. He removes the iron from the fire and, once hot, puts the blade of the object into some dirt in the ground by the anvil. He then dips the blade's edge into the water, takes a file and runs it over the blade. He then begins to move the blade over the fire slowly, and after he uses a stick that is frayed at the end and soaked in water and uses the stick to wet the blade section of the object. He does another round of heating and uses the soaked stick once again, then, when finished, sets the object across the water bowl and says he is finished.

When the smith was quenching the temperature only reached 710 Celsius, the heat reading could be seen as low for quenching and heat treating. The smith quenched and tempered the object after quenching. Not sure that the smith successfully completed this task, even with him checking the quench with a file. This could be due to the low temperature. Researcher 1 and 2 did not find any indication of quenching or tempering.

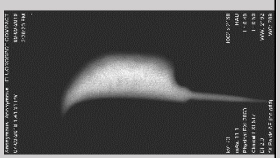
Object 2VS3

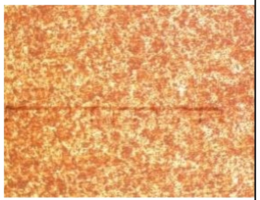
Researcher 1 did not find any production indications in any of the samples for object 2VS3. This object was forged by blacksmith 3 in Vypin. Researcher 2 states that sample one was heat-treated and that sample two was quenched. The smith followed the same process for this object as he did for object 1VS3 which was to place the object into the fire and let it get hot, then put the blade section into the dirt by the anvil. He then dips the sharp section of the blade into water. He then holds the iron over the fire, gently heating different sections of the blade, then uses a frayed end of a stick soaked in water to get the blade section of the object wet. He does this heating and using the stick to get the blade wet twice.

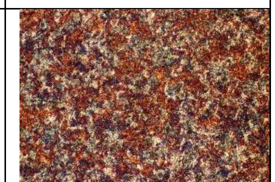
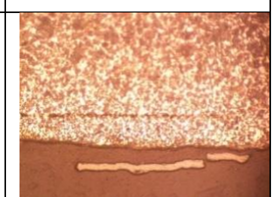
During the heat treating the fire reached a maximum heat of 710 Celsius. This temperature is the same as for the sample 1VS3, in which the researchers did not find any indication of heat treating, but with this sample, it was found to be quenched and heat treated. The process for the two different samples was the same, the smith was the same, and the temperatures were the same. The findings in the lab were different.

*Details that were not shared with the metals specialists are shaded in grey

Table 8.2 Researcher 1 lab analysis of object 3VS1.

Object 3VS1 From Kerala							
Description	X-Ray	Photo	Sample Number	Sample Location	Sample Description	Image Magnification	Micrograph
Elephant KnifeT			3VS13-1KB		Very fine structured eutectoid steel blade. Practically 0.8% carbon.	X 20	
						X 40	

			3VS13-2		Differential structure with the cutting tip being apparently unquenched here (?)...while the rest of the structure is fine ferrite and pearlite. The structure in part may be quenched to produce very fine pearlite microstructure. Directionality is evident in the way the ribbons of the unquenched part of the structure meets up the very fine-grained structure.	X 20	
						X 40	
						X 100	

			3VS13-3KB		The low magnification view shows a partially heat-treated edge with blue-etching possible martensite or very fine pearlite. Higher magnification shows patches of pearlite surrounded by lower carbon areas. At the areas between the different constituents, the areas look as if they have variable carbon content, but not especially high.	X 10	
						X 20	
						X 40	
						X 100	
			3VS13-4KB		A decarburised surface zone is quite thick here. The interior is practically a eutectoid steel. The carbon content drops off a lot to the outer surface here, becoming principally ferrite.	X 20	
						X 40	

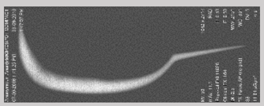
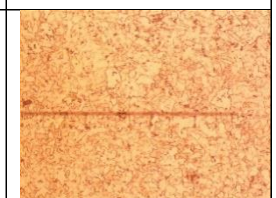
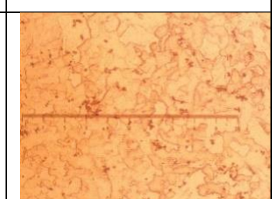
With object 3V513 forged by blacksmith 13 in Vaikom, researcher 1 had no information on production technology for samples one and four. For sample two, they said that the object was unquenched, and for sample three, the sample was partially heat treated. Researcher 2, for sample one noted that the sample was unquenched. For sample two, they said that the edge was only quenched and that the rest of the blade was probably protected by a coating of clay paste. Sample three stated that it was lightly quenched, and sample four did not mention any blacksmithing processes.

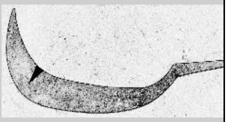
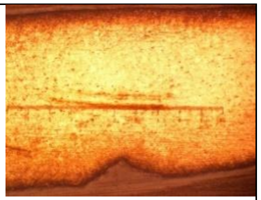
During the heat treating process, the smith forging this object heated the iron and then buried the blade into the dirt on the ground by the hearth; he then dips the blade's edge into water. Then the smith uses a file on the edge to sharpen the object. The object is returned to the fire with the edge facing the hottest section of the fire. The smith then removes the object from the fire and inspects the edge; he repeats this process five times. He then files the object and hits it with a hammer a few times, then plunges the blade section into water and sets it onto the anvil to finish cooling.

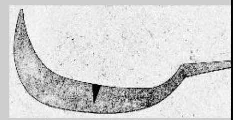
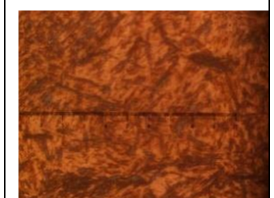
The smith reached temperatures of 1023 Celsius during the heat-treating process. With the location of the samples, it is interesting to look at what has been discovered about them by researcher 2 (see sample location in table 8.2). Sample one was taken from the very tip of the blade, which researcher 2 said was not quenched. The smith did not put this section on the object into the water when quenching, only the edge section in the middle section of the blade. Then with sample two, the researcher states that the sample was lightly quenched and tempered, that the middle of the blade was probably covered in a clay paste. While the object was not covered with a clay paste, the object's edge was only quenched after cooling a little in the air, which could cause the microstructure to appear this way. The smith also tempered the edge section of the blade. For sample three, researcher 2 says the sample is lightly quenched. This sample comes from the lower section of the edge, and it was quenched after cooling in the air for a short time. Then for sample four, researcher 2 did not mention any blacksmithing processes, which one would expect to find as the sample came from the back section of the blade, so this would be a more difficult location to see any processes. Researcher 2 discovered what was seen on the field reasonably accurately.

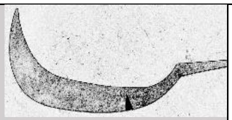
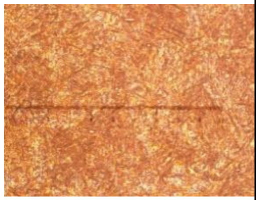
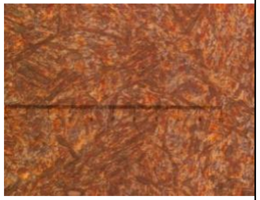
*Details that were not shared with the metals specialists are shaded in grey

Table 8.3 Researcher 1 lab analysis of object 4KS9.

Object 4KS9 From Kerala							
Description	**X-Ray**	**Photo**	**Sample Number**	**Sample Location**	**Sample Description**	**Image Magnification**	**Micrograph**
Large Sickle			4KS9-1KB		Very fine-textured eutectoid steel.	X 10	
						X 20	
						X 40	
						X 100	

			4KS9-2KB		On etching this sample, the edges have etched quicker than the interior, and looks as if it has a higher carbon content than the interior. The microstructure at high magnification looks acicular as if the material has been heat-treated to some extent. But there is no martensite. Fine acicular pearlitic microstructure.	X 10	
						X 20	
						X 40	
						X 100	
						X 400	

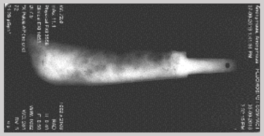
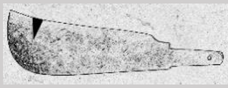
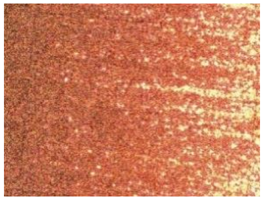
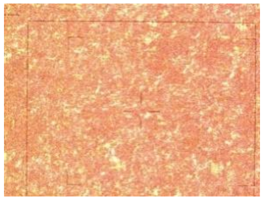
			4KS9-3KB		This sample is of a fine pearlitic steel with about 0.6-0.7% carbon in fine microstructure which looks very uniform throughout as a fine mixture of ferrite and pearlite.	X 10	
						X 200	
						X 1000	
						X 2040	

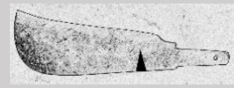
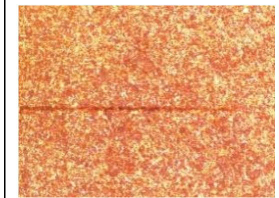
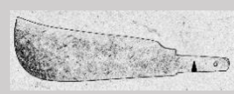
			4KS9-4KB		Almost a eutectoid steel. At x100 the steel has an acicular texture. At x20 the steel has a fine eutectoid microstructure, very even grains, very fine modern steel structure.	X 10	
						X 20	
						X 40	
						X 100	

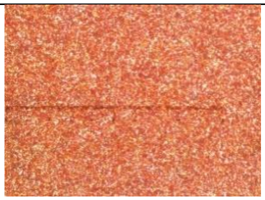
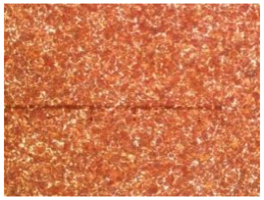
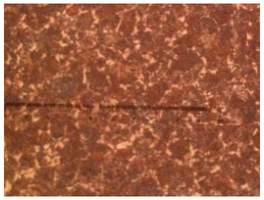
The smith for object 4KS9 was blacksmith number nine in Kollengode. Researcher 1 did not find any blacksmithing production information in three of the samples, but in sample two, the researcher states that the sample has been heat treated. Researcher 2 found that all four of the samples were quenched and that sample four was lightly tempered. The blacksmith, when heat treating this object, reached temperatures of 705.3 Celsius. He heated the object, ran a file over the sharp part of the blade quickly, and then placed the whole object into water. He then takes the file, runs it over the edge again, and returns the object to the fire. He removes the object from the fire and hits it with the hammer several times, making sure the object is straight. He then sits the object down to cool. The researcher's findings match the quenching of the object, but the smith did not attempt to temper the object.

*Details that were not shared with the metals specialists are shaded in grey

Table 8.4 Researcher 1 lab analysis of object 5TS5.

Object 5TS5 From Kerala							
Medium Flat Knife			5TS5-1KB		This sample looks as if heat-treated with exceptionally fine dark etching pearlitic structure and meeting up with a transitional zone of possibly high carbon steel. Certainly, these components have been heat-treated to create this microstructure.	X 10	
						X 20	
						X 40	

			5TS5-2KB		Fine, slightly coarser microstructure than 4KS9-3KB, has a slight directionality and a fine pearlitic microstructure with larger areas of pearlite which, like many of the samples here cannot be resolved using the eyepiece camera.	X 20	
						X 40	
						X 100	
			5TS5-3KB		Some decarburisation along the edge	X 10	

					of the sample. The interior is a fine pearlitic steel with about 0,6% carbon content.	X 20	
						X 40	
						X 100	

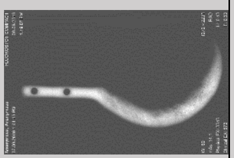
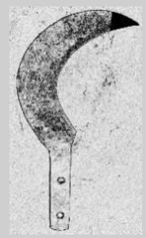
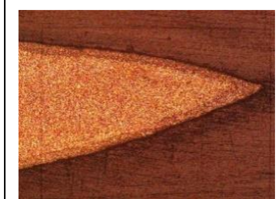
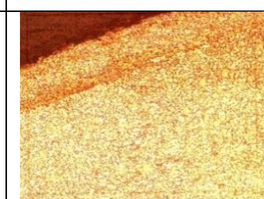
Object 5TS5 was forged by blacksmith 5 in Tirur. Researcher 1 states that sample one has been heat-treated, but he did not mention blacksmithing processes for the other two samples. Researcher 2 found that sample one was partially tempered, sample two was found to have no blacksmithing processes indications, and sample three was unquenched.

The smith began the heat treating by placing the iron back into the fire and getting the object hot. The smith moves the object around in the fire directing different sections on the blade's edge to the hottest section of the fire. He then removes the iron from the fire and slowly submerges the object into water blade first. He submerges the object in the water three times. Then takes a file and runs it across the edge of the blade several times. He then takes a wet stick that is frayed on one end and soaked in water, and runs it along the sharpened edge of the blade. He then takes that object and lays it on top of the fire, then removes and uses the stick to wet the blade section again. He then holds the sharp section of the blade over the fire, removes it, hits the blade section of the object with a hammer several times, and uses a file on the sharp section of the blade. He then again holds the blade over the fire, removes the object, and plunges the whole object into water. The highest temperature reached during heat treating was 636.9 Celsius.

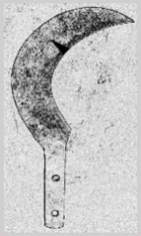
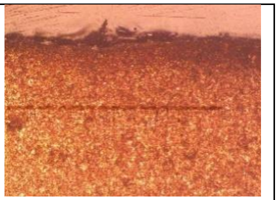
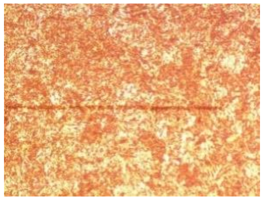
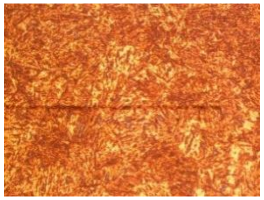
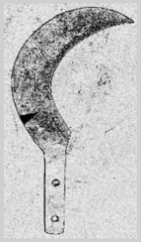
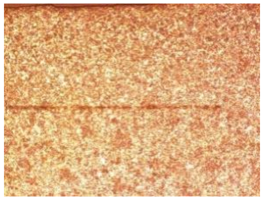
Looking at where the samples were removed from (table 8.4), the researchers' findings follow the data gathered in the field. The first sample was removed from the blade/edge section of the object. The researchers stated that sample one was heat-treated and partially tempered; this section of the object was quenched and tempered. Sample two was from the back, the unsharpened section of the blade and both the researchers did not find any information on blacksmithing processes. Researcher 2 stated that sample three was unquenched and that sample was removed from the handle section of the object, which was unquenched.

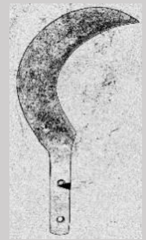
*Details that were not shared with the metals specialists are shaded in grey.

Table 8.5 Researcher 1 lab analysis of object 6KS17.

Object 6KS17 From Kerala							
Description	**X-Ray**	**Photo**	**Sample Number**	**Sample Location**	**Sample Description**	**Image Magnification**	**Micrograph**
Medium Sickle			6KS17-1KB		Good cutting edge produced with the welding on of an external strip around the core of the lower carbon steel. At higher magnification the join between these two areas can be clearly seen. Like all of these samples so far the microstructure is unlike ancient examples, totally clean and no slag content.	X 10	
						X 20	

					The external layer of the blade does not look too different from the underlying steel, but has a slightly higher carbon content. Towards the butt end, the slightly higher carbon content component moves around the back to some extent suggesting that this piece has been made by the welding together of two slightly different carbon steels, the outer edge one being perhaps 0.65% and the internal 0.5% carbon.		

			6KS17-2KB		Fine eutectoid steel with very even grain structure.	X 10	
						X 20	
						X 40	
			6KS17-3KB		Lower carbon steel with about 0.3% carbon content, otherwise similar to other examples here.	X 20	

			6KS17-4		Different from most other samples, this one is principally ferrite. At high magnification, a little slag can be seen together with a trace of carbide. Very close to being a pure wrought iron of ferrite.	No Data	No Data

6KS17 was forged by blacksmith 17 in Kollengode. The highest temperature the smith reached during heat treating was 888 Celsius. Researcher 1 discovered no blacksmith processing findings for samples two, three and four. For sample one, they state that the cutting edge was produced by forge welding an external strip of higher carbon steel into the core of the blade and states that in higher magnification, the joining from the two objects' welding can be seen (fig. 8.1).

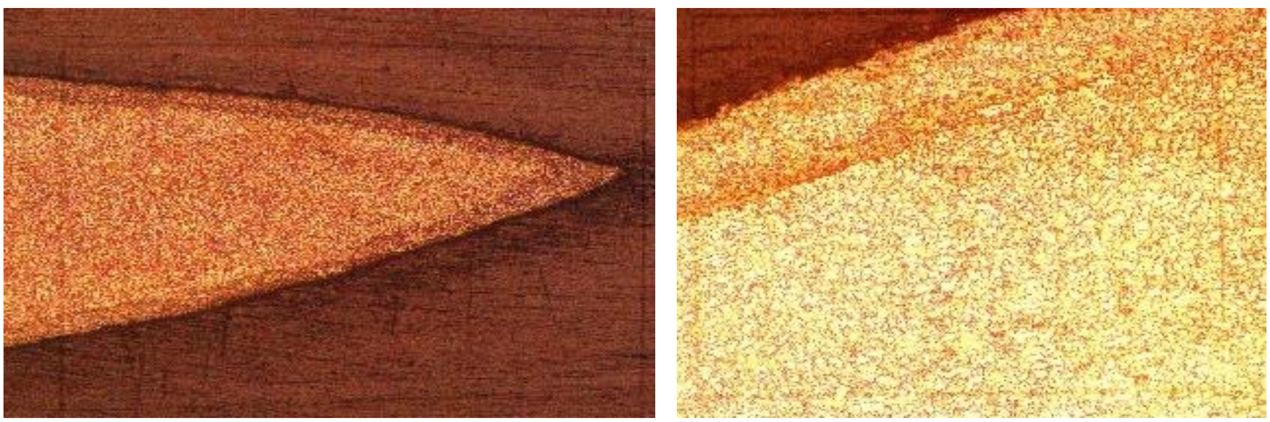


Figure 8.1 Sample 6KS17-1KB at x10 magnification (left) and x20 magnification (right).

Researcher 2 had no blacksmithing process findings for samples one, three and four. For sample two, they state that the tip or edge of the blade was fast quenched, and the inside of the blade was slow quenched. When heat treating the object, the blacksmith puts the iron into the fire and removes the object from the fire and plunges the whole object into water and leaves it in the water for a few seconds. Then takes a file and runs it over the edge. Researcher 2 in saying that sample two was quenched matched what was documented in the field. The object did not have any welded sections added to the blade, though as researcher 1 states. The micrographs backed up the findings by researcher 1; this finding could use more research with other smiths and objects.

Object 7KS9

Researcher 1 had no findings pertaining to the production technology of this object. Researcher 2 stated that sample one had been incompletely quenched, sample two had a banded microstructure and had been welded in layers, and sample three had no blacksmith production findings.

Object 7KS9 was forged by blacksmith nine in Kollengode. For the heat treating, the smith began by placing the object into the fire. He then removes the object from the fire, takes a large piece of rock salt dipped in water, and rubs the rock along the sharpened edge of the blade. He then places the object back into the fire; after the object is hot enough, the smith plunges the whole object into water. He then takes a file and runs it across the edge. The highest temperature reached during heat treating was 1270 Celsius.

The findings by the researcher do not match what was documented in the field. The object was quenched and had no welds during the forging process.

Object 8KS11

Researcher 1 had no blacksmith production comments about the samples. Researcher 2 for samples one and four has no remarks on the blacksmithing of the object. Sample two was stated to be quenched but not tempered, and sample three was not quenched.

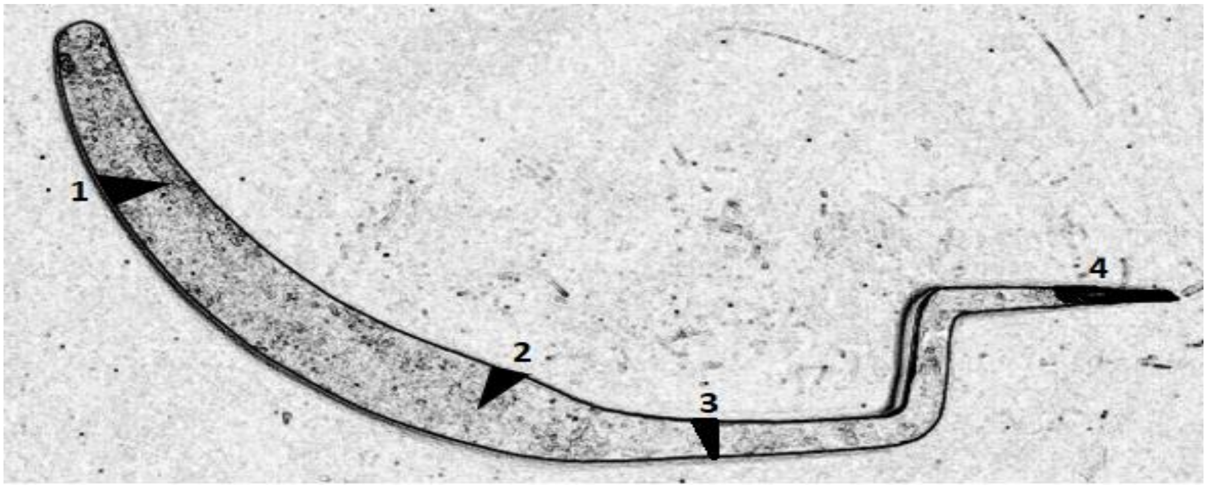


Figure 8.2 Locations of where samples were removed for object 8KS11.

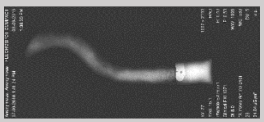
The blacksmith for object 8KS11 was blacksmith 11 from Kollengode. When heat treating this object, he placed the iron into the fire, and when he removed it, he took a rag soaked in water and dabbed it up and down the sharp section of the blade. He then replaces the iron in the fire, removes it, plunges the whole object into water, uses a bamboo brush, and runs it over the entire object. He then takes the object and places it just over the fire moving it around to direct heat to different areas of the object. He removes the iron from the fire and runs a file across the edge of the blade. The highest temperature recorded during heat treating was 692.8 Celsius.

When looking at the location of where the samples were taken from (fig. 8.2) the findings of researcher 2 are what is to be expected and closely resemble what was recorded in the field. Samples one and four are from areas that were not close to the edge of the blade. Sample three was close to the blade but is a thicker section of the object that did not have a sharp edge. Although the smith did quench the whole object, this might not show in a section without an edge, or possibly this is more difficult to detect without an edge, so it might not show as quenched. Sample two was said to be quenched, which was true; the researcher also states that the sample was not tempered. The smith did attempt to temper the edge of the blade.

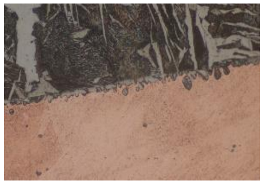
8.3.2 Sri Lanka

*Details that were not shared with the metals specialists are shaded in grey.

Table 8.6: Researcher 1 analysis for object SL2.

Object SL2 From Sri Lanka							
Description	**X-Ray**	**Photo**	**Sample Number**	**Sample Location**	**Sample Description**	**Image Magnification**	**Micrograph**
Medium "billhook" with Brazed Copper Socket			SL2-1		At low magnification, some decarburisation has occurred on one edge, there is a lamination or banded structure of ferrite and pearlite which looks to be unrelated to the direction of working of a point or blade edge. At higher magnification, the ribbons of ferrite can be seen to have some directionality, with fine eutectoid infill. Carbon	No Data	No Data

					content about 0.4%. No slag content and no quenching.		
			SL2-2		At low magnification a straited appearance can be seen running diagonally across the blade. No quenching and no slag present. At higher magnification, the structure can be seen to include a great deal of blocky ferrite with pearlite infill, carbon content about O.3 – 0.4%.	No Data	No Data
			SL2-3		Good brazed copper surface with no excessive diffusion of iron into the copper. The steel is a lower carbon steel with about 0.5-0.6% carbon and dark etching	No Data	No Data

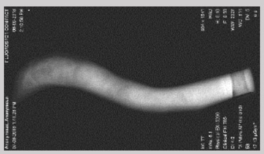
					very fine pearlite. The grain size is noticeably larger than SL3-2 OR SSLS-1. Not quenched.		
			SL2-4		Brazed copper central strip in join with iron. Dendrites of iron are visible in the copper. Steel is very dark etching with ferrite at former austenite grain boundaries. Some diffusion of iron into the copper along the join. Partially widmanstatten microstructure with about 0.6% carbon. Perhaps quickly cooled.	X 20	
						X 40	

The field data for these objects is taken from Bonnet (2013), and full notes on the forging of the objects can be found in appendix B in section 8 & 9. Object SL2 was forged by Nihal, a blacksmith located in the Village of Hatanpola, Sri Lanka.

Researcher 1 for samples one, two, and three stated that the object was not quenched and for sample four, they noted that sample four was quickly cooled. During the forging of SL2, the blacksmith did not seem to devote any time to heat treating the object. He worked on the blade heating and hammering, and after he was done hammering and with the finishing of the object, he plunged the object into water, but the object had been air-cooled for a while before being placed in the water. The researchers' findings for samples one, two and three-match what was seen in the field, but the analysis for sample four does not match as the object was not quickly cooled.

*Details that were not shared with the metals specialists are shaded in grey.

Table 8.7 Researcher 1 analysis for object SL3.

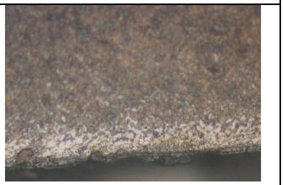
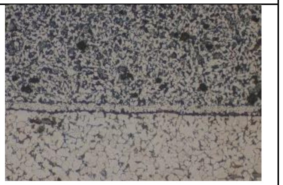
Object SL3 From Sri Lanka							
Description	**X-Ray**	**Photo**	**Sample Number**	**Sample Location**	**Sample Description**	**Image Magnification**	**Micrograph**
Medium “billhook”			SL3-1		Homogeneous carbon steel. No slag. Very even grained. At high magnification, can see ferrite at grain boundaries with fine pearlite infill. Carbon content about 0.7%. No quenching.	X 20	
						X 40	
			SL3-2		Good quality carbon steel with less than 0.8% carbon, the carbon content is about 0.7%. No slag content. At X100 the pearlite spacing can be seen in some areas.	No Data	No Data

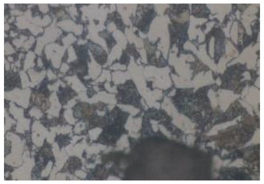
					Clean hypoeutectoid steel. No quenching.		
			SL3-3		Clean hypoeutectoid steel with no slag content. Carbon content about 0.6 – 0.7% carbon.	No Data	No Data
			SL3-4		Good hypoeutectoid steel.	No Data	No Data

Object SL3 was forged by Nihal, a blacksmith located in the Village of Hatanpola, Sri Lanka. The data on the forging of this object is taken from Bonnet (2013), and full notes on the forging of the object can be found in the appendix in section B.9. Researcher 1 found no information relating to the blacksmithing process in making this object for sample three and four. For sample one and two, they state that the object was not quenched. Researcher 1 findings match what was documented in the field from Sri Lanka. The smith did not devote any time to heat treating and did not quench the object.

*Details that were not shared with the metals specialists are shaded in grey.

Table 8.8 Researcher 1 analysis for object Julleff's samples from Sri Lanka.

Juleff's Samples From Sri Lanka							
Description	**X-Ray**	**Photo**	**Sample Number**	**Sample Location**	**Sample Description**	**Image Magnification**	**Micrograph**
Knife forged out of bloomery iron from experiments	No Data	No Data	GJ-38	No Data	At low magnification this looks like a eutectoid steel which has probably been heat-treated. The structure consists of a mass of interlocking needles, martensitic in effect. Probably 0.8% carbon steel quenched.	X 100	
			GJR-312		A classic sword or blade with a high carbon steel central core. Towards the cutting edge this section goes down to a high carbon edge and one low-carbon side, while in the central region the high-carbon steel strip is sandwiched between the	X 10	
						X 20	

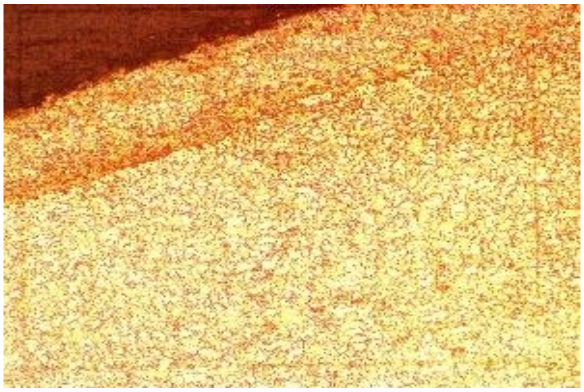
					two low carbon sides. The outer, low carbon outer surfaces are typical wrought iron with slag stringers, has no carbon content and is very soft. There appears to have been some diffusion from the higher carbon central strip as a little pearlite can be seen in the area of the weld. There is a weld line passing along the join which may be sue to some segregation during the heating and joining of the components. The inner steel core etches very fast towards the cutting edge showing that it has been heat treated in this area and has a martensitic aspect. Further back from this edge, ferrite begins to appear in this core and the carbon content is about 0.5 – 0.6%. So in the manufacture, a	X 100	

					wrought iron with typical slag content has been welded to a medium carbon steel central strip, with very little slag content, showing that the fabrication technology of these two components is quite different.		

All of the samples taken from Gill Juleff's research (1998) were removed from a knife that was forged using bloomery iron that was created during Juleff's iron smelting experiments.

The smith started with placing the full bloom in the fire to begin heating, letting the bloom get very hot. They then cut the bloom in two, then again cut a small piece off the half bloom. He then took the small cut off section and forged it into a rectangular billet. The smith then elongated the billet and formed a V-shaped groove into the side of the elongated sections. He then takes a strip of scrap steel, or lorry spring, and places this strip into the V-shaped groove in the billet. Muddy water was then splashed over the two sections of iron, then placed into the fire for heating. The whole object was then heavily hammered to weld the two different pieces together. When finished, only a tiny sliver of steel was visible at the end of the elongated section of the billet. The smith then proceeded to forge a fish knife out of the billet of bloom. The small piece of steel formed the point of the knife. Then the back section of the blade was quenched, and the rest of the knife was the filed clean. The edge of the blade was then heated and quenched. The smith then heated the knife again and quenched it again. A full transcript of the blacksmith's forging of the knife from Juleff's research can be found in appendix B.10.

Researcher 1 found that sample GJ- 38 was probably heat-treated and that it was quenched. Sample GJR-312 was found to have a high carbon central core and that it had been heat treated. They also state that the fabrication technology of the two differing types of iron is quite different. Researcher 1 had no comments about blacksmithing skills for sample GJ-39. Researcher 2 only analysed sample GJ-39 and thought that the sample was not intentionally tempered but possibly cooled slowly after forging.



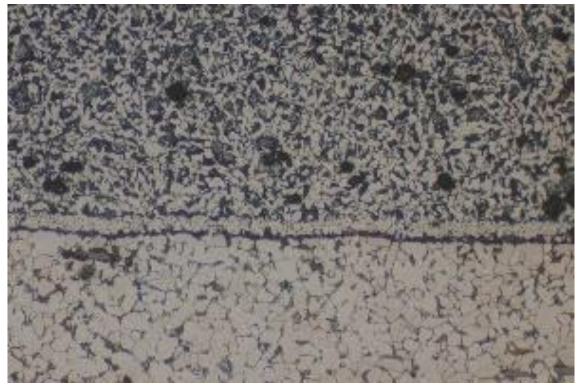


Figure 8.3 Samples 6KS17-1(left) and GJ-38 (right) said to be forged in the same way.

With this object researcher 1 was able to not only correctly identify that the object had a harder section of steel welded within the core of the object but also to be able to identify that the two different types of iron were different in the way they were smelted, or that the technology used in the fabrication of the iron was different. They did not say anything about this being seen in the micrographs. If we look back to object 6KS17 and sample 6KS17-1, the same researcher stated that this object also has a high carbon central core and used the micrographs to back this data up; this is not how the object was forged in the field. In the figure, the two samples, 6KS17-1 and GJ-38, can be seen side by side (fig. 8.3). The samples do look similar in the micrographs but were forged using different technology.

8.4 Praxis on Latour

In chapter 2, when discussing the methodology for this research, an introduction of Bruno Latour and his book *Pandora's Hope* (Latour 1999) was made. It was stated that his ideas were the foundation for the approaches to this study. Latour looks at how researchers take the observations that make about the world and translate real-world situations into words.

Latour described the scientific method as links in a chain where every new bit of knowledge adds a link into a constantly growing chain. As knowledge increases, links are added to either end of that chain. This chain needs to not have any breaks within it for the free flow of information to continue. If the chain has a missing piece, new information is required, and a hypothesis is formed and tested.

When forming these links in the chain, a process of transformation happens between what Latour calls “matter” or the subject being studied and “form” the finished written word, or in this case, thesis. He calls these transformations “circulating references”, and these are the links in the chain. It is essential that the flow of knowledge on this chain can travel in both directions. Thus final knowledge can be taken and traced back to the raw data and vice versa. In this way, a study can be repeated and understood.

Throughout this study, the idea of transformations was given careful thought, from how to describe the way the blacksmiths were found or how the blacksmiths forged an object down to how the researchers in the lab gave their feedback. The way in which this information was then taken and processed into data and then processed into the words in this thesis has been given reflection of the process Latour lays.

When looking at this study, the lab analysis aspect can clearly be seen as holding the concepts of the scientific method. People see lab, and they automatically associate it with the ideas of science and the processes involved with that type of research. When understanding the ideas of ethnographic research, one would not automatically associate this with the scientific method or the concepts that would be utilised within a lab. During this research, it has become clear that one is not so different from the other.

When in the field, we searched for smiths that fit specific criteria, how long they had been smiths, type of technology they utilised, and ties to temples. When looking for specialists to conduct the lab analysis again, specific criteria was sought, how long they had been working with metals analysis, how well were they known and how they approach analysis. When working in the lab, the equipment for the processing of the samples had to meet specific criteria the saw had to be a slow cooling saw, the resin had to be cold set, and the polishing had to have diamond suspension liquid.

Each step, whether in the field or the lab, had to fit into a pre-set category. In this way, it is easy to see how these processes are very similar and that the transformation of information, whether taken from the lab or the field, were treated the same way. Once the initial data was gathered from the fieldwork and the lab, the process of then transforming them into word was the same as well.

The lab analysis was put into charts, and counts were made on how many objects had information on blacksmith technology and good micrographs. With the field, data counts were made on how many smiths were located and the sizes of their work areas. With the forge work in the field, counts were made on hammer strikes, heat times and quenching. In this way, the fieldwork was no different than work conducted within a lab setting. How the information was gathered may differ, but how the data is processed and disseminated is the same. In a lot of research, lab work is often seen as the important work or “real science” part of the study. In this research, both of these aspects of the study were given equal weight and value as they were both approached in the same fashion and utilised the same methodology throughout. For this research, an interdisciplinary or holistic approach was the best foundation to understand all the details sought.

8.5 Research Implications and Limitations

In chapter one, the aims of this study were introduced. The overall objective of this research was to create a socio-technological baseline for future archaeological ferrous metals analysis. This is a serious statement and one that this study contributed to in a small amount in the big picture. In central Kerala, the knowledge gathered is much greater. No known smiths were in the central Kerala area. During fieldwork, 21 blacksmiths were recorded along with the remnants of an artesian village in Kollengode. When starting this study, it was thought that none would be found and that a move of research area might be needed. Several of these smiths were documented while working, so the technology that they are using at this point can be assessed in the future if needed. Their ties to the local temples and information on family temples were documented and how their religious life fuses with their everyday existence. Temple leaders were interviewed about the blacksmith communities ties to the temples and their long history together. While the impact on archaeology on a global scale might be small, the impact on the research of blacksmithing skills in Kerala is much more significant.

The study had three main research questions. The first questioned the contribution of the blacksmith within the social and political environment within central Kerala. While many social and political changes have happened over the years, the traditional rural blacksmith has not changed much. All are now paid in cash for the work done instead of rice or livestock as they would have been paid in the past. In the field, it was observed that a large portion of the smiths' work was in repairing and resharpening old tools. Very few new tools were made, and this would have been the same in the past. The smiths who have consumers who ask for objects for temple festivals, their families have been making these same objects for generations. Some smiths make iron objects for the temple festivals, like Premanath T.N. from Vypin, who makes a knife for the temple every festival. When asked about this knife and why it is made, he will simply reply that his family has the right to forge the knife, and they have held that right since the beginning of the temple. The location of the smithies is usually close to the smith’s home or the temple they may work for. These things have not changed over time.

What has changed is the amount of work that the smiths have. The cheap commodity world has made it where most people can now go to a shop and buy a knife for a low cost and quickly have a version of the item that they are needing. In the recent past, the idea of being a blacksmith was frowned upon, and it was considered dirty work with not much pay. Most would want more; more education and more money for a better life. Whereas in the past, the blacksmith trade would have held an esteemed position within society. These ideas are beginning to change within India; with heritage tourism and the desire to take back their story, the blacksmith families again understand the importance of embracing their heritage.

The next research question was what are the skills and techniques of traditional blacksmiths in central Kerala. Many of the technological skills of the blacksmiths in the area have not changed for hundreds of years. They still sit for forging; most use double bellows, charcoal for fire and use the same types of tools. Most of the smiths still do not have any source of electricity in their working areas either. Several more modern forge areas with electricity and electrical tools were found during the research, but most were more traditional. It would not be a far stretch to say that the techniques used today are probably the same as in the distant past. The smiths no longer use locally smelted iron, nor did they know anywhere that iron is still smelted today. Most said they had never worked with iron blooms. All the smiths only remember buying scrap metal.

Most of these skills have been passed on from generation to generation, and there is an understanding that once learned that that is the way it is done. Why change it if it works. One of the smiths that we met said that he tried a new electrical blower for his forge and did not like it. He only used it for a day and changed back to the traditional bellows because he found the fire easier to manage during forging. Many of the smiths did not seem interested in changing the way they worked and felt that the way they make items produces a better product. One that is more valuable and will last longer than items forged in modern forges or bought in a shop.

The last question was inquiring about what knowledge can be gained about blacksmithing through metals analysis. This was the most complex and tricky question as it is not a question answered through one study. Nor should it be. It has been exciting to see the results and compare them to what was carried out in the field. Overall, the researchers were able to pick out several samples and identify markers that indicate blacksmithing skills within the samples. Most of the variance between what was found in the lab and what actually happened in the field involved quenching. Most of the smiths would quench the objects to harden the cutting edge of the objects that they were forging. Whether they were successful in that hardening is the question. They might not have had the fire hot enough, but the smiths were within the range of heat that quenching is known to be performed in when checking this with the data. So, the reason for the differences in the samples and what the researchers found about quenching is unknown.

With sample 6KS17-1 and sample GJR-312, we can see comparisons between two samples that were interpreted through lab analysis to have been forge welded during production. Many knives in the archaeological record in various parts of the world have blades produced in this way. The smith would make blades in this fashion to aid with the durability of the blade. If the whole blade is too sharp or has too much carbon, it will become brittle and break easily, but the smith would want a sharp, durable cutting edge in the blade. So, they would use a lower carbon iron and forge a sliver of higher carbon steel into the middle of the lower carbon iron. After welding the two sections together, the smith then forges the blade as one would any other blade. It is difficult to see this weld without looking under a microscope in most cases. Many blades in the archaeological record are thought to have been forged in this manner, and it has been standard metallography that has interpreted these objects and found that they were forged in this way.

With Sample GJR-312, the researcher was correct in that the knife did have a section of scrap metal welded into the blade. The scrap was welded onto a forged section of bloom iron. They were amazingly able to catch on to the fact that the two iron pieces were produced using different technology: one modern and the other more traditional. With sample 6KS17-1, the story is a bit different.

The researcher states that this sample also had a welded section of higher carbon steel welded into a blade of lower carbon iron. This is not what happened in the field. The researcher even says that the weld is seen in the micrograph, and a very distinct line can be seen in the photo (fig. 8.1 & 8.3). When forging this object, the smith was meticulous in directing the heat of the fire to the specific section of the blade that he wanted to be heated during heat treating. Maybe this smith was so good at heat treating that he could gain that much carbon just into one section of the blade so that it looked like it was a section welded into the blade.

Another sample to discuss is 3VS3. The researcher states that the edge of the sample was the only part to be quenched and that the rest of the blade was probably protected by a clay paste during the heating and quenching process. This, again, was not the process that was observed during fieldwork. The smith heated the edge of the blade and then dipped only the blade's edge into water. He then heated the blade again and plunged the whole blade into water. There was no clay or any type of paste used during the heating or quenching process, and the iron was bare with nothing on it. Again, this may be due to the smith being so proficient with the heating and quenching process that they only harden the blade's edge.

This raises the question, when it comes to blacksmithing technology and microstructural analysis, what is the researcher actually seeing? Is it really the technology imprinted into the microstructures? Or could this be drawn from the researcher’s level of knowledge about smithing tasks and how they are preformed? If the person interpreting the microstructures is not aware of a smithing task, they will not know how to interpret this in the analysis. This could limit the blacksmithing skills that the researcher would be able to interpret and therefore limit the perceived level of technological skill of past blacksmiths.

Overall with the question of what can be gained about blacksmithing skills through metals analysis, this research is left with more questions than answers. What has been learned is that for future studies, the technology needs to match. In that, the technology of how the iron is made needs to match how the iron is forged. Most of the samples produced were nothing like the samples found within the archaeological record in that the iron is made using modern technology. It was not thought that this would be a big issue at the beginning of this research, but it became more difficult for the researchers when the samples were being interpreted. With any future studies like this, it will be fundamental and vital that the smiths work with bloom iron. The samples will look more like what is found in the archaeological record, and that interpretation matches closer.

8.6 Future research

It is hoped that this study can be an opening for much more fieldwork in Central Kerala. While working in the field, many opportunities for more research work were discovered. When working with Sree Subrahmanya Swami Temple in Vypin, it was discovered that they had a whole library of old palm-leaf manuscripts that have not been interpreted, and they did not even know the extent of the knowledge within them. It would be fruitful to look into the manuscripts to find the links between the blacksmithing communities and the temple.

Also related to the temple in Vypin, once a year, blacksmith 3, Premanath T.N. forges two different types of knives to present to the temple during the festival. This would be a great opportunity to observe a highly traditional blacksmithing practice in action. Questions concerning the significance and symbology behind the knives forged by the smith could be sought along with inquiries into the location of past knives.

Much more research could be conducted in Kollengode investigating the ties between the family temples and the blacksmiths. It would also be useful to study the other artesian communities within the village as two others, carpenter and ceramic were identified but not further investigated. In one of the family temples, it was discovered that a full human burial was located within the temple grounds. This can be seen as unusual for a Hindu temple, and investigating this would be good to gain better knowledge about small family temple complexes.

As mentioned above, one of the most important aspects for further research, as it pertains to this study, would be the bloom iron. If one is to investigate the knowledge gained about standard metals analysis, it is vital that the iron use ancient technological practices to manufacture the iron. Bloom iron must be used to match the metallography that is found within the archaeological record.

In closing, when this research was first beginning, it was seen as a way to answer questions about the veracity of metals analysis. In the end, it seems more like questions about how this type of research is conducted were answered. Yes, many smiths were located and lots of lab analysis was conducted, and some questions were answered. It was thought that the ethnographic part of the research was just a means to an end in order to get to the lab analysis that was the main focus of this study. Somewhere along the way, this changed, and a more holistic and less colonial (some would say) approach was embraced.

In more traditional ethnography and archaeological studies, the researcher rides in and gets what they need from the locals, who are obviously less knowledgeable than the researcher. Then the researcher returns from where they came from. They scientifically study the findings only to return to the study area and give the natives in the location the truth of what they found, like some kind of guru disseminating religious knowledge. It is thought that the natives should feel appreciative to the researcher and that what they say is the only answer to the questions about a heritage that is not their own.

During this research, the smiths began to take centre stage. They became research partners and the most vital source of information. They are the keepers and informants of their own heritage. The knowledge shared during fieldwork from the locals and smiths is given as much weight as the researchers conducting the lab analysis. It is also important to note that this study does not pretend to have all the answers but hopes that a discussion has been started.

Bibliography

Abdu, B. and Gordon, R. (2004) Iron artefacts from the land of Kush. *Journal of Archaeological Science,* 31: 979-998.

Andrews, J. (1992) *Edge of the Anvil: Resource Book for the Blacksmith*. Intermediate Technology Pubns.

Appadurai, A. (1974) Right and Left Hand Castes in South India. *The Indian Economic & Social History Review*, 11(2-3): 216-259.

Banerjee, A. and Iyer, L. (2005) History, Institutions, and Economic Performance: The Legacy of Colonial Land Tenure Systems in India. *American Economic Review*, 95(4), pp.1190-1213.

Bashforth, G. (1964) *The manufacture of iron and steel*. London, Chapman & Hall.

Bayley, J. and Crossley, D. (2008) *Metals and Metalworking: a research framework for Archaeometallurgy*. London: The Historical Metallurgy Society.

Bealer, A. W. (2009) *The Art of Blacksmithing*. Castle Publishing.

Bennett, A. (2015) Manufacture, use and trade of late prehistoric iron billhooks from mainland Southeast Asia, in Srinivasan, S., Ranganthan, S. and Giumlia-Mair, A. eds. (2015) *Proceedings of the Seventh International Conference on the Beginnings of the Use of Metals and Alloys (BUMA VII)*. Bangalore, National Institute of Advanced Studies: 68-77.

Bennett, A. (2013) Protohistoric Iron Weapons and Tools from a Burial Site in West Central Thailand. The World of Iron, eds.J. Humphries and T.Rehren, 371 -79. London: Archetype publication.

Blakelock, E. S. (2013) *The Early Medieval Cutting Edge of Technology: An archaeometallurgical, technological and social study of the manufacture and use of Angle-Saxon and Viking iron knives, and their contribution to the early medieval iron economy*. Bradford, University of Bradford.

Bonnet, K. (2014) *Iron Age Technology in Thailand: The manufacture and use of a protohistoric tool from Ban Don Ta Phet*, MA Experimental Archaeology Department of Archaeology, University of Exeter.

Buchanan, F. (1807) *A journey from Madras through the countries of Mysore, Canara, and Malabar, performed under the orders of the most noble the marquis Wellesley, governor general of India ...*. London: Cadell.

Chakrabarti, D.K. (1992) *The Early Use of Iron in India.* Delhi: Oxford University Press; USA

Codrington, H. (1909) The Kandyan Navandanno. *The Journal of the Ceylon Branch of the Royal Asiatic Society of Great Britain & Ireland*, 21(62): 221-253.

Coomaraswamy, A.K. (1956) *Mediaeval Sinhalese art: being a monograph on mediaeval Sinhalese arts and crafts, mainly as surviving in the eighteenth century, with an account of the structure of society and the status of the craftsmen*. New York, NY: Pantheon Books.

Coomaraswamy, A.K. (1909) *The Indian craftsman*. London: Probsthain & Co.

Coomaraswamy, A.K. (1979) *Mediaeval Sinhalese art*. [New York]: Pantheon Books.

Crew, P (1991) The Experimental Production of Prehistoric Bar Iron. *Historical Metallurgy* 25(1): 21-36.

David, N. and Kramer, C. (2001) *Ethnoarchaeology in action*. Cambridge: Cambridge University Press.

Davy, J. (1821) *An account of the interior of Ceylon, and of its inhabitants*. Dehiwala, Ceylon: Tisara Prakasakayo.

Defoe, D. (1781) *The life and adventures of Robinson Crusoe*. In two volumes. By Daniel Defoe. London: Printed for Harrison and Co. No. 18, Paternoster-Row.

Deloche, J. (2010) Roman trade routes in South India: Geographical and technical considerations (1st century BC–5th century AD). *Indian Journal of History of Science, 45*(1), 33–46.

De Silva, K. M. (1981) *A history of Sri Lanka*. Oxford, Oxford University Press.

Dirks, N. B. (2001) *Castes of Mind: Colonialism and the Making of Modern India*. Princeton, Princeton University Press.

Dougherty, J.W.D. and Keller, C.M. (1982) Taskonomy: A Practical Approach to Knowledge Structures. *American Ethnologist* 9(4): 763–774.

D'Oyly, J. and Turner, L. (1975) *A sketch of the constitution of the Kandyan Kingdom*. Dehiwala: Tisara Prakasakayo.

Duncan, J. S. (1990) *The city as text: the politics of landscape interpretation in the Kandyan kingdom*. Cambridge: Cambridge University Press.

Dumont, L. (1980) *Homo hierarchicus: the caste system and its implications*. Chicago: University of Chicago Press.

Dungworth, D. and Wilkes, R. (2009) Understanding hammerscale: the use of high-speed film and electron microscopy. *Historical Metallurgy* 43, 33–46.

Dunham, S.A., Dewey, A.G., and Cooper, N.I. (2010) *Surviving Against the Odds: Village Industry in Indonesia.* Durham, NC, Duke University Press.

Frank, K. (2012) *Crusoe.* New York: Pegasus Books.

Geiger, W. and Bode, M. (1912) *Mahavamsa: The Great Chronicle of Ceylon*. London: Oxford University Press.

Geiger, W. and Bode, M. (1964) *The Mahāvaṃsa*. London: Published for the Pali Text Society by Luzac & Co.

Geiger, W. and Bode, M. (1912) *Mahavamsa: The Great Chronicle of Ceylon*. London: Oxford University Press, pp.59-130.

Geselowitz, M. N. (1993) Archaeology and the Social Study of Technological Innovation. *Science, Technology & Human Values* 18(2): 231–246.

Ghurye, G. (1969) *Caste and race in India.* Bombay: Popular Prakashan.

Girbal, B.M. (2017) *The Technological Context of Crucible Steel Production in Northern Telangana, India.* PhD thesis. University of Exeter

Google. (2021a) *Pujari Damodara Sarma's family home location in relation to the temple.* Available at: <https://www.google.com/maps/search/kochi,+Kerala,+India+sri+subramanya+swami+temple+/@10.0307647,76.2280323,273m/data=!3m1!1e3> [Accessed 24 July 2022)

Google. (2021b) *Location of Premanath's forge in relation to the temple.* Available at: https://www.google.com/maps/search/kochi,+Kerala,+India+sri+subramanya+swami+temple+/@10.0308414,76.2273208,229m/data=!3m1!1e3 [Accessed 24 July 2022]

Google. (2022) *Map showing South India and Sri Lanka, indicating specific research locations.* Available at: https://www.google.co.uk/maps/@8.950984,78.5649825,7.1z [Accessed 20 August 2022]

Gosselain, O. P. (2016) To hell with ethnoarchaeology!. *Archaeological Dialogues 23 (2): 215-88.*

Graça da Silva, S. and Tehrani, J. J. (2016) Comparative phylogenetic analyses uncover the ancient roots of Indo-European folktales. *Royal Society Open Science* 3:150645. Available at : <http://dx.doi.org/10.1098/rsos.150645> [Accessed 29 July 2021].

Heeb, J., & Ottaway, B.S. (2014) Experimental Archaeometallurgy. In *Archaeometallurgy in global perspective: methods and syntheses*. Roberts, B. W, and Thornton, C. eds. New-York: Springer: 161-192.

Helms, M. (2013) *Craft and the Kingly Ideal*. Austin: University of Texas Press.

Henderson, J. (1990) *Scientific analysis in archaeology.* Oxford: Oxford University Committee for Archaeology, Institute of Archaeology.

Herbert, E. (1993) *Iron, Gender, and Power: Rituals of Transformation in African Societies (African systems of thought)*. Indiana, Indiana University Press.

Hodges, H. (1976) *Artifacts: an introduction to early materials and technology*. London, Baker.

Hodgkinson, J. (2009) *The Wealden iron industry*. Stroud, Tempus.

Holt, J. (2004) *The Buddhist Visnu*. New York: Columbia University Press.

Houlbrook, C. and Armitage, N. (2015) *The Materiality of Magic*. Oxford, Oxbow Books.

Hurcombe, L. (2007) A sense of materials and sensory perception in concepts of materiality. *World Archaeology* 39(4): 532–545.

Ingold, T. (2001) *The perception of the environment: essays on livelihood, dwelling and skill*. London: Routledge.

Jamison, S. W. and Brereton, J. P. (2014) *The Rigveda: The earliest religious poetry of India*. Oxford: Oxford University Press.

Jennings, P. (2014) *Blacksmith Gods: Myths, Magicians & Folklore*. Moon Books.

Juleff ,G. (1998) *Early Iron and Steel in Sri Lanka: a Study of the Samanalawewa Area.* Mainz, Verlag Philipp von Zabern.

Juleff, G., Craddock, P., Malim, T., Freestone, I. and Cartwright, C. (2009) In the footsteps of Ananda Coomaraswamy: Veralugasmankada and the archaeology and oral history of traditional iron smelting in Sri Lanka. *Historical Metallurgy,* 43: 109-134.

Juleff, G., Srinivasan, S. and Ranganathan, S. (2011) "Telengana Field Survey: post-survey analysis of field data', 'Pioneering metallurgy: origins of iron and steel making in the southern Indian subcontinent. Telengana Field Survey, Interim Report 2011', National Institute of Advanced Studies and University of Exeter, pp.24-28.

Juleff, G. (2013) Invention, Innovation and Inspiration: Optimisation and resolving technological change in the Sri Lanka archaeological record. In Humphris, J. and Rehren, Th. Eds. *The World of Iron*, London, Archetype Publications: 137-45.

Juleff, G., Jaikishan, S., Srinivasan, S., Ranganathan, S. and Gilmour, B**.** (2014) Northern Telangana, an Iron and Crucible Steel Production Landscape in India. *ISIJ International*, *54*(5): 1030-1037.

Keay, J. (2001) *India discovered*. London: HarperCollins.

Keller, C. and Keller, J. D. (1993) Thinking and acting with iron. In Chaiklin, S. and Lave, J. eds. *Understanding Practice: Perspectives on Activity and Context, Learning in Doing: Social, Cognitive and Computational Perspectives*, Cambridge, Cambridge University Press: 125–143.

Lepp, H. (1977) *Geochemistry of Iron*. Stroudsburg, PA: Dowden, Hutchinson & Ross.

Keller, C. and Keller, J. D. (1993) Thinking and acting with iron, In Chaiklin, S. and Lave, J. (eds.), *Understanding Practice: Perspectives on Activity and Context, Learning in Doing:*

Social, Cognitive and Computational Perspectives, Cambridge, Cambridge University Press, pp. 125– 143.

Keller, C. M. and Keller, J. D. (2008) *Cognition and tool use: the blacksmith at work.* Cambridge: Cambridge University Press.

Knox, R. (1818) *An account of the captivity of Capt. Robert Knox*. London: Printed for J. Hatchard.

Knox, R. (1911) *An historical relation of Ceylon.* Glasgow: James MacLehose and Sons.

Lancy, D.F. (1980) Becoming a Blacksmith in Gbarngasuakwelle*. Anthropology & Education Quarterly,* 11(4): 266–274.

Lang, J. (1988) Study of the Metallography of some Roman Swords, *Britannia*,19: 199–216.

Latour, B. (1993) *We Have Never Been Modern.* Cambridge, Massachusetts: Havard University Press.

Latour, B. (1999) *Pandora's Hope: Essays on the Reality of Science Studies*. Cambridge, Massachusetts: Harvard University Press.

Lawrence, R. (1898) *The magic of the horseshoe*. Boston: Houghton, Mifflin and Company.

Martinón-Torres, P. M. (2002) Chaîne Opératoire: The concept and its applications within the study of technology. *Gallaecia* 21: 29–43.

Mudhol, M.S. (1997) *A Technical Study of Megalithic Metal Objects.* Mysore: Directorate of Archaeology and Museums.

Neogi, T. (2017) *Technology and Identity: an ethnoarchaeological study of the social context of traditional iron-working in northern Telangana, India.* PhD Thesis. University of Exeter

Obidi, S. S. (1995) Skill Acquisition through Indigenous Apprenticeship: A case study of the Yoruba blacksmith in Nigeria. *Comparative Education*, 31(3): 369– 384.

Parker, H. (1909) *Ancient Ceylon*. London: Luzac & Co.

Percival, R. (1805) *An account of the island of Ceylon*. London: Printed by and for C. and R. Baldwin.

Pfaffenberger, B. (1992) Social Anthropology of Technology. *Annual Review of Anthropology* 21(1): 491–516.

Pieris, R. (1956) *Sinhalese social organisation*. [Colombo]: Ceylon University Press Board.

Pleiner, R. (2000) *Iron in Archaeology. The European Bloomery Smelters*. Praha: Archaeologický ústav AVČR.

Poggo, S. (2006) The origins and culture of blacksmiths in Kuku society of the Sudan, 1797–1955.

Porter, J. H. (1895) 'Caste in India'. *American Anthropologist* 8, no. 1 (1895): 23-30.

Prasad, D. (1978) 'Politics and Ethics in Kautilya's Arthashastra'. *The Indian Journal of Political Science*, 39(2), 240-249.

Ribeiro Joao, ̃ and Pieris, P. E. (1999) *The historic tragedy of the island of Ceilā o*. New Delhi: Asian Educational Services.

Remesh, M. and Manji, C. N. (2009) 'Ethnobryological notes from Western Ghats, India'. *The Bryologist*, 112(3), 532-537.

Royal Museum Greenwich. (2022) *Captain Robert Knox*. Available at: https://www.rmg.co.uk/collections/objects/rmgc-object-14298?fbclid=IwAR2ms6ACDQ_m5A_EcLzcn4HzFlpcaOmq0GEVJ3aHS8pDoo2Ei7dE9oTyn-0 [Accessed 06 August 2022]

Ryan, B. (1953) *Caste in modern Ceylon*. New Brunswick: Rutgers University Press.

Sastri, K Nilakanta. (1966) *A history of South India from prehistoric times to the fall of Vijayanagar*. [Madras]: Indian Branch, Oxford University Press.

Schmidt, P.R. (1997) *Iron Technology in East Africa: Symbolism, Science and Archaeology*. Oxford: James Currey Publishers.

Scott, B. G. (1977) Metallographic Study of Some Early Iron Tools and Weapons from Ireland. *Proceedings of the Royal Irish Academy: Archaeology, Culture, History, Literature*, 77: 301-317.

Scott, B. G. (1989) The Analysis of Texts and Metal Artifacts: Problems and Potential. In Henderson, J. ed. *Scientific Analysis in Archaeology*, Oxford, Oxford University Committee for Archaeology and Institute of Archaeology: 237–249.

Scott, D.A. (1991) Metallography and microstructure of ancient and historic metals. Marina del Rey, CA: Getty Conservation Institute.

Scott, D. A. (2015) Metallography and Microstructure of Metallic Artifacts. In Roberts, B.W. and Thornton, C. eds. *Archaeometallurgy in Global Perspective: Methods and Syntheses*, New-York, Springer: 67-192.

Serneels, V. and Perret, S. (2003) Quantification of smithing activities based on the investigation of slag and other material remains. In *Archaeometallurgy in Europe- Proceedings of the International Conference*. Milan: Associazione Italiana di Metallurgia: 469-478.

Schubert, H. (1957) *History of the British iron and steel industry from c. 450 B.C. to A.D. 1775*. London, Routledge & Kegan Paul.

Sim, D. and Ridge, I. (2002) *Iron for the eagles: the iron industry of Roman Britain*. Stroud, The History Press.

Sim, D., & Ridge, I. (2011) *Iron for the Eagles the Iron Industry of Roman Britain*. Stroud (GB): The history Press.

Soulignac, R. and Serneels, V. (2013) Forging with Dogon smiths (Mali). In Dungworth, D. and Doonan, R. C. P. eds. *Accidental and Experimental Archaeometallurgy*. London, Historical Metallurgical Society: 119–126.

Srinivasan, S. (2013) Indian iron and steel, with special reference to southern India, In *The World of Iron*, Humphris, J. and Rehren, T. eds. (2013) London, Archetype Press: 83-90.

Trustees of the British Museum. (2022) *1794 example showing different regions of South India*. Available at https://www.britishmuseum.org/collection/object/P_1869-0508-360?fbclid=IwAR2xyckqIqeK10z0M5TigfAbrqqp62YWTB2qNe3QhWhoif0TVBuzhKTh6ns [Accessed 06 August 2022]

Tylecote, R. F. (1962) *Metallurgy in Archaeology: a prehistory of metallurgy in the British Isles*. London: Edward Arnold.

Unglik, H. (1991) Observations on the structures and formation of microscopic smithing residues from Bixby Blacksmith Shop at Barre Four Corners, Massachusetts, 1824-55 *Historical Metallurgy*, 25(2): 92-98.

Unknown Author. (1907) *The Indian Nation Builders, Vol. 3*,. Ganesh & Co. Publishers, Madras.

Victoria and Albert Museum, London. (2021) *The Cosmic Man*. Available at: https://collections.vam.ac.uk/item/O154643/vishnu-as-vishvarupa-cosmic-or-painting-unknown/?fbclid=IwAR0D2EquMertiTofb4VFsK4REDYUrka2fi26ma9CA0eW65T5wreKvhUlRtc [Accessed 06 August 2022]

Wickremesekera, C. (2004). *Kandy at war: indigenous military resistance to European expansion in Sri Lanka, 1594-1818*. New-Delhi: Manohar.

Yalman, N. (1967). *Under the bo tree: studies in caste, kinship, and marriage in the interior of Ceylon*. Berkeley: University of California Press.

Appendix A- Ethnographic Work

A.1 Blank Blacksmith Interview Form

A.2 Filled in forms for Blacksmiths Located within Central Kerala

A.3 Fieldwork Ethics

A.4 Family Temple Survey Notes

A.5 Damodara Sarma (Pujari) Interview Transcripts

A.6 Blacksmith Interview Transcript- Chellappan

A.7 Blacksmith Interview Transcript- Krishnan Kutty

A.8 Forge Survey Field Notes- Vypin

A.9 Forge Survey Field Notes- Toddy Shop- Kollengode

A.10 Forge Survey Field Notes- Large Hut – Kollengode

A.11 Forge Survey Field Notes- Abandoned Forge

A.12 Basic Blank Interview Form

A.13 India Summer Fieldwork 2017

A.14 Kollengode Puja Notes

A.1 Blank Blacksmith Interview Form

<u>Interview Information</u>

Location of Interview:

Interview Date:

Local Time:

Interviewed By:

Data Recorded (i.e. video, audio, notes etc.):

Data Location (i.e. field notebook, computer etc.):

<u>Blacksmith Information</u>

Name:

Age:

Time as a Blacksmith:

Smithing Heritage (i.e. family tradition etc.): Yes/No –

Time Spent in Current Village/City:

Time Spent in Current Forge:

Age of Current Forge:

Professional Affiliations (i.e. related temples etc.):

Do You Make our Own Charcoal: Yes/No –

Forge Information

Bellows Type:

Grinding/Sharpening Type:

Sitting or Standing when:

- **Forging:**
- **Grinding/Sharpening:**

Anvil Shape/Size:

Source of Iron:

GPS Location Reading:

Other Notes

Local Weather Conditions:

General Demeanor:

Miscellaneous Notes:

A.2 Filled in forms for Blacksmiths Located within Central Kerala

Blacksmith 1

Interview Information

Location of Interview: Cochin

Interview Date: 02/03/2017

Local Time: 11:15

Interviewed By: KB

Data Recorded (i.e. video, audio, notes etc.): Fieldnotes and photos on phone

Data Location (i.e. field notebook, computer etc.): Notes and Photos in KB's computer and backed-up in dropbox

Blacksmith Information

Name: Gabriel

Age: 50's

Time as a Blacksmith: 34 years

Smithing Heritage (i.e. family tradition etc.): Yes/No – No

Time Spent in Current Village/City: Whole life

Time Spent in Current Forge: Unknown

Age of Current Forge: Unknown

Professional Affiliations (i.e. related temples etc.): Unknown

Do You Make our Own Charcoal: Yes/No – No, buys from local store

Forge Information

Bellows Type: Electrical

Grinding/Sharpening Type: Electrical

Sitting or Standing when:

2 **Forging:** Sitting

3 **Grinding/Sharpening:** Standing

Anvil Shape/Size: Square, not placed in ground

Source of Iron: Unknown

GPS Location Reading: 9°57’504”N 76°14’49.2E

Other Notes

Local Weather Conditions: Hot and Humid

General Demeanor: Good…was very interested in what I was doing and about me in general

Miscellaneous Notes:

Blacksmith located in the middle of Fort Kochi. In a normal house off the road. The forge is at the front of the house. The smith said he had been working as a blacksmith full time for about 34 years. That his father was not a blacksmith. His dad worked for what I can only translate to the local port authority. The forge itself was an electrical forge with blowers very like the ones that Nihal uses in Sri Lanka. It looks like a leaf blower. Then it had a clay part running to the hearth.

It is also interesting to note that the smith had all his tools right next to him. Almost sitting on them. He had a small wooden stool that he would sit on with everything he needed within arm's reach. If he needed to work on something long, he would stand up. That is the only time I saw him standing while working. When he gets a new piece of iron or charcoal or coal he is always sitting. He was using charcoal for most of the work, but then he would pound and grind up coal and add the dust to the fire. He said this made the fire hotter and easier to work with the iron. He has no relatives to pass the blacksmithing skills on.

Blacksmith 2

Interview Information

Location of Interview: Vypin

Interview Date: 18/03/2017

Local Time: 3:53

Interviewed By: KB with translator

Data Recorded (i.e. video, audio, notes etc.): Fieldnotes and phone photos

Data Location (i.e. field notebook, computer etc.): KB's computer and backed-up on dropbox

Blacksmith Information

Name: Unknown

Age: estimating around 50

Time as a Blacksmith: 30 years

Smithing Heritage (i.e. family tradition etc.): Yes/No – Yes

Time Spent in Current Village/City: Whole life

Time Spent in Current Forge: 5 years

Age of Current Forge: 5 Years

Professional Affiliations (i.e. related temples etc.): No

Do You Make our Own Charcoal: Yes/No – No buys from local market

Forge Information

Bellows Type: Crank

Grinding/Sharpening Type: Electric

Sitting or Standing when:

2. **Forging:** Sitting
3. **Grinding/Sharpening:** Mostly standing, but can bring a chair to sit in

Anvil Shape/Size: Square

Source of Iron: Scrap

GPS Location Reading: 9°59’13.2”N 76°13’30.0”E

Other Notes

Local Weather Conditions: Hot and humid

General Demeanor: Good

Miscellaneous Notes:

Smith located in Vypin about 5 Km outside of Cochin. The smith was using a crank bellow. He would sit opposite it with the fire and anvil in front of him, using a long stick to crank the bellows. He has been working as a blacksmith for about 30 years. He is from a family of blacksmiths and he learned the craft from his father. The iron he uses is spring steel from cars and the charcoal he uses is from coconut shell and that he buys. He uses a modern grinder that he made himself. He had several items he was working on, they looked mainly like knives that fisherman use. He had several in different stages of production, and several that has been left by the owners for him to fix and sharpen. He said that total forge time on one of these knives is 2 hours and 6 hours to complete with grinding and wood handle. He said that his father's forge (and the first forge he worked on) was a few KM closer to town, but that he moved to where he is now about 5 years ago.. I also asked him if he had any children to carry on his work…he said that he had two girls that are both grown and married. He said that nobody would be carrying on his work. He also stated that his brother used to smith as well but has since moved on to a more profitable occupation.

Blacksmith 3

Interview Information

Location of Interview: Vypin

Interview Date: 18/03/2017

Local Time: 5:15

Interviewed By: KB with translator

Data Recorded (i.e. video, audio, notes etc.): Fieldnotes and phone photos

Data Location (i.e. field notebook, computer etc.): KB's computer and backed-up on dropbox

Blacksmith Information

Name: Unknown

Age: Around 50

Time as a Blacksmith: all his life

Smithing Heritage (i.e. family tradition etc.): Yes/No – Yes

Time Spent in Current Village/City: whole life

Time Spent in Current Forge: whole life

Age of Current Forge: 80+ years

Professional Affiliations (i.e. related temples etc.): Yes

Do You Make our Own Charcoal: Yes/No – No

Forge Information

Bellows Type: Double Bellows

Grinding/Sharpening Type: Hand

Sitting or Standing when:

- **Forging:** Sitting
- **Grinding/Sharpening:** Sitting

Anvil Shape/Size: Square

Source of Iron: Spring Steel from cars

GPS Location Reading: 10°01’48.0”N 79°13’12.0”E

Other Notes

Local Weather Conditions: Hot and humid

General Demeanor: Good

Miscellaneous Notes:

This smith has very old double bellows that he said some of the pieces are 700 years old. He does not use electricity at all. His house was just behind the forge. He said that a lot of his work comes from making tools for masonry and woodworking. He is also responsible for forging knives for the temple once a year and that the land that he lives on is owned by the temple. His family has the only right to make the temple knives for 700 years. So, once a year he makes two knives (2 different types of knife, one of each) for this festival which is in December. He had many traditional tools many of them very old. The land that he lives on is owned by the temple. He said that his family had the only right to make the temple knives for 700 years.

Blacksmith 4

Interview Information

Location of Interview: Tirur

Interview Date: 23/03/2017

Local Time: 1:18

Interviewed By: KB with translator

Data Recorded (i.e. video, audio, notes etc.): Fieldnotes and phone photos

Data Location (i.e. field notebook, computer etc.): KB computer and backed-up on dropbox

Blacksmith Information

Name: Unknown

Age: around 45

Time as a Blacksmith: unknown

Smithing Heritage (i.e. family tradition etc.): Yes/No – No

Time Spent in Current Village/City: unknown

Time Spent in Current Forge: 2 years

Age of Current Forge: 2 years

Professional Affiliations (i.e. related temples etc.): No

Do You Make our Own Charcoal: Yes/No – No

Forge Information

Bellows Type: Electrical

Grinding/Sharpening Type: Electrical

Sitting or Standing when:

- **Forging:** Sitting
- **Grinding/Sharpening:** Sitting

Anvil Shape/Size: Square

Source of Iron: Spring steel from cars

GPS Location Reading: 10°49’48.0”N 76°03’00.0”E

Other Notes

Local Weather Conditions: Hot and humid

General Demeanor: Good but was not very interested

Miscellaneous Notes:

This smith is said to be only a knife sharpener. Although he can make things per order he usually sharpens tools and knives. He has a place in a garage/shop that he stays for so many hours a day so people can come to him to get their tools sharpened only. His time while at the shop was for only for sharpening tools. He had an electric blower he was using for bellows. He dug a hole in the concrete floor of the shop and used clay as a tryer for them. He bought his charcoal and it was made of coconut. He also used an electrical angle grinder for sharpening the tools.

Blacksmith 5

Interview Information

Location of Interview: Tirur

Interview Date: 23/03/2017

Local Time: 2:25

Interviewed By: KB with translator

Data Recorded (i.e. video, audio, notes etc.): Fieldnotes and phone photos

Data Location (i.e. field notebook, computer etc.): KB's computer and backed-up on dropbox

Blacksmith Information

Name: Unknown

Age: 55

Time as a Blacksmith: Whole life

Smithing Heritage (i.e. family tradition etc.): Yes/No – Yes

Time Spent in Current Village/City: Whole life

Time Spent in Current Forge: 40+years

Age of Current Forge: 40+years

Professional Affiliations (i.e. related temples etc.): No

Do You Make our Own Charcoal: Yes/No – No

Forge Information

Bellows Type: Crank

Grinding/Sharpening Type: Hand

Sitting or Standing when:

- **Forging:** Sitting
- **Grinding/Sharpening:** Sitting

Anvil Shape/Size: Square

Source of Iron: Spring steel from cars

GPS Location Reading: 10°48’00.0”N 76°03’00.0”E

Other Notes

Local Weather Conditions: Hot and humid

General Demeanor: Good

Miscellaneous Notes:

This smith has a forge in front of his home which is set back off a small road. The smith had a crank blower for bellows, but he had a bicycle wheel attached to the crank. He does not use electricity for any part of the forging or finishing processes. He said that he was taught smithing from his father and that he comes from a long line of smiths. He buys his charcoal from a local market and he uses spring steel. He is not affiliated with a temple, but he has been asked by several people involved with temple festivals to repair swords and knives.

Blacksmith 6

Interview Information

Location of Interview: Tirur

Interview Date: 23/03/2017

Local Time: 4:16

Interviewed By: KB with an interpreter

Data Recorded (i.e. video, audio, notes etc.): Fieldnotes and phone photos

Data Location (i.e. field notebook, computer etc.): KB's computer and backed-up on dropbox

Blacksmith Information

Name: Unknown

Age: 85

Time as a Blacksmith: 50 years

Smithing Heritage (i.e. family tradition etc.): Yes/No – Yes

Time Spent in Current Village/City: Whole life

Time Spent in Current Forge: 40+ years

Age of Current Forge: 40+years

Professional Affiliations (i.e. related temples etc.): No

Do You Make our Own Charcoal: Yes/No – Yes

Forge Information

Bellows Type: Crank

Grinding/Sharpening Type: Hand

Sitting or Standing when:

- **Forging:** Sitting
- **Grinding/Sharpening:** Sitting

Anvil Shape/Size: Square

Source of Iron: Spring steel from cars

GPS Location Reading: 10°54’00.0”N 75°54’00.0”E

Other Notes

Local Weather Conditions: Hot and humid

General Demeanor: Good

Miscellaneous Notes:

This smith is 85 years old. He comes from a long line of smiths who have lived in the Tirur area for generations. He does not know of anywhere else his family has lived. He has been smithing for about 50 years. He learned from his father. He uses a crank blower for bellows and does not use electricity for any part of the forging or finishing process. He also uses a bow drill still. He is older in years so I am going to have him forge something a bit smaller and do a long simi-formal interview with him. While I was there he told me a story about the king and him asking for crafters to make a cup to hold water for a day. Each crafter made the cup but the only one still with good water in the cup was the smith. I have never heard this story and it might be good to have him tell this story about so I can document it. He also will be good to ask about how smithing has changed in his area since he was small.

Blacksmith 7

Interview Information

Location of Interview: Thrissur

Interview Date: 25/03/2017

Local Time: 11:00

Interviewed By: KB with an interpreter

Data Recorded (i.e. video, audio, notes etc.): Fieldnotes and phone photos

Data Location (i.e. field notebook, computer etc.): KB's computer and backed-up on dropbox

Blacksmith Information

Name: Unknown

Age: Unknown

Time as a Blacksmith: Unknown

Smithing Heritage (i.e. family tradition etc.): Yes/No – No

Time Spent in Current Village/City: Unknown

Time Spent in Current Forge: Unknown

Age of Current Forge: Unknown

Professional Affiliations (i.e. related temples etc.): No

Do You Make our Own Charcoal: Yes/No – No

<u>Forge Information</u>

Bellows Type: Crank

Grinding/Sharpening Type: Electric

Sitting or Standing when:

- **Forging:** Sitting
- **Grinding/Sharpening:** Standing

Anvil Shape/Size: Square

Source of Iron: Unknown

GPS Location Reading: 10°26’09.6”N 76°15’50.4”E

<u>Other Notes</u>

Local Weather Conditions: Hot and humid

General Demeanor: Poor

Miscellaneous Notes:

His forge is modern for India. He had all electric to work with.

Upon arrival, the smith was asleep on the floor by the entrance door. Once he got up he took us around his workshop a bit. He was not interested with us at all and did not like me asking questions and did not want to give his full name. He did allow me to take a few photos and I took GPS reading. He did tell us of another smith that was on the other side of town that he used to work with that still had a very traditional forge.

Blacksmith 8

Interview Information

Location of Interview: Thrissur

Interview Date: 25/03/2017

Local Time: 2:15

Interviewed By: KB with an interpreter

Data Recorded (i.e. video, audio, notes etc.): Fieldnotes and phone photo

Data Location (i.e. field notebook, computer etc.): KB's computer and backed-up on dropbox

Blacksmith Information

Name: Unknown

Age: around 50

Time as a Blacksmith: Whole life

Smithing Heritage (i.e. family tradition etc.): Yes/No – Yes

Time Spent in Current Village/City: Whole life

Time Spent in Current Forge: 30+years

Age of Current Forge: 60+years

Professional Affiliations (i.e. related temples etc.): No

Do You Make our Own Charcoal: Yes/No – No

Forge Information

Bellows Type: Double bellows

Grinding/Sharpening Type: Hand

Sitting or Standing when:

(e) **Forging:** Sitting

(f) **Grinding/Sharpening:** Sitting

Anvil Shape/Size: Square

Source of Iron: Spring Steel

GPS Location Reading: 10°16’04.8”N 76°16’37.2”E

Other Notes

Local Weather Conditions: Hot and humid

General Demeanor: Good

Miscellaneous Notes:

He has a small forge in the front of his home. The smith said that his father built the forge about 50 to 60 years ago and that he is from a family of smiths. He does not use any electricity had installed electric blowers at one time and did not like them so he put the traditional double bellows back in the forge.

Blacksmith 9

Interview Information

Location of Interview: Kollengode

Interview Date: 04/04/2017

Local Time: 11:15

Interviewed By: KB with an interpreter

Data Recorded (i.e. video, audio, notes etc.): Fieldnotes with phone photos

Data Location (i.e. field notebook, computer etc.): KB's computer with back-up on dropbox

Blacksmith Information

Name: Unknown

Age: around 55

Time as a Blacksmith: Whole life

Smithing Heritage (i.e. family tradition etc.): Yes/No – Yes

Time Spent in Current Village/City: whole life

Time Spent in Current Forge: 40+years

Age of Current Forge: 40+years

Professional Affiliations (i.e. related temples etc.): Yes

Do You Make our Own Charcoal: Yes/No – No

Forge Information

Bellows Type: Double bellows

Grinding/Sharpening Type: Hand

Sitting or Standing when:

(c) **Forging:** Sitting

(d) **Grinding/Sharpening:** Sitting

Anvil Shape/Size: Square

Source of Iron: Spring Steel

GPS Location Reading: 10°36'25.2"N 76°39'14.4'E

Other Notes

Local Weather Conditions: Hot and humid

General Demeanor: Good

Miscellaneous Notes:

This smith is in a small hut close to the road on the way into Kollengode. He had no electricity at all in the hut. He said he had been smithing in that location for about 40 years. He came from a long line of smiths. The charcoal in this area is acquired from people who make it in the mountains from a tree found there. When asked what types of forge work he did he said that he sharpened tools that were brought to him and that he made tools for tree chopping and sickles. He is part of the local blacksmithing temple.

Blacksmith 10

Interview Information

Location of Interview: Kollengode

Interview Date: 04/04/2017

Local Time: 11:30

Interviewed By: KB with an interpreter

Data Recorded (i.e. video, audio, notes etc.): Fieldnotes with phone photos

Data Location (i.e. field notebook, computer etc.): KB's computer with back-up on dropbox

Blacksmith Information

Name: Unknown

Age: Unknown

Time as a Blacksmith: Unknown

Smithing Heritage (i.e. family tradition etc.): Yes/No – Yes

Time Spent in Current Village/City: Unknown

Time Spent in Current Forge: Unknown

Age of Current Forge: Unknown

Professional Affiliations (i.e. related temples etc.): Yes

Do You Make our Own Charcoal: Yes/No – Unknown

Forge Information

Bellows Type: Electric

Grinding/Sharpening Type: Electric

Sitting or Standing when:

- **Forging:** Unknown
- **Grinding/Sharpening:** Unknown

Anvil Shape/Size: Round

Source of Iron: Unknown

GPS Location Reading: 10°36'21.6"N 76°36'14.4"E

Other Notes

Local Weather Conditions: Hot and humid

General Demeanor: Good

Miscellaneous Notes:

This smith was very modern and had a shop in the front of the forge where he had tools for sale. The forge in the back was all electric and the smith was not even in the day I was there. The lady in the shop said that the smith only works once or twice a week and to keep up with demand in the store and to make special orders. The shop had many different tools for sale and even had paintings on the wall of the types of tools customers could order.

Blacksmith 11

Interview Information

Location of Interview: Kollengode

Interview Date: 04/04/2017

Local Time: 12:15

Interviewed By: KB with an interpreter

Data Recorded (i.e. video, audio, notes etc.): Fieldnotes with phone photos

Data Location (i.e. field notebook, computer etc.): KB's computer and backed-up on dropbox

Blacksmith Information

Name: Unknown

Age: 50's

Time as a Blacksmith: Whole life

Smithing Heritage (i.e. family tradition etc.): Yes/No – Yes

Time Spent in Current Village/City: Whole life

Time Spent in Current Forge: 30+years

Age of Current Forge: 80+ years

Professional Affiliations (i.e. related temples etc.): Yes

Do You Make our Own Charcoal: Yes/No – No

Forge Information

Bellows Type: Double bellows

Grinding/Sharpening Type: Hand

Sitting or Standing when:

1- **Forging:** Sitting
2- **Grinding/Sharpening:** Sitting

Anvil Shape/Size: Square

Source of Iron: Spring Steel

GPS Location Reading: 10°36'21.6"N 76°39'25.2"E

Other Notes

Local Weather Conditions: Hot and humid

General Demeanor: Good

Miscellaneous Notes:

This forge was also in a hut down a dirt path next to a building off the road. No electricity in in the hut. He said that he was the one responsible to make the temple swords for the festivals and that he is the only one that can make them for the family temple. He also makes tools for the tea plantations in the mountains. He said that his forge was about 80 years old. He also had a different station set up just for grinding and sharpening the tools. He did have a few other knives used for chopping trees. This smith talked to us for quite a while and was very friendly.

Blacksmith 12

Interview Information

Location of Interview: Kollengode

Interview Date: 04/04/2017

Local Time: 1:15

Interviewed By: KB with an interpreter

Data Recorded (i.e. video, audio, notes etc.): Fieldnotes and phone photos

Data Location (i.e. field notebook, computer etc.): KB's computer with backup in dropbox

Blacksmith Information

Name: Unknown

Age: 40's

Time as a Blacksmith: 25+ years

Smithing Heritage (i.e. family tradition etc.): Yes/No – Yes

Time Spent in Current Village/City: Whole life

Time Spent in Current Forge: 25+ years

Age of Current Forge: 25 years

Professional Affiliations (i.e. related temples etc.): Yes

Do You Make our Own Charcoal: Yes/No – No

Forge Information

Bellows Type: Double bellows

Grinding/Sharpening Type: Hand

Sitting or Standing when:

2) **Forging:** Sitting

3) **Grinding/Sharpening:** Sitting

Anvil Shape/Size: Square

Source of Iron: Spring steel

GPS Location Reading: 10°36'21.6"N 76°39'28.8"E

Other Notes

Local Weather Conditions: Hot and humid

General Demeanor: Good

Miscellaneous Notes:

This forge is just off the road on the way into Kollengode. This forge is more modern and is in a metal building. The smith also had bricks built over his furnace. He said this was to keep the charcoal from throwing sparks and causing a fire. Evidently, he used to have a thatch hut, but it caught fire….3 times. He then decided it was logical to get a metal hut. The forge in in front of his family home. He said he was also related to all the smiths in the area. He still did not use any electricity in his forge and did all his sharpening and grinding by hand.

Blacksmith 13

Interview Information

Location of Interview: Viakom

Interview Date: 07/04/2017

Local Time: 10:15

Interviewed By: KB with an interpreter

Data Recorded (i.e. video, audio, notes etc.): Fieldnotes and phone photos

Data Location (i.e. field notebook, computer etc.): KB's computer with backup on dropbox

Blacksmith Information

Name: Unknown

Age: Unknown

Time as a Blacksmith: 30+ years

Smithing Heritage (i.e. family tradition etc.): Yes/No – No

Time Spent in Current Village/City: Unknown

Time Spent in Current Forge: Unknown

Age of Current Forge: Unknown

Professional Affiliations (i.e. related temples etc.): No

Do You Make our Own Charcoal: Yes/No – Yes

<u>Forge Information</u>

Bellows Type: Electric

Grinding/Sharpening Type: Electric

Sitting or Standing when:

2) **Forging:** Standing
3) **Grinding/Sharpening:** Standing

Anvil Shape/Size: Square

Source of Iron: Spring steel

GPS Location Reading: 9°47’09.6”N 76°23’42.0”E

<u>Other Notes</u>

Local Weather Conditions: Hot and humid

General Demeanor: Good

Miscellaneous Notes:

This smith has an electric blower for bellows and uses electric for grinding and sharpening. The smith has made a crude power hammer to work with as well. This smith made only tools that were needed for the family business which was keeping and maintaining elephants. He made everything from the chains to hole the animals, the tools to help keep them under control, the tools to groom them and to feed them. He had several tools that I had not seen before at any one the smith's forges. He also makes his own charcoal. Even with his forge being a bit modern for Kerala it might be useful to work with him for that matter.

Blacksmith 14

Interview Information

Location of Interview: Vaikom

Interview Date: 07/04/2017

Local Time: 12:16

Interviewed By: KB with an interpreter

Data Recorded (i.e. video, audio, notes etc.): Fieldnotes and phone photos

Data Location (i.e. field notebook, computer etc.): KB’s computer and backup on dropbox

Blacksmith Information

Name: Unknown

Age: 60’s

Time as a Blacksmith: 45+ years

Smithing Heritage (i.e. family tradition etc.): Yes/No – Yes

Time Spent in Current Village/City: Whole life

Time Spent in Current Forge: 45+ years

Age of Current Forge: 45+ years

Professional Affiliations (i.e. related temples etc.): No

Do You Make our Own Charcoal: Yes/No – No

<u>Forge Information</u>

Bellows Type: Double bellows

Grinding/Sharpening Type: Hand

Sitting or Standing when:

2) **Forging:** Sitting
3) **Grinding/Sharpening:** Sitting

Anvil Shape/Size: Square

Source of Iron: Spring steel

GPS Location Reading: 9°45'36.0"N 76°23'24.0"E

<u>Other Notes</u>

Local Weather Conditions: Hot and humid

General Demeanor: Good

Miscellaneous Notes:

This smith had an old double bellows and did not use electricity for any of his forge work. He came from a long line of smiths and his forge was about 45 years old. His forge was next to his son's auto workshop. We asked him if he would be willing to work with me in the future and he said yes. We took a few photos…sadly not any of the forge area turned out. He is one of the only smith found to date that says that he will pass his skills on to a family member. He said his son knows how to forge and he will also teach his grandson.

Blacksmith 15

Interview Information

Location of Interview: Vaikom

Interview Date: 07/04/2017

Local Time: 1:00

Interviewed By: KB with an interpreter

Data Recorded (i.e. video, audio, notes etc.): Fieldnotes and phone photo

Data Location (i.e. field notebook, computer etc.): KB's computer and backup on dropbox

Blacksmith Information

Name: Unknown

Age: Unknown

Time as a Blacksmith: Unknown

Smithing Heritage (i.e. family tradition etc.): Yes/No – Yes

Time Spent in Current Village/City: Unknown

Time Spent in Current Forge: Unknown

Age of Current Forge: 80+years

Professional Affiliations (i.e. related temples etc.): Unknown

Do You Make our Own Charcoal: Yes/No – Unknown

<u>Forge Information</u>

Bellows Type: Double bellows

Grinding/Sharpening Type: Hand

Sitting or Standing when:

> **Forging:** Sitting
>
> **Grinding/Sharpening:** Unknown

Anvil Shape/Size: Square

Source of Iron: Unknown

GPS Location Reading: 9°39’36.0”N 76°25’19.2”E

<u>Other Notes</u>

Local Weather Conditions: Hot and humid

General Demeanor: Poor

Miscellaneous Notes:

This smith was located next to a modern forge. The two forges were run by brothers. The brother who worked the old forge with the double bellows and not electric would not come and talk to me due to me being English. He said he did not want to bother. His brother that ran the modern forge let us take photos and answered some questions.

Blacksmith 16

Interview Information

Location of Interview: Vaikom

Interview Date: 07/04/2017

Local Time: 3:46

Interviewed By: KB with an interpreter

Data Recorded (i.e. video, audio, notes etc.): Fieldnotes and phone photos

Data Location (i.e. field notebook, computer etc.): KB's computer and backup on dropbox

Blacksmith Information

Name: Unknown

Age: 50's

Time as a Blacksmith: 35+years

Smithing Heritage (i.e. family tradition etc.): Yes/No – Unknown

Time Spent in Current Village/City: Unknown

Time Spent in Current Forge: 35+years

Age of Current Forge: 30 years

Professional Affiliations (i.e. related temples etc.): No

Do You Make our Own Charcoal: Yes/No – No

Forge Information

Bellows Type: Double bellows

Grinding/Sharpening Type: Electric

Sitting or Standing when:

- **Forging:** Sitting
- **Grinding/Sharpening:** Standing

Anvil Shape/Size: Square

Source of Iron: Spring steel

GPS Location Reading: 9°40’12.0”N 76

Other Notes

Local Weather Conditions: Hot and humid

General Demeanor: Good

Miscellaneous Notes:

This smith was down a side street off the main road in Vaikom. He had a double bellows, but used electricity to grind and sharpen his tools. He said he came from a family of smiths and that his forge was around 30 years old. He bought his charcoal from a local man.

Blacksmith 17

<u>Interview Information</u>

Location of Interview: Kollengode (located in paddy)

Interview Date: 17/08/17

Local Time: 9:30 am

Interviewed By: KB translation by Paul

Data Recorded (i.e. video, audio, notes etc.): Notes and Photos

Data Location (i.e. field notebook, computer etc.): KB's computer and backed up on dropbox

<u>Blacksmith Information</u>

Name: Vellappan V

Age: 51

Time as a Blacksmith: Since he was 16

Smithing Heritage (i.e. family tradition etc.): Yes/No – Yes

Time Spent in Current Village/City: Born here

Time Spent in Current Forge: 5 years

Age of Current Forge: 5 years

Professional Affiliations (i.e. related temples etc.): Local temple

Do You Make our Own Charcoal: Yes/No – No, buys from market

<u>Forge Information</u>

Bellows Type: Double Bellow

Grinding/Sharpening Type: Hand

Sitting or Standing when:

- **Forging:** Sitting
- **Grinding/Sharpening:** Sitting

Anvil Shape/Size: Iron from a steam engine

Source of Iron: Scrap

GPS Location Reading: 10°36.198‘N 76° 39.364’E

<u>Other Notes</u>

Local Weather Conditions: Hot and Humid

General Demeanor: Good

Miscellaneous Notes:

Blacksmith 18

Interview Information

Location of Interview: Kollengode (located by back of wall of family temple #1)

Interview Date: 18/08/17

Local Time: 11:12 am

Interviewed By: KB and interpreted by Stubert

Data Recorded (i.e. video, audio, notes etc.): Notes and Photos

Data Location (i.e. field notebook, computer etc.): Notes typed stored on KB computer. Photos on KB computer and both backed up on dropbox

Blacksmith Information

Name: Murali M

Age: 49

Time as a Blacksmith: 30 years, started working at the age of 19

Smithing Heritage (i.e. family tradition etc.): Yes/No – Yes

Time Spent in Current Village/City: Born in village (said he worked in Tamil Nadu for 10 years then moved back)

Time Spent in Current Forge: 20 years (he built)

Age of Current Forge: 20 years

Professional Affiliations (i.e. related temples etc.): Family and local temple

Do You Make our Own Charcoal: Yes/No – No, buy from market

<u>Forge Information</u>

Bellows Type: Double Bellows

Grinding/Sharpening Type: Hand

Sitting or Standing when:

- **Forging:** Sitting
- **Grinding/Sharpening:** Sitting

Anvil Shape/Size: Round

Source of Iron: Scrap (leaf)

GPS Location Reading: 10°36.15’N 76°39.322’E

<u>Other Notes</u>

Local Weather Conditions: Hot Humid

General Demeanor: Good

Miscellaneous Notes:

Related to Krishnan Kutty T.P. is his uncle on his mother’s side

Kerala Blacksmith 19

Interview Information

Location of Interview: Kollengode

Interview Date: 18/08/17

Local Time: 10:40 am

Interviewed By: KB and Stubert

Data Recorded (i.e. video, audio, notes etc.): Fieldnotes and photos

Data Location (i.e. field notebook, computer etc.): On KB's computer and backed up on dropbox

Blacksmith Information

Name: Kandamuthan C

Age: 61

Time as a Blacksmith: from the age of 15

Smithing Heritage (i.e. family tradition etc.): Yes/No – Yes

Time Spent in Current Village/City: Born in the village

Time Spent in Current Forge: 16 years

Age of Current Forge: 16 years

Professional Affiliations (i.e. related temples etc.): Family temple

Do You Make our Own Charcoal: Yes/No – Buys from Tamil Nadu and is made from the Kariulekm tree.

<u>Forge Information</u>

Bellows Type: Electric (leaf blower for yard work)

Grinding/Sharpening Type: Hand and electric

Sitting or Standing when:

- **Forging:** Sitting
- **Grinding/Sharpening:** Normally sitting, but standing when using electric grinder

Anvil Shape/Size: Rectangle

Source of Iron: Scrap

GPS Location Reading: 10°36.156’N 76°39.334’E

<u>Other Notes</u>

Local Weather Conditions: Hot and humid

General Demeanor: Good

Miscellaneous Notes:

Krishnan Kutty’s cousin on his father’s side

Kerala Blacksmith 20

Interview Information

Location of Interview: Pachattiri(Kollengode)

Interview Date: 23/08/17

Local Time: 7:00 pm

Interviewed By: KB and Paul

Data Recorded (i.e. video, audio, notes etc.): Fieldnotes, photos

Data Location (i.e. field notebook, computer etc.): Notes and photos on KB's computer and backed up in dropbox

Blacksmith Information

Name: Krishnan Kutty T.P.

Age: 72

Time as a Blacksmith: From the age of 15

Smithing Heritage (i.e. family tradition etc.): Yes/No – Yes

Time Spent in Current Village/City: 12 years at current house and born in the village

Time Spent in Current Forge: 12 years

Age of Current Forge: 12 years

Professional Affiliations (i.e. related temples etc.): None

Do You Make our Own Charcoal: Yes/No – Yes. Buys coconut from the local store and makes from that

<u>Forge Information</u>

Bellows Type:

Grinding/Sharpening Type:

Sitting or Standing when:

- **Forging:**
- **Grinding/Sharpening:**

Anvil Shape/Size:

Source of Iron:

GPS Location Reading: 10°54.005'N 75°54.176'E

<u>Other Notes</u>

Local Weather Conditions:

General Demeanor: Good

Miscellaneous Notes:

Recorded a formal interview with BS. His forge was over run and collapsing.

Managed to get a small survey of the forging area.

Kerala Blacksmith 21

Interview Information

Location of Interview: Pattampy (Tirur)

Interview Date: 23/08/17

Local Time: 3:45 pm

Interviewed By: KB and Stubert

Data Recorded (i.e. video, audio, notes etc.): Fieldnotes and photos

Data Location (i.e. field notebook, computer etc.): On KB's computer and backed up on dropbox

Blacksmith Information

Name: Vanugopal N.P.

Age: 63

Time as a Blacksmith: 51 years

Smithing Heritage (i.e. family tradition etc.): Yes/No – yes

Time Spent in Current Village/City: Was born in the village

Time Spent in Current Forge: 51 years

Age of Current Forge: Several generations ago (*see notes below)

Professional Affiliations (i.e. related temples etc.): No

Do You Make our Own Charcoal: Yes/No – Both, will make his own out of coconut and also buys

<u>Forge Information</u>

Bellows Type: Crank

Grinding/Sharpening Type: Hand

Sitting or Standing when:

- **Forging:** Sitting
- **Grinding/Sharpening:** Sitting

Anvil Shape/Size: western style (90 Kg)

Source of Iron: Spring Steel (scrap)

GPS Location Reading:

<u>Other Notes</u>

Local Weather Conditions: Hot and humid

General Demeanor: Good

Miscellaneous Notes:

He also makes brass swords for different temple festivals. These are requested by the individual involved in the temple festivities and not the temple itself. He changed his bellows from double bellows to crank around 30 years prior. x

A.3 Fieldwork Ethics

All participates will be informed that I am undertaking PhD research for my thesis and which institutions I represent. They will be informed about my research and what their part in it would be should they chose to participate. They will also be told they will be compensated for the items they make during the research and for the time spent. They will be informed of how they will be documented and if this is ok. No taboos about video, audio or photos are held in any of the areas I will be working. Some of the participants will also be asked if I would be able to measure areas around the forge and take photos and details about the tools they use. This decision will be based on the approximate age the forge has been in use. They will also be asked if they will mind me asking several questions pertaining to their blacksmithing and blacksmithing history in the area. These questions will be conducted in a very informal way and through a translator. If I am to bring a form and read questions from this, I am afraid once again this may seem a bit too formal and may intimidate the blacksmiths. I will keep a list of the basic questions in my notebook to look at to make sure all questions are covered and not to look like I am reading a formal document. All questions and answers will be documented through either video/ audio or both. These questions will be asked each time I work with them. At any time if the participants say they do not agree with any or all of the questions then adjustments will be made to the information that will be used. Below can be found the basic questions I will be asking.

1) Would you be willing to participate with my research?

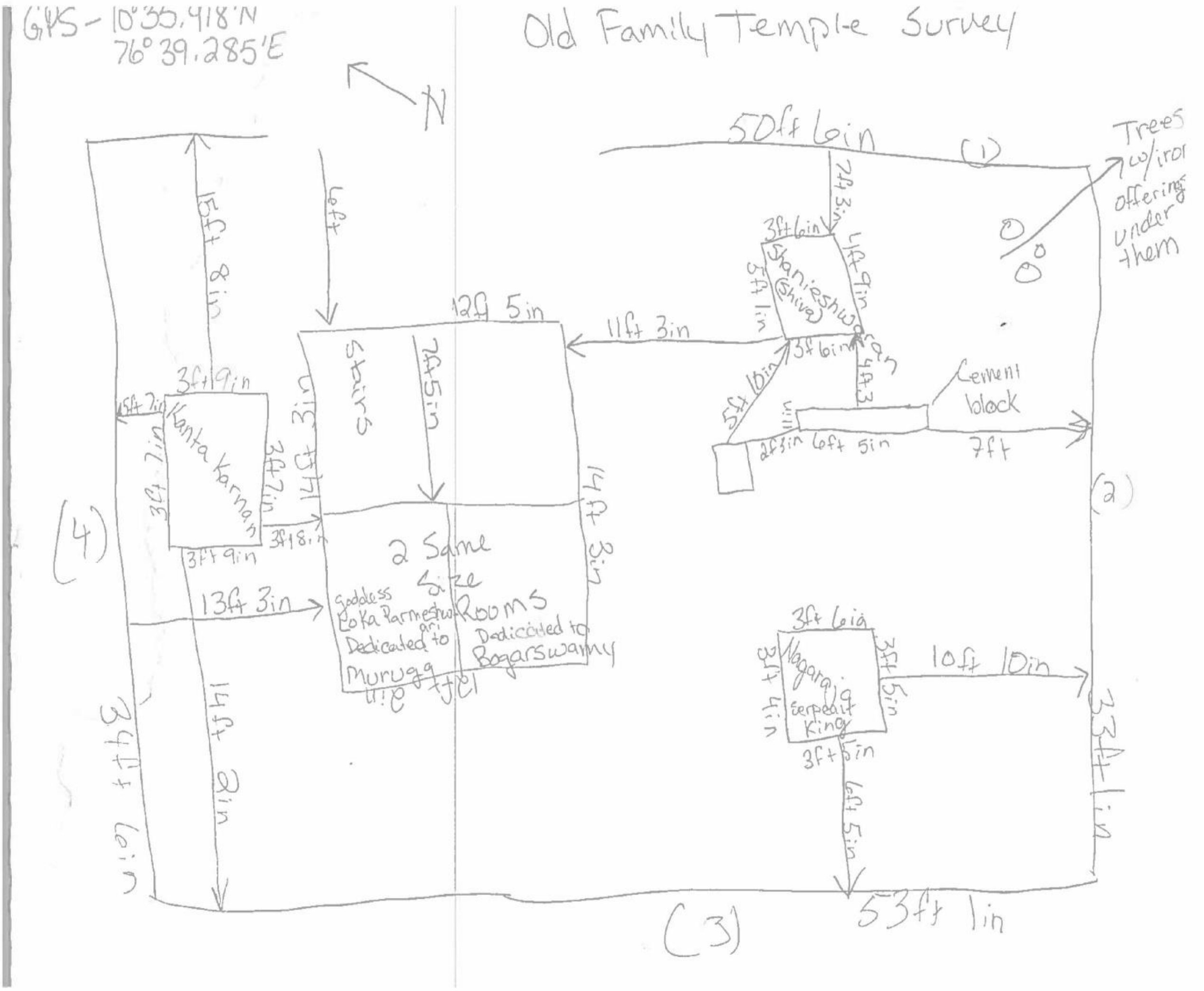
2) Are you ok with me taking photos, video, audio and written documentation.

3) Do you give consent for this information to be published? Including names, genealogy and basic location?

4) Will it be ok to ask you many questions about your blacksmithing and history?

5) Will it be ok to measure and document the forge area and tools?

A.4 Family Temple Survey Notes



burial Lady who started the temple
Thambatty Muthi

Nobody remembers what year she was buried as it was many years ago

Small shrine next to hers is believed to be for a male frind of hers


(3)
22ft 8in
Parmashaury
maha vashnu
6ft
6ft
6ft
(2)
8ft 6in
(4)
murkan
8ft 6in
66ft 6in
56ft 2in
44ft
(1)
Family temple (#2)

40 Ft 3in to door of Forge (by front of Temple)

67 ft 4in forge to Gate
Gate to temple door 39 ft 11 in

GPS
old Forge Ruin — 10° 36.139'N 76° 39.347'E
Forge front of Temple — 10° 36.156'N 76° 39.334'E
Temple — 10° 36.145'N 76° 39.333'E
Forge behind temple — 10° 36.151'N 76° 39.322'E

A.5 Damodara Sarma (Pujari) Interview Transcripts

Name: Damodara Sarma

Age: 70

Title in the Temple: Oorayma – means Owners of the Temple. But temple was taken over by the government of Cochin state in 1905

How many people are associated with the temple? Worship/Work/Live

Around 2000 families are there who comes here for worshipping. Around 25 people work in the temple.
Every day 25 people work here.

What is your job within the temple? Daily/Weekly:

Our work includes opening the temple, lighting the lamp, taking the diety for a procession around the Sreekovil (the sanctum sanctorum)

How long has your family been associated with this temple?

Right from the very beginning of the temple (say around 800 years)

Can you tell us a little about the beginning or history of the temple?

It is believed that the statue of diety made of stone was originally in Thiruchendur in Tamil Nadu. The statue got damaged and it was thrown into the sea. The stone statue floated in the sea and reached this place. The statue was installed here and temple was erected. Story says that 5 arrows were shot in different directions and the arrow which stuck here could not be removed so the temple was constructed here.

Who is the main presiding deity of this temple?Others?

Lord Subramanya who is also known in different names like Lord Muruga, Lord Shanmuga etc..

Is there any association of the blacksmiths with Lord Muruga?

There is no such association as far as I know. Lord Muruga is mostly worshipped more in Tamil Nadu and the blacksmiths in Kollengode, because of the close proximity to Tamil Nadu might have worshipped Lord Muruga. Normally the blacksmiths in Kerala worship other Gods like Lord Vishnu, Lord Shiva etc..

Any history about Lord Muruga?

Lord Muruga is Lord Shiva's son. Lord Muruga also known as Lord Subramanya. Subramanya means a person with complete knowledge of all the Vedas. Mythologically he is son of Shiva and Parvathy. It is believed that the Universe had Devas and Asuras (Gods & Demons). An Asura called Tarakasura prayed to Lord Bhrama for immortality and got a boon that he will die only if a child below 6 years can kill him. Lord Muruga, when he was below 6 years of age killed this Asura. The philosophical meaning is that by knowledge only you can defeat evil powers. Ignorance can be overcome only by knowledge. In Hindu religion every diety has philosophical background.

How did the crafters become associated with the temple?

From the very construction of the temples the carfters are associated with temple. Crafters like Masons, Carpenters, Blacksmiths, bronze smiths and goldsmiths were given land here by the then administrators. In olden days there were no means of communication so the crafters were given land here so they could stay here and do the construction work.

What types of crafters worked for the temple?

Crafters like Masons, Carpenters, Blacksmiths, bronze smiths and goldsmiths. Sculptors also were there. Then there were washermen, soldiers to protect the temple. The Temple was under the administration of a group called as Sanketha which was selected by the people of the place. The King could not interfere in the running of the temple. The sankethas had the power even to fine the king for any mistakes done by his people.

Do you know what the largest number of crafters associated with the temple were?

It was a huge construction and that too before so many years so can't give a figure.

In the beginning, what was the crafters jobs and payment for the work done?

The crafters were given land. The remuneration they were given was rice. The initial temple was not big as the present temple. The present temple was constructed 200 years back. There was no coins or money in that period so the wages were paid as rice, paddy etc. They were paid accordingly to the job and the rice was measured in measuring vessel called Nazhi, Edangazhi and the Para.
4 nazhi made an Edangazhi and 10 edangazhi made a Para.

How many crafters now?

Now only the blacksmith and carpenter is here.

How has the crafters jobs and payment changed over the years?

Now the crafters are paid in money.

A.6 Blacksmith Interview Transcript- Chellappan

Name: Chellapan

Age:

How long have you been a blacksmith?

I started at the age of 16. I have not learned much.

Who did you learn your blacksmithing skills from? (what age)

I learnt from my uncle (father's younger brother). My father was a blacksmith, but fell ill (Leporsy) at my very young age so I learned mainly from my uncle and bit from my cousin brothers who were all blacksmiths.

What were the first jobs given to you?

I made knifes used in the tea estates. There were quite a lot of tea and coffee estates some kilometers from here and we used to get lot of orders for making such knifes which were used there.

How did these jobs change as time progressed?

Lot of changes have happened over the years. During my younger days we had to beat big chunks of iron scrap. But now we can get the scrap in thinner sizes or get hammered into required sizes and then start the work.

What is your first memory associated with blacksmithing?

I have made koduval (big knife)as well as Mangalapuram knife, Shornur knife, Thengasi knife. I have made knifes required in the estates. Nowadays nobody makes such knifes. We used to get drawings of knifes and we made them accordingly.

Did you ever learn/train/work with any other smith?

How long did you learn? What age did you begin to work on your own? Or how many years did you have smithing training?

My father and my uncle had their forges around here and right from my very young age I was helping them and learning from them. I started to work on m own at the age of 16.

How long has you/your family lived in the village?

Right from my birth Iam staying here. My father , my grandfathers all lived here.

How long has your family been blacksmiths?

We have been blacksmiths from my forefathers time. Don't know exactly the period.

Where is your forge?

My forge is right there. Since last 3-4 years Iam not working
How long has it been located there?
It has been there since 1971.

As a smith, what was the most common object you made?

I have made many things but the most common things that I have made is Mullu Kothu (estate knife) and Kada Para (a tool to dig sand or make big holes in the estates to plant trees.

What was your favorite thing to make?

Nothing like that. All my work were favorite to me. I used to get orders from estates and I did all the jobs or orders given to me.

How has the village/blacksmiths in the area changed since you were young?

The Village has’nt changed much.

How many smiths are working now compared to when you were young?

There were quite a lot of blacksmiths. Now only a few are doing this job. From my family itself there were lot of smiths. No nobody from the new generation want to do this job. Even my children are not in this job.

How has the work the smiths are doing changed over the years?

Only minor changes have happened. The changes are now we get the scrap in thin slices. Except that the work is the same.

Has smithing work become more solitary? (ie did smithing work used to be more of group/striker related)

Yes. Earlier we used to work in groups, but now it has become more solitary.

Have the tools or forge area used changed over the years?

The forge has not changed. Tools earlier we used to make own tools like file etc which we now buy from the store.

Have the materials used changed? (bloom/scrap, charcoal -store bought/self-made)

Yes. Earlier we used to make things from big chunks of iron like axle of big vehicles, but now mostly springs (leaf) of vehicles are used. We used to make big axes and knifes (Elavanchery Koduval) which were quite famous. The charcoal has also changed. The charcoal earlier were big pieces.
We have not bought iron from the smelters. We used to get the scrap from Pallakkad town. The mail scrap earlier were Axle and wheel drums of big lorries.

Has how the smiths are paid changed?

Right from when I started working we are getting paid in cash for the work done by us. But during my father's young age they were paid in Rice grains.
What is the blacksmiths association with the local temple?

It is our own community temple.

Has that changed over the years?

Nothing has changed.

Do you recall any folk stories relating to blacksmiths? Any songs?

There were lot of songs. We have played lot of dramas and I have acted in the role of Raja Harichandra. There were lots of songs also. Whenever I was working in the forge I used to hum the songs.

If so can you sing/relay them?

Singing a folk song from the drama Raja Harischandra and the song is about the princess.

Is there anything else you would like people to know about the blacksmithing heritage of your village?

Nothing. Our Village Elavanchery earlier had 71 families of our community

A.7 Blacksmith Interview Transcript- Krishnan Kutty

Name: Krishnankutty T. P

Age: 72

How long have you been a blacksmith?

From the age of 15.

Who did you learn your blacksmithing skills from?

From my father.

How long have you/your family lived in the area?

In this house since 12 years. But in this area since my birth.

How long has your family been blacksmiths?

We have been blacksmiths since my forefather’s time.

Where is your forge?

Here in my house

How long has it been located there?

12 years

Who did you learn your blacksmithing skills from? (what age)

What were the first jobs given to you?

I started by fixing handles of the fish knifes and vegetable knifes

How did these jobs change as time progressed?

Lot of changes has taken place. Now modern machines have taken over our job. Earlier we used to make big tools by hitting the heavy metal pieces ourselves. Now there is power hammer to get the metal spread.

What is your first memory associated with blacksmithing?

My father and my brothers were all blacksmiths. I remember making small fish knife at a very young age.

Did you ever learn/train/work with any other smith?

No. I learned from my father.

.
How long did you learn? What age did you begin to work on your own? Or how many years did you have smithing training?

I have studied in school only till the 7th class. After that I joined with my father and started helping hime in the forge. I was the eldest child in my family and had 6 younger siblings. So it was a time of poverty so had to stop studying and helped my father.

As a smith, what was the most common object you made?

Earlier the most commonly made objects were Carpenters chisel, Coconut climbers knife, Goldsmith's knife and the tongs for the bronze smith's, big tools to cut stones. But now I make a special knife called
Malapuram knife.

What was your favorite thing to make?

All the objects that I make are favourite to me. However now I prefer making the special knife called Malapuram knife and a ornamental door lock called Manichitra Thazhu.
How has the blacksmiths in the area changed since you were young?

How many smiths are working now compared to when you were young?

Apart from me there are no traditional blacksmiths in this area now. There are few modern ITI's where they do the tools using modern machines.

How has the work the smiths are doing changed over the years?

Now there are modern tools for drilling, cutting grinding etc. Earlier we used make holes in the keys using this tool called Valikunna Vaar instead of a drill.

Have the tools or forge area used changed over the years?

Yes modern tools have taken over now. But I still use the old tools and old methods.

Has smithing work become more solitary? (ie did smithing work used to be more of group/striker related)

Yes we used to have two or three people working in the forge. One person to beat the iron scrap, one person to rotate the wheel of the blower and one person to do the forging. No it has become solitary.

Have the materials used changed? (bloom/scrap, charcoal -store bought/self-made)

Not much. Earlier the mostly used scrap were big springs from Vehicles, but now we get the same in thinner sizes.

Has how the smiths are paid changed?

Earlier the price we got for the objects that we made were very less. Nowadays we get better price.

Can you tell something about the Malapuram Knife?

Malapuram Knife is quite famous. You can get normal knifes, but it is difficult to get this Malapuram knife. It was mostly used by the Muslims of Malapuram. They used to wear a thick belt and the belts had a separate pocket to hold this knife. They used it to cut the Beetel nuts into small pieces. It is made from solid spings of vehicles. It takes about 7 days to make one. There are brass engravings on the knife and it comes with a beautiful handle.

What is the handle of this knife made of?

Earlier the handles were made of deer horn. But now since it is illegal to use deer horns we use expensive wood to make the handle.

What wood do you use for the handle?

We use Rose wood to make the handle.

Last time I was here you told me the story about the cups used to hold water. Would you mind telling the whole story again?

The story is that the king asked the carpenter, the blacksmith, the goldsmith, the cobbler and the bronze smith to make a cup. The carpenter made a cup from wood, the blacksmith made a cup from iron, the gold smith made a golden cup, the cobbler made a cup from leather and the bronze smith made a bronze cup. They were then asked to fill water in the cups they made. After few days when the cups were checked it was found that leather cup was full of worms. The King then discarded the Cobler clan from the community and from then the cobbler clan is considered to be a lower clan. But now it has all changed.

Do you recall any other folk stories relating to blacksmiths? Any songs?

Don’t remember any songs

If so can you sing/relay them?
-

Is there anything else you would like people to know about your blacksmithing heritage?

No. The new generation is not interested to do this job as it requires lot of hardship. Nowadays there are modern machines so no one is interested. Out wages are also a big issue. Some tools take days to finish, but we have a certain fixed price for the objects, so even if we do it in 3 days or 6 days we get the fixed price only.

Did your women go for any other work?

No our women helped us in the forge by turning the blower forge.

Did you have any special celebrations? How did you celebrate?

We didn’t have any special celebration. We celebrated Onam & Vishu. We used to drink toddy and enjoy.

A.8 Forge Survey Field Notes- Vypin

Smithy Survey

Basic Survey Information

Location of smithy: Vipin

Survey Date: 26/08/17

Local Time: 12:15 pm

Surveyed by: KB, Paul, Tom

Data Recorded (i.e. video, audio, notes etc.):

Data Location (i.e. field notebook, computer etc.):

Owner of smithy:

Basic Smithy Information

Bellows Type: Double Bellows

Grinding/Sharpening Type: hand

Sitting or Standing when:

- Forging: Sitting
- Grinding/Sharpening: Sitting

Anvil Shape/Size: 2 Anvils on odd shape one square

Source of Iron: Scrap

GPS Location Reading: 10°1.854'N ~~#~~ 76°13.373'E

map 5cm=1m

Measurements of Smithy

Area: map

-Wall 1: 8ft 5in (2.6m)

-Wall 2: 11ft 5in (3.5m)

-Wall 3: 5ft 2in (1.6m) 8 7

-Wall 4: 4ft 6in (1.4m)

wall5: 11ft (3.4m)

Anvil:5 (1+2) Anvil 1 is closest to the forge

-Top: (1ft 10in X 1ft) (10in X 10in) (.56m X .30m) 2.8 X 1.5 (.25m X .25m) 1.3 X 1.3

-Hight: (1¼ inch) (1¼ inch)

-Location in Smithy

-Wall 1 to midpoint: (1) (6ft 4in) (2) (5ft 1in) (1) 9.5 (1.90m) (2) 7.5 (1.5m)

-Wall 2 to midpoint: (3ft 11in) (3ft 7in) (1.12m) (1.1m) 6 5.5

-Distance from midpoint to midpoint of-

-Hearth: (2ft 11in) (4ft 2in)

-Smith Stool: (2ft 5in) (2ft 10in)

Hearth:

-Top (5in X 4in) (.13m X .10m) .65 X .50

-Hight 3in

-Location in Smithy

Grinding/Sharpening Location

Stool:

Same area as smithing

-Top

-Hight

-Location in Smithy

-Wall___________to midpoint:

-Wall___________to midpoint:

-Tools:

Other Notes

Local Weather Conditions:

General Demeanor:

Miscellaneous Notes:

Anvil #1 was Round now after time + use is odd shape and about a foot undu ground

Anvil #2 is about 1/2 foot undrground

* Bellows —

Top: (2ft 5in X 1ft 1in) (.74 mX .33m)
3.7 X 1.65

hight: 1ft 3in

Location:

Wall 1 — 11ft 3in (3.4m) 17
Wall 5 — 4ft 9in (1.4m) 7

Stick for bellows —
6ft 2in

Hearth

-Wall 1 to midpoint: 9ft 2in (2.8m) 14

-Wall 2 to midpoint: 4ft 3in (1.3m) 6.5

-Distance from midpoint to midpoint of-

-Anvil: (2ft 11in) (4ft 2in)

-Smith Stool: (2ft 11in)

Smith stool:

-Top: (1ft x 10in) (.30m x .25m) 1.5 x 1.3

-Hight: 3 1/4 in

-Location in Smithy

-Wall 1 to midpoint: 7ft 5in (2.3m) 11.5

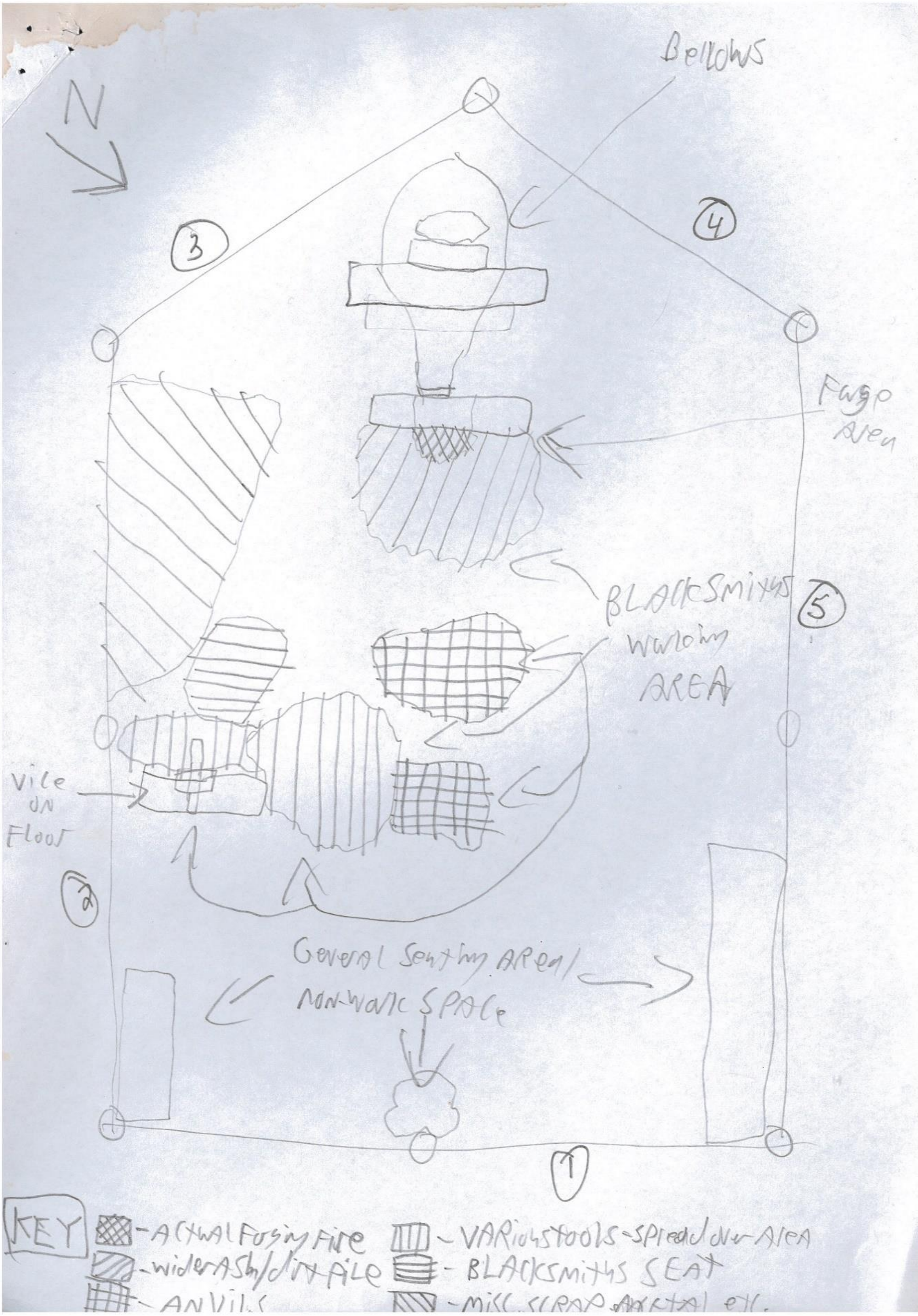
-Wall 2 to midpoint: 1ft 10in (.56m) 2.8

-Distance from midpoint to midpoint of-

-Hearth: (2ft 11in)

-Anvil: (2ft 5in) (2ft 10in)

-Tools:



N
Bellows
3
4
Forge Area
BLACKSMITHS WORKING AREA
5
Vice on Floor
2
General Seating Area/
non-work SPACE
1
KEY
- Actual Forging Fire
- VARIOUS TOOLS - SPREAD OVER AREA
- wider Ash/dirt pile
- BLACKSMITHS SEAT
- ANVILS
- MISC. SCRAP METAL etc.

A.9 Forge Survey Field Notes- Toddy Shop- Kollengode

Toddy Shop

Smithy Survey

Blacksmith #9

Basic Survey Information

Location of smithy: Kollengode

Survey Date: 16/08/17

Local Time: 4:25 pm

Surveyed by: KB, TR, Paul

Data Recorded (i.e. video, audio, notes etc.):

Data Location (i.e. field notebook, computer etc.):

Owner of smithy:

Basic Smithy Information

Bellows Type: Double Bellows

Grinding/Sharpening Type: hand

Sitting or Standing when:

- Forging: Sitting
- Grinding/Sharpening: Sitting

Anvil Shape/Size: Square

Map
5cm = 1m

Source of Iron: Scrap (sprig Steel) from nearby village

GPS Location Reading:

10° 36, 428'N
76° 39, 268'E

(1)

Measurements of Smithy

Area:

map

-Wall 1: 9ft 5in (2.9m) 14.5

-Wall 2: 14ft 1in (4.3m) 21.5

-Wall 3: 9ft 11in (2.8m)

-Wall 4: 14ft 1in (4.3m)

Anvil: 7in x 7in = .18m x .18m

.9

-Top: 18 cm x 18

-Hight: 10 cm = 3.9in .10m

-Location in Smithy

map

-Wall 4 to midpoint: 5 ft 2 in (1.6m) x 5 = 8

-Wall 1 to midpoint: 6ft 11 in (1.9m) = 9.5

-Distance from midpoint to midpoint of-

-Hearth: 1ft 7in (.52m) = 2.6

-Smith Stool: 2ft 5 in (.76m) = 3.8

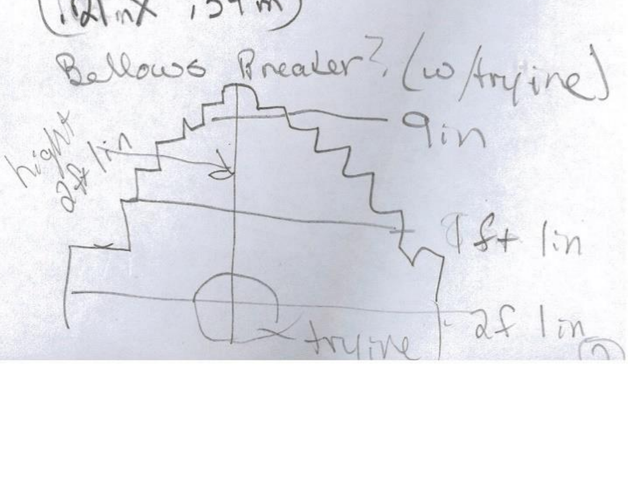
Hearth:

1.0 x 1.7

-Top – .62in x 1f 1in (.21m x .34 m)

-Hight 5 in

-Location in Smithy



Map

-Wall 4 to midpoint: 5ft 1in (1.5m) = 7.5

-Wall 1 to midpoint: 8ft 10in (2.5m) = 12.5

-Distance from midpoint to midpoint of-

-Anvil: 1ft 9in

-Smith Stool: 2ft 9in

Smith stool:

-Top: 6in X 1ft (.18m X .30m)
.9 X 1.5

-Hight: 1in

-Location in Smithy

-Wall 2 to midpoint: 3ft 1in (.94m) = 4.7

-Wall 1 to midpoint: 7ft (2.1m) = 10.5

-Distance from midpoint to midpoint of-

-Hearth: 2ft 9in (.88m) = 4.4

-Anvil: 2ft 5in (.76m) = 3.8

-Tools:

(3)

Grinding/Sharpening Location

Stool: uses same location as when forging

-Top

-Hight

-Location in Smithy

-Wall___________to midpoint:

-Wall___________to midpoint:

-Tools:

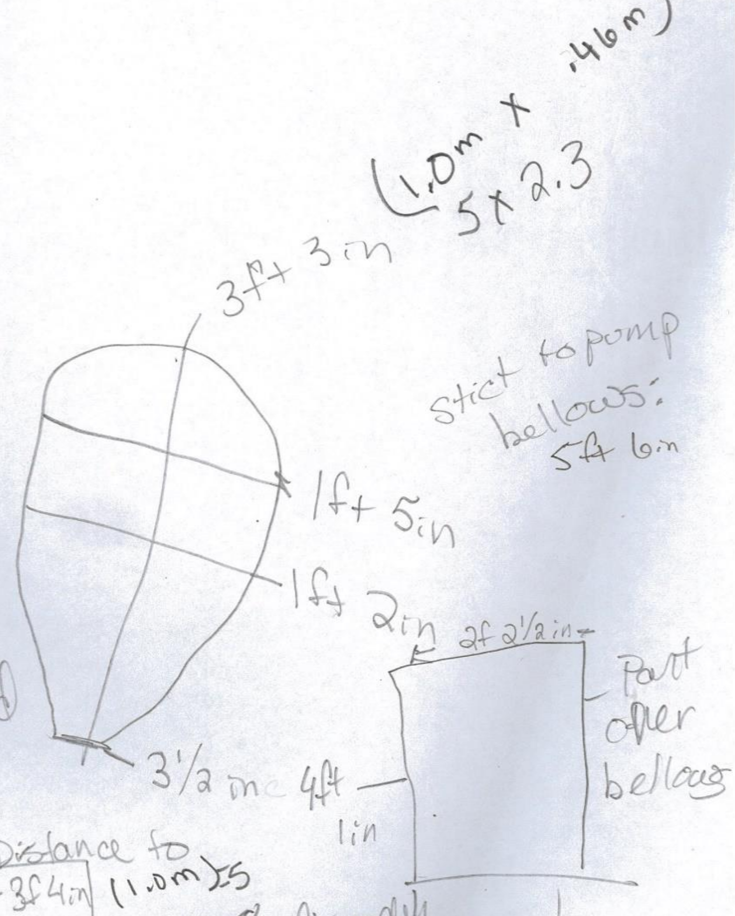
Other Notes

Local Weather Conditions:

General Demeanor:

Miscellaneous Notes:

Bellows:

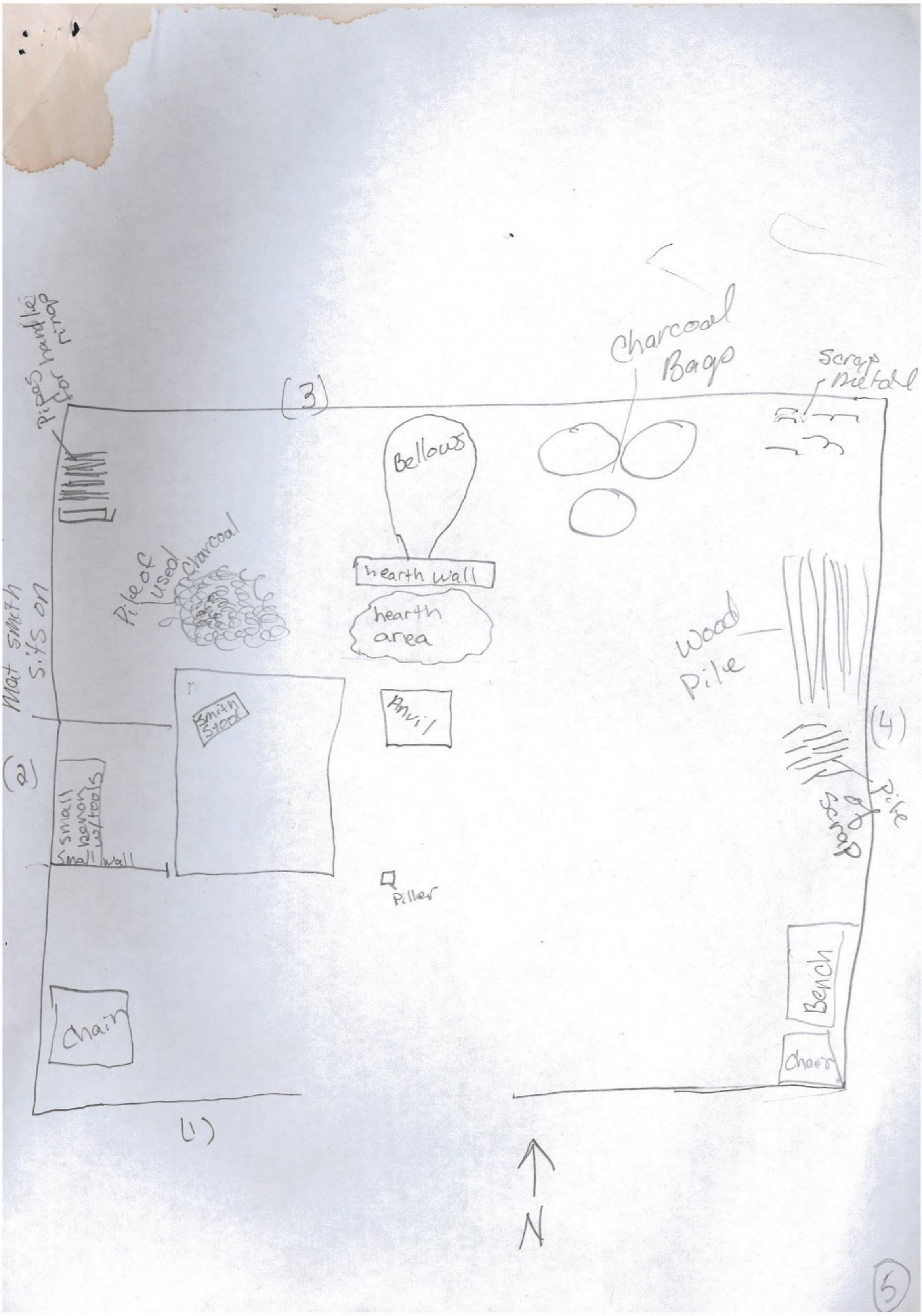


hight top wood to bottom wood is 1ft 9in

Distance to

wall 3 - 3f 4in	(1.0m) 1.5
wall 4 - 5f 4in	(1.6m) -8

4


Pipes for handle ring
Mat smith sits on
(3)
Bellows
Charcoal Bags
Scrap metal
Pile of used charcoal
hearth wall
hearth area
Wood Pile
Smith Stool
Anvil
(2)
small bench w/tools
small wall
(4)
Pile of scrap
Piller
Bench
Chair
Chair
(1)
N
5

A.10 Forge Survey Field Notes- Large Hut - Kollengode

BS #11

Smithy Survey

Large Hut!

Basic Survey Information

Location of smithy: Kollengode

Survey Date: 19/08/17

Local Time: 10:20 am

Surveyed by: KB and Stu

Data Recorded (i.e. video, audio, notes etc.):

Data Location (i.e. field notebook, computer etc.):

Owner of smithy:

Basic Smithy Information

Bellows Type: Double Bellows

Grinding/Sharpening Type: hand

Sitting or Standing when:

- Forging: Sitting
- Grinding/Sharpening: Sitting

Anvil Shape/Size:

Source of Iron: Scrap.

GPS Location Reading:
10° 36.377'N
76° 39.442'E

5cm = 1 meter

Measurements of Smithy

Area:

-Wall 1: 11ft 2in map (3.4 m)

-Wall 2: 16ft 6in (5.0 m)

-Wall 3: 11ft 3in (3.4 m)

-Wall 4: 16ft 3in (5.0m)

Anvil: weight 65Kg

-Top: 1ft 4in X 1ft (.43m X .30m) 2.5 X 1.5

-Hight: 4in (.12m)

-Location in Smithy

-Wall 4 to midpoint: 5 ft 2in (1.6m) 8

-Wall 3 to midpoint: 7 ft 3in (2.2m) 11

-Distance from midpoint to midpoint of-

-Hearth: 2ft 10in

-Smith Stool: 2ft 5in

Hearth:

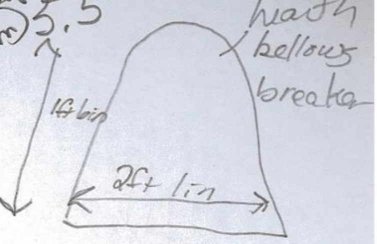
-Top 2ft 3in X 9in (.70mX .27m) 3.5 X 1.3

-Hight 1 inch (.03m)

-Location in Smithy

-Wall___4___to midpoint: 3ft 7in (1.1m) 5.5 map

-Wall___3___to midpoint: 4 ft 2in (1.3m) 6.5



-Distance from midpoint to midpoint of-

-Anvil: 2 ft 10 in

-Smith Stool: 3 ft 1 in

Smith stool:

-Top: 1ft 1in X 8in (.33m X .24m) 1.65 x 1.2

-Hight: 3in (.91m)

-Location in Smithy

-Wall___3___to midpoint: 5ft 9in (1.8m) 9

-Wall___2___to midpoint: 4ft 6in (1.4m) 7

-Distance from midpoint to midpoint of-

-Hearth: 3ft 1in

-Anvil: 2ft 5in

-Tools:

Bellows   map

hight - 2ft (.60m)

width x Length - 1ft 3½ inc X 3ft
(.40m X .91m)
2 + 4.55

Locatoon

Wall 4 to midpoint 2ft 1in (.64m)
3.2

Wall 3 to midpoint 2ft 1in (.64m)
3.2

Grinding/Sharpening Location

Stool:

-Top 1ft 3in X 7in (.40m X .21m) maf 2 x 10.05

-Hight 3in

-Location in Smithy

-Wall 1 to midpoint: 2ft 4in (.73m) 3.65

-Wall 2 to midpoint: 4f 8in (1.5m) 7.5

-Tools:

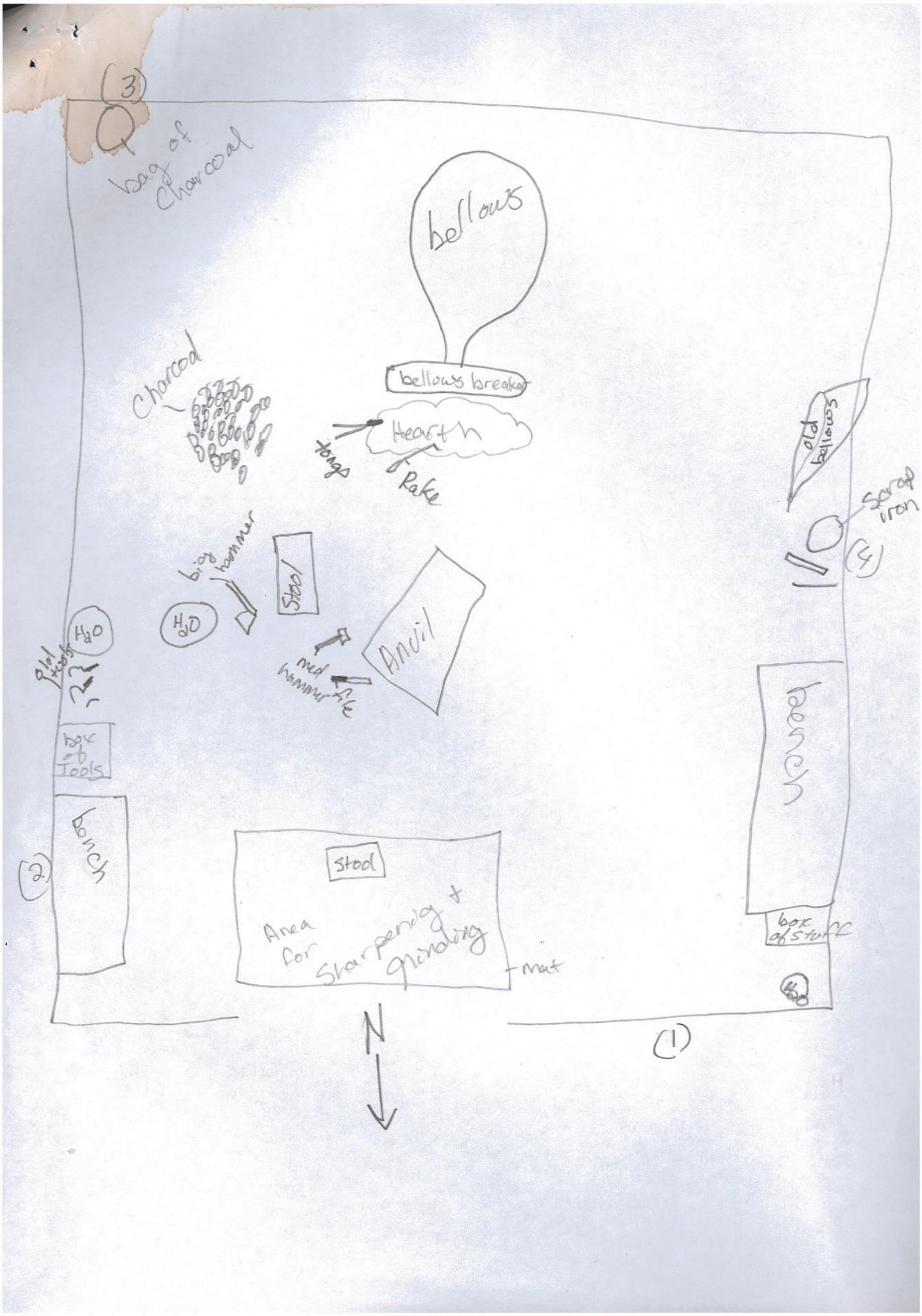
Other Notes

Local Weather Conditions: humid

General Demeanor: Good

Miscellaneous Notes:

Vallaramkal (white stone he used for sharpening) bought at pharmacie Aravadic


(3)
bag of Charcoal
bellows
bellows breaker
Charcoal
Hearth
tongs
Rake
old bellows
scrap iron
(4)
big hammer
Stool
Anvil
H2O
H2O
old tools
med hammer
file
box of Tools
bench
bench
(2)
Stool
Area for Sharpening + grinding
mat
box of Stuff
N
(1)

A.11 Forge Survey Field Notes- Abandoned Forge

*When did he abandon the forge? OR how long has it been sitting w/o use? *3 years

Smithy Survey

Basic Survey Information

Location of smithy: Kollengode
older smith

Survey Date: 17/08/17

Local Time: 10:30

Surveyed by: KB + StU

Data Recorded (i.e. video, audio, notes etc.):

Data Location (i.e. field notebook, computer etc.):

Owner of smithy:
have complete interview w/ him.

Basic Smithy Information

Bellows Type: Double bellows

Grinding/Sharpening Type: Hand

Sitting or Standing when:

- Forging: Sitting
- Grinding/Sharpening: Sitting

Anvil Shape/Size:

Source of Iron: Scrap

GPS Location Reading:
10°36.139'N
76°39.347'E

map
5cm = 1m

①

Measurements of Smithy

Area:

-Wall 1: 10 ft 5 in - (3.2m)

-Wall 2: 11 ft 5 in (3.5m)

-Wall 3: 10 ft 5 in (3.2m)

-Wall 4: 11 ft 2½ in (3.4m)

Anvil: horn

-Top: 2 ft 3 in X 6 in (.68cm X 15.2m)

-Hight: 4 inch (.12m)

-Location in Smithy

-Wall 1 to midpoint: 3 ft 9 in (1.2m) +5 map =6

-Wall 4 to midpoint: 5 ft 9 inch (1.8m) +5 =9

-Distance from midpoint to midpoint of-

-Hearth: 3 ft 6 in (1.1m)

-Smith Stool: 1 ft 8 in (.55m)

Hearth:

-Top 1 ft 5 in X 1 ft 5 in (.46 X .46 m) 43.0cm x 43.0cm

-Hight N/A

-Location in Smithy

215

1cm = 20cm rw

1cm = .5m

(2)

map

-Wall 2 to midpoint: 4 ft 10 in (1.35 m) vs 6.5

-Wall 1 to midpoint: 6 ft 11 in (1.9m) vs 9.5

-Distance from midpoint to midpoint of-

-Anvil: 3 ft 6 in (1.1m)

-Smith Stool: 4 ft 5 in (1.4m)

Smith stool:

-Top: 1 ft 2 in X 8 1/2 in (.37 X 2.4 m)

35cm X 21.0 cm

-Hight: 2 in (.06)

map → 175 X 105 map/5

-Location in Smithy

-Wall 1 to midpoint: 3 ft 4 in (1.0m)

-Wall 4 to midpoint: 4 ft 1 in (1.2m) 6

-Distance from midpoint to midpoint of-

-Hearth: 3 ft 6 in (1.1m)

-Anvil: 1 ft 8 in (.55m)

-Tools:

(3)

Grinding/Sharpening Location

Stool:

-Top

-Hight

-Location in Smithy

-Wall___________to midpoint:

-Wall___________to midpoint:

N/A

-Tools:

Bellows Back →

Other Notes

Local Weather Conditions:

Hot and Humid

General Demeanor:

Good

Miscellaneous Notes:

This was a survey of an old abandoned forge. It is not a compeete survey but thought parts of the area could be used for comparison as the smith has not changed anything and tried to preserve the location. This area no longer has walls or ceiling. only the beams remain. Was a Palm leaf hut Style. (4)

Top: 2 ft 8in X 1 ft 6in (.85 X .49 m)
Hight: 1 ft 3in (.40 m)   81cm X 46cm

Location in Smithy

wall _ to midpoint

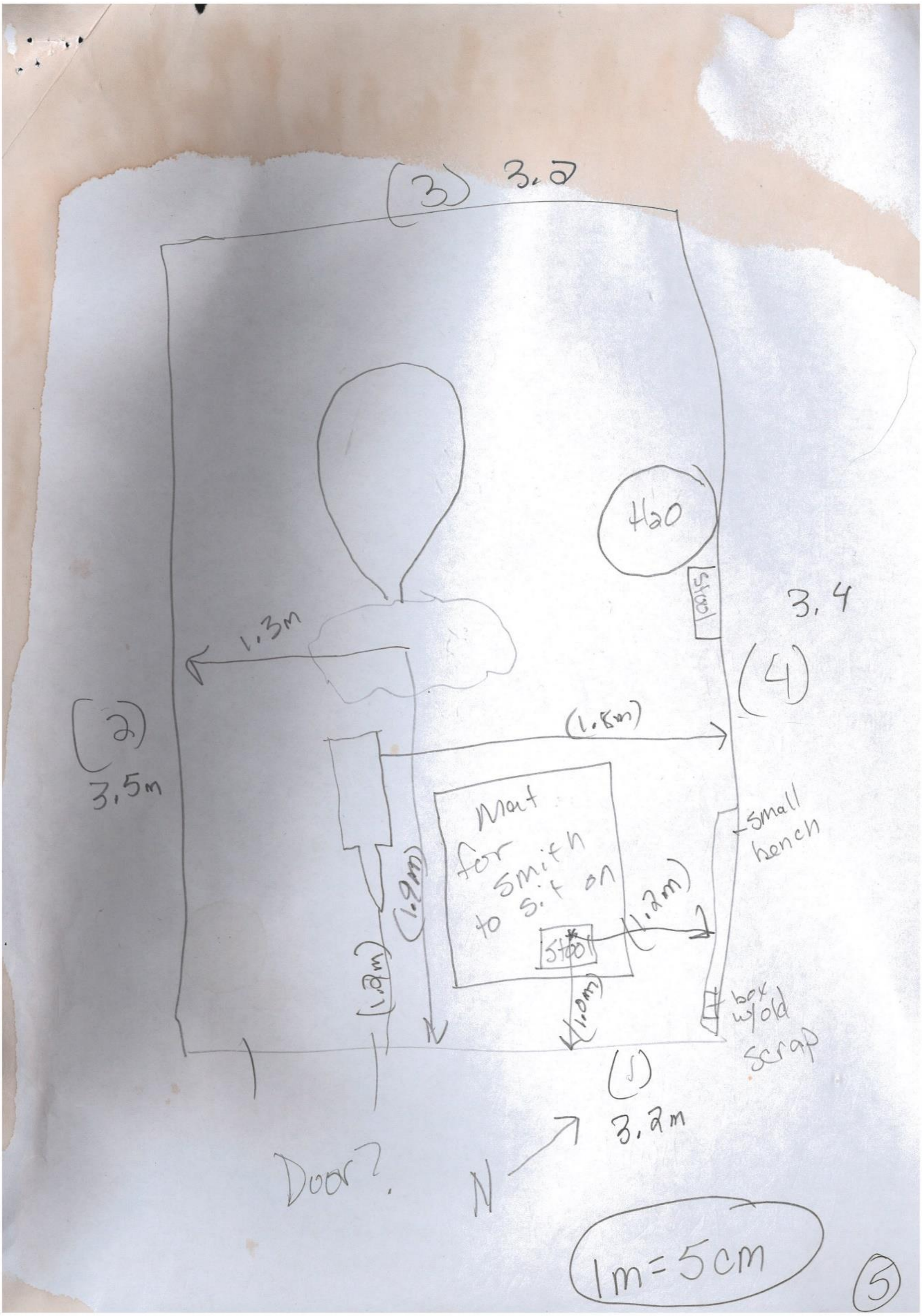
wall — to midpoint

Distance to

Heath

Stool

405 X 2030


(3) 3.2
Hao
stool
3.4
1.3m
(4)
(2)
3.5m
(1.8m)
Mat
for
Smith
to sit on
small
bench
(1.9m)
(1.2m)
stool
(1.2m)
(1.0m)
box
w/old
scrap
(1)
3.2m
Door?
N
1m=5cm
5

- he still has the tools

Did not do anything to close the forge
he fell ill and had to live w/ his
son for a while during this
time his forge was robbed or
people of the village decided to
take his tools. When he returned
he did what he could to conserve
what was left of the forge.
ie covering the bellows.
1971 built forge

Tools for a new smith when
he begins to work full time.
they make themselves sometimes
they are handed down.
they are handed down unless broke
then they make new

A.12 Basic Blank Interview Form

Name:

Age:

How long have you been a blacksmith?

Who did you learn your blacksmithing skills from? (what age)

What were the first jobs given to you?

How did these jobs change as time progressed?

What is your first memory associated with blacksmithing?

Did you ever learn/train/work with any other smith?

How long did you learn? What age did you begin to work on your own? Or how many years did you have smithing training?

How long has you/your family lived in the village?

How long has your family been blacksmiths?

Where is your forge?

How long has it been located there?

As a smith, what was the most common object you made?

What was your favorite thing to make?

How has the village/blacksmiths in the area changed since you were young?

How many smiths are working now compared to when you were young?

How has the work the smiths are doing changed over the years?

Has smithing work become more solitary? (ie did smithing work used to be more of group/striker related)

Have the tools or forge area used changed over the years?

Have the materials used changed? (bloom/scrap, charcoal -store bought/self-made)

Has how the smiths are paid changed?

What is the blacksmiths association with the local temple?

Has that changed over the years?

Do you recall any folk stories relating to blacksmiths? Any songs?

If so can you sing/relay them?

Is there anything else you would like people to know about the blacksmithing heritage of your village?

India Summer Fieldwork 2017

1.1 Introduction

Fieldwork was carried out from July 26th to August 29th in Kerala. Due to time constraints when possible many of the dates for work were prearranged before arrival. We stayed in Kollengode for a week working from sun up to past sun down. Issues with needed equipment delayed work for a week, but all planned work was completed for this trip.

2.1 Forge Work/ Iron Objects

It is difficult for me to gauge how well the forge work went as this was a blind part of the study. I only know a small amount of information. Tom Raisen and Paul M.S were entrusted with the important task of collecting the information for me to utilize. When we established a date and time to work with a smith we would all arrive at the forge and set up with me deciding where the locations for the cameras and heat monitors would be located. I would make sure all the weights needed before work to begin was taken and everything was ready. Then we would start the video recorder and with Paul's assistance translating we would record the ethics questions. Then I would leave until after the forge work was finished. Tom and Paul would record the weight of the charcoal and take photos of the tools the smith used during the forging of the iron object. This is the process we used for all the forge work that was done.

In all 8 iron objects were forged by 6 smiths. Three of these smiths were in Kollengode and they forged four of the items, with one of the smiths forging two of the objects. A smith in Tirur and Viakom both forged one object and a smith in Vypin forged two. I have provided photos and the local name for all the objects forged below along with the smith’s name and location the object was forged.

Figure 1: Left- Small Knife, *Cheriya Kathi/ Chirata Kari.* Right- Big Knife, *Kathi.* Both forged by Premnath, T.N.. in Vypin.

Figure 2: Left- Coconut Knife, *Thengu Kayatta Karude Kathi.* Forged by Subramanian in Kollengode. Right- Knife, *Vettu Kathi,* forged by Valayudhan, K.K. in Tirur.

Figure 3: Left- Elephant Nail Cutter, *Kollengode Kathi*, forged by Chandran, S, in Viakom. Right- Old Style Small Sickle, *Arival*, forged by Vellappan, V, in Kollengode.

Figure 4: Left- Coffee Knife, *Kavath*. Right- Sickle, *Koythu Arival*, both forged by Prabhakaran, C, in Kollengode.

During the forge work a total 34,093 temperature readings were taken and over 14 hours of video was taken. Along with many photos and notes were taken. These are now stored on a hard drive and in folders located at Exeter where they will remain until the iron lab work is finished. It is difficult for me to ascertain how well this part of the research is doing so far, as I have not been able to look at the notes or watch the video.

3.1 Smithy and Temple Surveys

Four smithy surveys were completed with three of them carried out in Kollengode. One of these surveys was on a rundown forge area that no longer was functional, but it was the oldest forge area I have seen yet in Kerala and thought the data could prove useful. This rundown forge area is also the only survey where we did not do any forge work with the smith as the smith is retired due to age. I hope to be able to take the measurements from these surveys and put them into a computer design program and create scale maps of each.

While in Kollengode I discovered that the local blacksmithing community not only had one temple dedicated just for the blacksmithing community, but they had two of these temples. The newly located one is much older than the one previously found. The date of the older one is not known at this time as everyone asked could not give a date. Answers to this question would range from before my grandfather's grandfather to before I was born. It is not uncommon to see small family temples all throughout Kerala, but the blacksmith temples in Kollengode are a bit larger and they both offer puja in the morning and evening every day. One of the blacksmiths I worked with is the pujari at the older temple.

Figure 5: Kalyani, who helps care for the old family temple, praying to Thambatty Muthi who is buried in the temple grounds.

While visiting the oldest family temple and talking to the caretakers we were granted permission to survey the temple and record the evening puja that afternoon. While conducting the survey, it was discovered that a woman is buried at the location. Again, it is not known how long this woman has been buried at the location, but most people said for a very long time, or shortly after the blacksmiths moved to the village. This woman evidently was responsible for the building of the temple and was buried at the temple as the locals venerated her before her death. Now people of the village come to pray to her and she is part of the daily prayers carried out in the temple. The main deities of the temple were noted and the puja was recorded that evening. There were no smithies located at this time around this family temple, but they did say that in the past there would have been many. When the village began to grow, the smiths needed more room and that is why the new temple located on the other side of the village was build. Then after time, when the main road connecting the larger towns was build the smiths started to move the smithies closer to the roads in hopes of gaining more work.

The newer blacksmith temple in Kollengode is being rebuilt and the deities are housed in a temporary building. I decided that it might be a good chance to compare the two temples so we also conducted a survey at this location and documented the deities. We were not able to observe the daily morning and evening pujas though. This temple had three smithies in very close proximity and I included measurements to these in the survey of the temple.

4.1 Interviews and Future Work

During the fieldwork, many informal interviews were carried out and three formal interviews were recorded in video and audio. All three formal interviews have been translated and transcribed. Two of the interviews were with elder blacksmiths one who was no longer able to work due to medical issues. They both had long histories in the area and they were valuable sources of information. The third interview was with the Pujari of Sree Subrahmanya Swami Temple who allowed me to interview him about the establishment of the temple and the arrival of the crafters related to the temple which is said to have been built around 800 years ago, and still has some of the original crafter families associated with the temple. These interviews proved to be very useful in learning the changes that have taken place in the blacksmithing communities in Kerala.

During this time, another five blacksmiths were located and documented. Four of which were in Kollengode bringing the total in that village to 8 and a total of 21 documented in central Kerala.

A.14 Kollengode Puja Notes

Pujari unlocks the door to the shrine of Bogarswamy then unlocks the door to Murugg. He then rings the bell 3 times then opens the door to the shrine of Murugg then opens the door to Bogarswamy's shrine. He then takes a silver tray and cloth and enters the shrine of Murugg and picks up the old flowers and remains of incense and puts them on the tray he then wipes the whole area down including the floor with the cloth.

He then enters the shrine of Bogarswamy and repeats the same process. He then takes the old offerings to the left side of the temple fence and throws the offerings outside the fence into the field. He then takes the tray and cloth to the cement block where Thanbatty Muthi is buried and cleans the area with the cloth. Then again takes the offerings to the fence and throws them into the field. He then goes to the shrine of Nagaraja and collects the flowers and remains of the incense and wipes it off with the cloth. Then does the same at the shrine of Shanieshwaran and again at the shrine of Kanata Karnan then he takes the tray of old offerings and goes to the fence and throws them into the field.

He then picks up a bag filled with incense, wicks and oil for lamps. He then takes the bag to where Thambatty Muthi is buried and he refills two bronze oil lamps with oil and new wicks. He then takes one and places it next to Thambatty's burial then another of the shrine to her friend. He then lights incense sticks off of the oil lamp and places then next to the shrines after encircling the oil lamp placed on Thambatty's shrine 3 times he then places one stick on each shrine. He then says prayers to each shrine and walks around both in a clockwise direction.

He then goes to the shrine of Murugg and again wipes the whole area down with the cloth. Then enters the shrine of Bogarswamy and does the same. Then enters back into the room of Murugg he lights a larger bronze oil lamp in the shrine then takes another smaller oil lamp and lights it. Then taking the smaller lamp with him he enters the shrine of Bogarswamy and lights the bronze oil lamp there with the small oil lamp. He then gets incense and takes the small oil lamp into the shrine to Murugg and lights the incense sticks, then again doing the same thing in the shrine for Bogarswamy.

He then takes the small oil lamp and the bag of oil, wicks and incense to the shrine of Nagaraja filling the oil lamp and adding a new wick. He then lights the lamp and several incense sticks leaving one stick at the shrine he then walks to the shrine of Shanieshwaran and places one of the incense sticks on the shrine then adds oil to the oil lamp and a new wick then lights the lamp. He then walks to the shrine of Kanta Karnan and repeats the same process.

By the time he is finishing with the lamp at the shrine of Kanta Karnan an elderly lady from the family is already praying at the shrine of Murugg. The Pujari gathers up the bag with the incense, oil and wicks and places it just inside the shrine for Bogarswamy. He then takes the small oil lamp and places it inside the shrine for Murugg. He then begins to pray at the shrine of Murugg while the older lady moves on to the shrine of Bogarswamy. He then moves on to the shrine of Bogarswamy to say prayers. They both move on to the shrine of Nagaraja again offering payers. He then moves to the shrine of Shanieshwaran and then to Kanta Karnan repeating the process of saying payers and bowing. He then takes a small bowl places outside the shrine of Murugg and takes the chalk from inside on his forehead.

The lady after saying prayers to Nagaraja then gois to the shrine where Thambatty Muthi is buried and the shrine to her friend and says prayers. Then moves on to Shanieshwaran then Kanta Karnan again saying prayers to both shrines. She then takes the bowl placed outside the shrine of Murugg and places a mark on her forehead she then takes a pinch of the chalk and rubs it on the outside of her right leg.

This whole process took 16 minutes and 49 seconds. This process is repeated every morning and evening at this family temple. This puja did not include the offering of flowers with is evident they do because when the puja cleaned the shrines, he picked up many flowers in the process. No body entered the temple until the pujari was close to the end of the puja routine and nobody is allowed to enter the housed shrines except the pujari that is conducting the puja.

Appendix B- Forge Work

B.1 Notes on Forging Object 1VS3 and 2VS3

B.2 Notes on Forging Object 3VS13

B.3 Notes on Forging Object 4KS9

B.4 Notes on Forging Object 5TS5

B.5 Notes on Forging Object 6KS17

B.6 Notes on Forging Object 7KS9

B.7 Notes on Forging Object 8KS11

B.8 Notes on Forging Object SL2- from Bonnet's Research

B.9 Notes on Forging Object SL3- from Bonnet's Research

B.10 Notes on the Forging of Knife Used from Juleff's Research

B.11 Fieldwork Notes Taken during Forge Work

B.1 Notes on Forging Object 1VS3 and 2VS3

Notes on Forging of Object 1VS3 & 2VS3 by Blacksmith 3 in Vypin

Video begins with going over spelling of names and verifying some of the basic questions on the blacksmith forms. Then covers the ethics questions.

Begins forging 1VS3

8:24- begins forging, already had iron in fire, this is when he started the bellows

8:33- adds a handful of charcoal

8:51- adds a handful of charcoal

12:07- removes iron from fire

Takes chisel places it on the iron and hammers the end of the chisel

Using the large hammer, hits the iron 18 times until a small piece of the hot iron come off

13:00- places the iron in the fire

14:07- removes iron from fire

Hits the iron 3 times with the large hammer

Picks up the medium hammer and hits the iron 7 times

Changes to large hammer again and hits the iron 16 times

Changes to medium hammer hits the iron 9 times

As he works, he changes back and forth between two different anvils in the ground

15:11- places iron back into fire

15:21- adds handful of charcoal

16:24- video ends

Video picks up directly where it previously stopped

00:34(16:58)- adds handful of charcoal

2:14(19:12)- takes iron out of fire

Uses large hammer to hit the iron 30 times

2:50(19:48)- places iron into fire

3:43(20:41)- adds handful of charcoal

4:54(21:52)- removes iron from the fire

Hits iron 23 times

5:30(22:28)- places iron back into fire

6:13(23:11)- takes iron out of fire

Hits iron 22 times

Picks up chisel

Hits back of chisel 7 times

Picks up small hammer

Hits the small piece of iron cut with chisel 9 times until it breaks away and falls off

7:17(24:15)- places iron into fire

7:26(24:24)- adds handful of charcoal

8:22(25:20)- removes iron from fire

Picks up medium hammer

Hits the iron 44 times

9:12(26:10)- puts the iron back into the fire

9:21(26:19)- adds handful of iron

10:57(27:55)- removes iron from fire

Hits iron 62 times

Picks up chisel

Uses medium hammer to hit the back of the chisel 4 times removing very small pieces off the iron object

13:29(30:27)- places iron into the fire

13:43(30:41)- adds handful of charcoal

15:31(32:29)- adds handful of charcoal

16:33(33:31)-removes iron from fire

Picks up large hammer and hits the iron 32 times

17:17(34:15)- places iron into fire

18:17(35:15)- adds handful of charcoal

19:00(35:58)- takes iron out of fire

Dunks large hammer into water

Hits the iron 35 times

19:44(36:42)- puts iron into the fire

20:40(37:38)- removes iron from fire

Hits the iron 24 times

21:14(38:12)- places iron back into the fire

21:57(38:55)- removes iron from fire

Hits iron 30 times

Picks up medium hammer and hits the iron 4 times

22:41(39:39)- places iron into the fire

23:03(40:01)- adds handful of charcoal

23:48(40:46)- removes iron from fire

Dumps medium hammer into water

Hits iron 61 times

24:37(41:35)- places iron into the fire

25:19(42:17)- removes iron from fire

Dunks medium hammer into water

Hits the iron 101 times

27:12(44:10)- places iron into the fire

27:28(44:26)- adds handful of charcoal

28:54(45:52)- removes iron from fire

Hits iron 12 times

Dunks hammer into water

Hits iron 40 times

29:46(46:44)- puts iron in fire

29:53(46:51)- adds handful of charcoal

00:53(47:51)- removes iron from fire

Hits iron 2 times

Dunks hammer into water

Hits the iron 56 times

1:40(48:38)- places the iron into the fire

1:48(48:46)- add handful of charcoal

2:49(49:47)- removes iron from fire

Hits the iron 23 times

3:13(50:11)- places iron into fire

3:41(50:39)- removes from fire

Picks up chisel

Hits back of chisel 7 times

Smith gets up to check the thermocouple. He is worried he has kicked it out of the fire. He is told that it is all ok. Then he sits for a time talking and laughing with people.

Picks up the chisel again and hits the back of it one more time then inspects the iron object a little

6:12(53:10)- places iron into the fire

6:50(53:48)- adds handful of charcoal

8:39(55:37)- removes iron from fire

Hits the iron 25 times

9:18(56:16)- places iron into the fire

9:50(56:48)- adds handful of charcoal

10:40(57:38)- removes iron from fire

Hits iron 49 times

11:27(58:25)- places iron into fire

11:55(58:53)- removes iron from fire

Hits the iron 56 times

Plunges hammer into water

Hits iron 34 times

13:44(01:00:42)-puts iron into fire

14:41(01:01:39)- adds handful of charcoal

15:18(01:02:16)- adds handful of charcoal

15:38(01:02:36)- removes iron from fire

Picks up a piece of bull horn that looks old and very used

Rubs the horn into the blade section of the iron object

15:59(01:02:57)- returns iron to fire

16:12(01:03:10)- removes iron from fire

Once again rubs the horn into the blade section of the iron object

16:32(01:03:30)- takes the iron object and sets it to the side of the fire

Smith then spends a bit of time searching through his tools that are next to where he is sitting

Gets up and walks away from forging area, still looking for something, returns with a short piece of iron which he places in the tongs

Smith begins forging 2VS3

The smith then places this new piece of iron into the fire

20:44(01:07:42)- places new iron into fire

21:56(01:08:54)- adds handful of charcoal

Picks up large hammer

24:44(01:06:06)- removes the iron from the fire

Hits the iron 25 times

Picks up the medium hammer and hits the iron 4 times

25:33(01:12:31)- places iron back into fire

26:50(01:13:48)- removes iron from fire

Uses the large hammer and hits the iron 8 times

Takes medium hammer and hits 8 times

27:20(01:14:18)- puts iron back into the fire

27:57(01:14:55)- removes iron from fire

Hits the iron 38 times

29:03(01:16:01)- places iron back into fire

29:11(01:16:09)- adds handful of charcoal

00:55(01:17:53)- takes iron from fire

Picks up large hammer and hits the iron 20 times

Takes medium hammer and hits the iron 9 times

1:51(01:18:49)- places the iron into the fire

2:08(01:19:06)- adds handful of charcoal

2:50(01:19:48)- removes iron from fire

Takes large hammer and hits the iron 23 times

5:58(01:22:56)- places iron into fire

6:13(01:23:11)- adds handful of charcoal

7:01(01:23:59)- removes iron from fire

Picks up chisel hits back of chisel 7 times until the end of the iron object comes off

7:35(01:24:33)- puts iron in fire

8:40(01:25:38)- removes iron from fire

Hits the iron 11 times

Picks up a small hammer and hits the iron 47 times

9:22(01:26:20)- places iron back into the fire

10:06(01:27:04)- removes iron from fire

Take medium hammer and hits the iron 51 times

10:59(01:27:57)- puts iron into fire

11:54(01:28:52)- removes iron from fire

Hits the iron 24 times

12:22(01:29:20)- places iron into fire

12:30(01:29:28)- adds handful of charcoal

14:19(01:31:17)- removes iron from fire

Hits iron 54 times

15:34(01:32:32)- puts iron back into fire

16:00(01:32:58)- adds handful of charcoal

16:30(01:33:28)- removes iron from fire

Hits the iron 49 times

17:30(01:34:28)- puts iron into fire

18:00(01:34:58)- removes iron from fire

Hits the iron 57 times

19:10(01:36:08)- Puts iron into fire

19:45(01:36:43)- removes iron from the fire

Pick up the small hammer and hits the iron 65 times

20:26(01:37:24)- puts iron into fire

21:21(01:38:19)- removes iron from fire

Picks up medium hammer

Hits the iron 57 times

22:08(01:39:06)- puts iron into fire

22:18(01:39:16)- adds handful of charcoal

23:01(01:39:59)- removes iron from fire

Hits iron 14 times

Plunges hammer into water

Hits iron 83 times

24:27(01:41:25)- puts iron into fire

25:37(01:41:57)- removes iron from fire

Hits iron 31 times

Video cuts off at 26:09(01:42:29)

New video restarts where last cut off

Smith begins filling object 1VS3

Picks up a rock and rests the knife in a position that he can file the blade section

Smith changes he mind and turns the knife over to file the back blunt section of the blade area

3:01(01:44:58)- begins filing 459 strokes

Turns iron around so he can file one of the sharp sides of the blade and changes back and forth to file on both sides of the blade

9:00(01:50:57)- files 927 strokes

Changes to a smaller file

24:50(02:06:47)- files 268 strokes

29:25(02:11:22)- hands 1VS3 over as finished

Starts filing for 2VS3

Video ends at 30:00 and new video picks up were left off

Places the iron object on the stone with the back side of the blade section on the object facing up

00:31(02:12:28)- begins to file 221 strokes

Turns object over and begins to file on the sharp side of the blade

Files 1165 strokes

22:39(02:34:36)- finished filing on 2VS3

The smith starts to clear the area and loosen the dirt on the ground a short distance from the fire

Begins work on 1VS3 again

26:34(02:38:31)- adds handful of charcoal

26:44(02:38:41)- puts iron in the fire

26:52(02:38:49)- adds handful of charcoal

Video ends at 29:47 new video starts

00:13(02:41:57)- adds handful of charcoal

1:00(02:42:44)- removes iron from fire

Plunges iron into the dirt pile that is in front of the fire, moves the iron back and forth under the dirt

Takes the iron and dips the sharp section of the blade into water

Takes a file and quickly runs it across the blade

The smith then puts the blade just over the fire and slowly moves it across the fire. He then takes an old stick with one of the ends frayed and in water, uses the frayed water-soaked end to spread water all over the blade of the iron. He then once again places the iron just over the fire moving the iron slowly over the fire. Then again going back to the stick to soak the iron in water. He then places the iron object across the bowl of water.

3:39(02:45:23)- done with 1VS3

Picks up the second iron object

Starts back on object 2VS3

4:03(02:45:47)- puts iron into fire

4:30(02:46:14)- adds handful of charcoal

5:22(02:47:06)- removes iron from fire

Plunges iron into dirt and moves back and forth while keeping blade under the dirt

5:46(02:47:30)- dips sharp edge into water

Quickly rubs a file on the blade section

Places iron over the fire and slowly runs the iron over the top of the fire

Takes stick with frayed end in water and uses frayed end to get water all over the blade section of the iron

Again places the iron over the fire and slowly moves the iron across the fire

Takes the stick and soaks the iron in the water

6:56(02:48:40)- finished with object 2VS3

Notes*

Forged blade first then handle section for big knife (1VS3) and then handle first then blade on small knife (2VS3)

Very loud and busy area next to a busy road. This smith socializes more than the others while forging and smith also took breaks while forging. The forging area had people in and out of the area to have the smith do work for them, socialize or they lived in the adjoining houses and were normally around. He also had another smith working around the forge area but this smith did not help or do any work with the objects he made for this research.

Details for object 1VS3-

Summary			
Total time iron was in fire		37m	36s
Work time outside of fire		21m	33s
Time spent heat treating		06m	52s
Total forge time	1h	01m	58s
Total finishing and sharpening time		26m	24s
Total time spent on object	1h	28m	22s
Total hammer strikes	836		
File Strokes	1654		

Details for object 2VS3-

Summary			
Total time iron was in fire		17m	45s
Work time outside of fire		21m	28s
Time spent heat treating		02m	53s
Total forge time		37m	54s
Total finishing and sharpening time		22m	08s
Total time spent on object	1h	02 m	55 s
Total hammer strikes	685		
File Strokes	1386		

B.2 Notes on Forging Object 3VS13

Notes on Forging of Object 3VS13 by Blacksmith 13 in Vaikom

Video starts with translator reviewing the ethics questions set out for the research and getting approval from the smith.

2:04- Smith picks up a pre-formed (shape of a knife) piece of iron. Begins to use an angle-grinder on the iron

He cut a piece of iron off the handle end of the iron.

2:32- stops using the angle grinder and places iron into fire

2:34-adds a handful of charcoal to the fire

3:40-adds a handful of charcoal to the fire

6:25- removes iron from fire

(working on the handle side)

Strikes the iron 38 times

7:28- places the iron back into the fire

7:34- adds handful of charcoal

7:43- adds handful of charcoal

8:38- adds handful of charcoal

9:37- adds handful of charcoal

10:10- removes iron from the fire

(working on the blade end)

Strikes the iron 32 times

10:46- places iron back into the fire

11:11- adds a handful of charcoal

11:15- adds a handful of charcoal

11:37- removes iron from fire

Strikes the iron 30 times

13:13- places iron back into fire

13:35- adds handful of charcoal

14:57- removes iron from fire

Hits the iron 42 times

15:45- places the iron back into the fire

Smith picks up a bowl and leaves, returns with water in the bowl

16:45- removes iron from the fire

Hits the iron 7 times

Dunks the hammer he is using into the bowl of water

Hits the iron 17 more times

17:17- places the iron back into the fire

18:10- adds handful of charcoal to the fire

18:27- removes the iron from the fire

Strikes the iron 34 times

Dunks the hammer into the bowl of water

Strikes the iron 27 more times

Smith moves from the fire and picks up a small piece of wood to prop the iron object against. Rearranges his seat and picks up a disk for the angle grinder. The smith changes the disk in the angle grinder.

(working on the blade side of the object)

21:01- begins to grind/file the iron with the angle grinder

21:32- dunks the iron into the bowl of water

(cutting what will become the sharp part of the blade)

21:38- begins to grind/file the iron

22:10- stops grinding

Takes hammer and hits the section that he just cut. Hits the iron 17 times before the cut piece falls off.

22:40-begins grinding

Turns iron to work on handle

23:44- stops grinding

Takes hammer to again remove a cut section from the iron. Hits the iron 7 times before the piece falls away.

23:56- begins grinding again

24:57- stops grinding

Takes hammer to remove a cut section of the iron. Hits the iron 6 times before the piece falls away.

25:05- places iron into the fire

25:20- adds handful of charcoal

25:30- adds handful of charcoal

27:07- removes iron from fire

Hits iron 43 times

27:56- places iron into fire

28:12- adds handful of charcoal

29:15- removes iron from fire

Hits iron 21 times

Plunges hammer into bowl of water

Hits iron 11 times

Plunges hammer into bowl of water

Hits iron 35 times

(working on blade end)

00:15(30:15)- places iron into the fire

00:35(30:35)- adds handful of charcoal

1:35(31:35)- adds 2 handfuls of charcoal

2:09(32:09)- removes iron from the fire

Hits the iron 15 times

Plunges hammer into bowl of water

Hits the iron 28 times

3:01(33:01)- Places the iron back into the fire

3:49(33:49)- adds handful of charcoal

3:58(33:58)- removes iron from fire

Hits iron 21 times

Plunges hammer into bowl of water

Hits the iron 16 more times

4:41(34:41)- places iron in fire

5:42(35:42)- removes iron from fire

Hits iron 6 times

Plunges hammer into bowl with water

Hits iron 20 times

Plunges iron into bowl of water

Hits iron 19 times

6:37(36:37)- places iron into fire

7:11(37:11)- adds handful of charcoal

7:41(37:41)- removes iron from fire

Hits iron 9 times

Plunges iron into bowl of water

Hits iron 24 times

8:18(38:18)- puts iron into fire

8:57(38:57)- removes iron from fire

Hits iron 18 times

Plunges hammer into water

Hits iron 14 times

Plunges hammer into water

Hits iron 22 times

Plunges iron into water

Hits the iron 28 times

Plunges the hammer into water

Hits the iron 5 times

10:36(40:36)- puts iron back into fire

11:07(41:07)- adds handful of charcoal

11:38(41:38)- removes iron from fire

Hits iron 39 times

Plunges iron in water

Hits the iron 14 times

12:31(42:31)- places iron in fire

13:29(43:29)- adds handful of charcoal

13:40(43:40- adds handful of charcoal

13:56(43:56)- removes iron from fire

(working on handle)

14:01(44:01)- plunges handle part of iron into water

14:16(44:16)- places iron against wood board and uses angle grinder to make small line in end of handle section

14:29(44:29)- places iron in fire

14:56(44:59)- adds handful of iron

15:36(45:36)- removes iron from fire

Hits the iron 6 times

15:46(45:46)- puts iron in fire

16:08(46:08)- adds handful of charcoal

16:42(46:42)- removes iron from fire (iron is sparking)

Hits iron 23 times

17:19(47:19)- puts iron into fire

17:53(47:53)- removes iron from fire

Hits the iron 19 times

18:14(48:14)- places iron into fire

19:05(49:05)- removes iron from fire

Hits the iron 47 times

19:57(49:57)- puts iron in fire

Smith looks around and finds an iron tool that has a hole in the end of it

20:47(50:47)- adds two handfuls of charcoal

Takes the iron out of the fire to check if the end (handle section) will fit on the end of the iron tool he has found, then quickly places the iron back into the fire

21:23(51:23)- removes iron from fire

Places the end (handle section) of the object being forged into the hole on the iron tool. Stands the object being forged up with the handle section at the top. Then hits the iron tool 3 times causing the tool to move down the piece being forged. He hits the iron tool 41 more times. Removes iron tool. Hits the iron being forged 3 times with the hammer.

22:10(52:10)- places iron in forge

22:45(52:45)- removes iron from fire

Hits the iron 4 times

Plunges hammer in bowl of water

Hits iron 22 times

Plunges hammer in water

Hits iron 21 times

Plunges hammer into water

Hits iron 15 times

23:37(53:37)- puts iron in fire

24:34(54:31)- adds handful of charcoal

25:21(55:21)- removes iron from the fire

Picks up wood block and uses it to scrap the iron from top to bottom, repeatedly running the block up and down and back and forth.

Tom (running the video) asks if the smith can describe what he is doing. Paul (interpreter) translates the question to the smith.

26:42(56:42)- plunges haft end of iron into the water then flips the iron over so the blade end is in the water

Picks up angle grinder and places iron against the block of wood

27:30(57:30)- starts to grind iron on the handle end

28:26(58:26)- stops grinding

Takes hammer and hits the end of the object 21 times until a cut piece falls off

28:54(58:54)- places the iron in the fire

29:01(59:01)- adds handful of charcoal

Smith picks up a disc for the angle grinder and changes the disc on the grinder

00:57(1:00:57)- adds two handfuls of charcoal

1:24(1:01:24)- removes iron from fire

Hits the iron 31 times

2:16(1:02:16)- places iron into fire

2:59(1:02:59)- removes iron from fire

Hits the iron 32 times

Plunges hammer into the water

Hits the iron 17 more times

3:54(1:03:54)- puts iron into the fire

4:38(1:04:38)- adds handful of charcoal

5:00(1:05:00)- removes iron from fire

Picks up the iron tool with the hole on the end and places it on the handle/tang section of the object being forged. Hits the iron tool 17 times which cause the tool to slowly slide down the handle/tang. Removes iron tool from object being forged.

Hits the iron 18 times

Plunges iron into the water

Hits the iron 28 times

6:10(1:06:10)- places iron into the fire

6:59(1:06:59)- removes iron from the fire

Takes wood board and rub the board over the whole of the object being forged.

Hits the iron 8 times

Sets the iron on the edge of the anvil to cool

Picks up angle grinder

Puts iron in large standing vice

10:58(1:10:58)- begins grinding

12:08(1:12:08)- removes iron from vice and moves to the floor and places iron against a large wood board

12:12(1:12:12)- begins grinding

Holding the iron object using tongs and the angle grinder in the other hand he grinds the object moving both hands to target the area he is working on.

19:09(1:19:09)- changes disc on angle grinder

19:25(1:19:25)-begins grinding

21:00(1:21:00)- stops grinding and inspects the object

21:15(1:21:15) begins grinding

24:45(1:24:45) stops grinding

Says that he is going to temper the object now

24:59(1:24:59)- places iron back into the fire

25:18(1:25:18)- adds two handfuls of charcoal

26:48(1:26:48)- removes iron from fire

Begins to bury the iron in the ground/dirt by the hearth moving it back and forth in the ground

27:04(1:27:04)- dips the sharp part of the blade into water

Sets the object on the anvil

Smith locates a hand file

27:57(1:27:57)- uses hand file to file the sharp section of the blade

Files 21 times

Set the iron on top of the fire with the blade section pointing to the hottest part of the fire for a few seconds then removes looks at the blade and repeats, he does this 5 times, and begins to file again.

Files 4 times

Picks up hammer hits the iron 3 times

Files 17 times

Plunges blade section of the object into the water. Sets object on the anvil

29:31(1:29:31)- is finished forging object

Summary	
Total time iron was in fire	35 m 03 s
Work time outside of fire	51 m 50 s
Time spent heat treating	02 m 58 s
Total forge time	1 h 04 m 55 s
Total finishing and sharpening time	08 m 33 s
Total time spent on object	1 h 27 m 27 s
Total hammer strikes	959
File Strokes	42

B.3 Notes on Forging Object 4KS9

Notes on Forging of Object 4KS9 by Blacksmith 9 in Kollengode

Video begins right as the smith begins work on the object. He begins with starting the fire and preparing the hearth area to forge. He lights his fire using straw and handfuls of sawdust.

00:53- adds iron to fire

00:57- adds handful of charcoal to fire

01:59- takes 3 handfuls of water and sprinkles them over the fire

02:41- adds handful of charcoal

03:50- removes iron from fire

Takes medium hammer and hit the iron 35 times

04:20- puts iron into fire

05:14- adds 2 handfuls of charcoal

Uses what looks like a small bamboo broom to clean off the anvil

06:02- adds handful of charcoal

06:55- removes iron from fire

Picks up the large hammer and stands to hit the iron hard

Hits the iron 18 times

He then sits, picks up the medium hammer and hits the iron 28 times

07:44- puts iron into fire

08:04- adds handful of charcoal

08:12- adds handful of charcoal

Uses bamboo again to clean off anvil

09:10- removes iron from fire

Picks up large hammer and stands

Hits the iron 15 times

Picks up medium hammer and hits the iron 38 times

09:58- puts iron into fire

10:21- adds handful of charcoal

Uses bamboo to clean anvil

11:05- removes iron from fire

Picks up large hammer and stands

Hits the iron 7 times

Picks up medium hammer and hits the iron 31 times

Uses bamboo to clean off anvil

Picks up chisel

Hits the back of the chisel 4 times

Then hits the iron with the hammer 5 times till the piece that was cut by the chisel falls away

12:10- puts iron into fire

12:29- adds handful of charcoal

12:57- removes iron from fire

Uses medium hammer to hit the iron 33 times

13:22- puts iron in fire

13:29- adds handful of charcoal

Uses bamboo to clean off anvil

Picks up small hammer

14:04- removes iron from fire

Hits the iron 38 times

14:32- puts iron into fire

14:41- adds handful of charcoal

Uses bamboo to clean anvil

Dips bamboo brush end into water then uses it to sprinkle water onto the fire

15:39- removes iron from fire

Picks up large hammer and stands

Hits the iron 14 times

Picks up medium hammer and hits the iron 11 times

16:10- puts iron into fire

16:24- adds handful of charcoal

Uses bamboo to clean anvil

16:47- removes iron from fire

Uses medium hammer and hits the iron 68 times

17:33- puts iron into fire

17:49- adds handful of iron

18:13- removes iron from fire

Hits the iron 41 times

Picks up the chisel, hits the chisel 8 times

Picks up small hammer and hits the iron 7 times until the piece that was cut falls off

19:04- puts iron into fire

19:19- adds handful of charcoal

Uses bamboo to clean anvil

Picks up small hammer

19:42- removes iron from fire

Hits the iron 33 times

Picks up medium hammer and hits the iron 42 times

20:36- puts iron into fire

20:43- adds handful of charcoal

Uses bamboo to clean anvil

Gets small hammer ready

21:18- removes iron from the fire

Hits iron 37 times

Picks up medium hammer and hits the iron 48 times

22:12- puts iron into fire

22:17- adds 2 handfuls of charcoal

Uses bamboo to clean anvil

Picks up medium hammer

22:56- adds handful of charcoal

23:29- removes iron from fire

Hits the iron 58 times

24:09- puts iron in fire

24:31- adds 2 handfuls of charcoal

Picks up medium hammer

25:04- removes iron from fire

Hits the iron 44 times

25:37- puts iron in fire

25:56- adds handful of charcoal

Uses bamboo to clean anvil

26:26- removes iron from fire

Uses small hammer to hit iron 27 times

Picks up medium hammer and hits the iron 14 times

26:54- puts iron into fire

27:05- adds handful of charcoal

Uses bamboo to clean anvil

Sets up large hammer in front of the anvil to use as a small anvil to create a bend in the object handle

27:33- removes iron form fire

Uses small hammer to hit the iron 34 times

Picks up medium hammer and hits the iron 15 times

Hits iron 21 times with small hammer

28:16- puts iron in fire

Picks up medium hammer

29:01- removes iron from fire

Hits iron 38 times

Gets ruler and measures the length of the object

29:34- puts iron in fire

29:43- adds 2 handfuls of charcoal

Video ends at 30:00 new video picks up right were left off

01:06(31:06)- removes iron from fire

Uses small hammer to hit the iron 15 times

Picks up medium hammer and hits the iron 75 times

02:04(32:04)- puts iron into fire

02:51(32:51)- removes iron from fire

Uses medium hammer to hit the iron 73 times

03:41(33:41)- puts iron in fire

03:48(33:48)- adds handful of charcoal

Uses bamboo to clean anvil

04:24(34:24)- remove iron from fire

Uses small hammer to hit the iron 27 times

Picks up medium hammer and hits 58 times

05:13(35:13)- puts iron into fire

05:24(35:24)- adds 2 handfuls of charcoal

Uses bamboo to clean off anvil

06:16(36:16)- removes iron from fire

Uses small hammer to hit to iron 16 times

Picks up medium hammer and hits the iron 151 times

Forging stops at 08:27(38:27) and filing and sharpening begins

Sets up large hammer on the ground to use as a base to lean the iron object

Picks up a file and starts to file

Files 689 strokes

16:38(46:38)- picks up a small chisel and small hammer

Goes back to working on anvil

17:19(47:19)- Starts to make very small chisel marks on the sharp blade section

Taps the chisel and slides it along the blade to make small marks

Hits the chisel 520 times

22:46(52:46)- finishes making chisel marks

Smith spends a bit of time explaining what the marks are for. Stating that they help to cut grassy type plants.

He then takes the sharp side of the blade and runs it along the anvil twice once on each side

23:50(53:50)- picks up a file and files 50 strokes

Gets fire burning again

24:43(54:43)- adds handful of charcoal

Start of heat treat

24:55(54:55)- puts iron onto fire

24:58(54:58)- adds 2 handfuls of charcoal

27:29(57:29)- removes iron from fire

Takes a file and rubs it up and down the sharp part of the blade

Then puts the whole iron object into the water bucket

Removes the object from the water after waiting a bit

Takes the file and runs it over the sharp section again

28:16(58:16)- puts iron back into fire

28:33(58:33)- removes iron from fire

Picks up medium hammer and hits the iron 22 times checking to make sure the object is strait after every couple of hits

29:36(59:36)- finished with making the iron object

*Notes- This smith had more hammer scale compared to the other smiths. He forges the blade section first then handle. He had a specific size and shape he was going for; shown by the measuring he did with a ruler and he was very particular about the shape of the object while forging.

Summary	
Total time iron was in fire	24m 19s
Work time outside of fire	15m 46s
Time spent heat treating	04m 41s
Total forge time	37m 31s
Total finishing and sharpening time	21m 43s
Total time spent on object	59m 36s
Total hammer strikes	1747
File Strokes	739

B.4 Notes on Forging Object 5TS5

Notes on Forging of Object 5TS5 by Blacksmith 5 in Tirur

Short interview at the beginning of the video. Start with the ethics questions. Then ask about the person who is running the bellows and the relation to the smith. He is the smiths' brother-in law. Then asked about the temple that is located on the premises, between the smiths' home and the forge location. Smith states that they originally had only a small platform, but recently they built the larger structure. The temple/shrine is dedicated to two goddesses, Duga and Bovanisha. Once a year they have a formal puja at this temple/shrine but they light lamps and give offerings every day. When they have puja, they bring in a pujari from the nearby temple to perform.

Start forging at 4:41 into the video

4:41- places iron into the fire

5:03- adds two small handfuls of charcoal to the fire

6:21- rakes the fire several times and adds another handful of charcoal

6:45- rakes fire a couple of times checking the iron

(starts to form the blade)

7:05- takes iron from fire

Hits the iron 42 times

7:44- places iron back into the fire

8:05- adds a handful of charcoal to the fire

8:31- removes iron from fire

Hits the iron 58 times

9:25- places the iron back into the fire

10:07- takes iron from fire

Hits the iron 90 times

11:29- places the iron into the fire

11:48- adds a handful of charcoal

12:35-removes iron from the fire

Hits iron 45 times

13:19- places iron back into fire

13:34- picks up a smaller hammer

13:57- adds a handful of charcoal to fire

14:02-removes iron from fire

(begins forging the handle)

Hits the iron 38 times

14:40- places the iron back into the fire

15:07- removes iron from the fire

Hits the iron 24 times

15:33- places iron back into the fire

15:59- removes iron from fire

Hits the iron 45 times

16:35- places the iron back into the fire

16:57- adds a handful of charcoal to the fire

17:05- changes back to the bigger hammer

17:29- removes iron from the fire

(working on the blade again)

Hits the iron 60 times

18:21- returns the iron to the fire

18:45- adds a handful of charcoal to the fire

19:05- removes iron from the fire

Hits the iron 63 times

19:59- places iron back into the fire

20:25- adds handful of charcoal to the fire

21:08- removes iron from the fire

Hits the iron 67 times

22:05- places iron back into the fire

22:21- picks up smaller hammer

22:43- takes iron out of the fire

Hits the iron 22 times

22:59- places the iron back into the fire

23:12- removes iron from the fire

Hits the iron 17 times

23:28- picks up the bigger hammer

Hits the iron 25 more times

23:47- places the iron back into the fire

24:04- adds handful of charcoal

24:29- removes iron from fire

Hits the iron 100 times

25:46- places iron back into fire

26:03- adds a handful of charcoal to fire

26:21- adds another handful of charcoal to the fire

26:59- removes iron from the fire

Hits the iron 156 times

29:00- places the iron back into the fire

29:13- picks up another piece of iron that looks like another unfinished tool

29:47- removes iron from fire

Uses the other iron implement to hit the iron being forges 35 times shaping the area between the blade and the handle

(working on the handle section)

(video starts over exactly where the last one stopped)

00:18 (30:18)- Places iron back into fire

00:45(30:45)- removes iron from the fire

Hits the iron with the other iron implement 16 times

00:59 (30:59)- picks up smallest hammer and hits the iron 25 times

1:23 (31:23)- places the iron back into the fire

1:35(31:35)- adds a handful of charcoal to the fire

2:00 (32:00)- removes iron from the fire

Hits the iron 17 times

2:18 (32:18)- picks up medium hammer and hits the iron 34 times

2:47 (32:47)- places the iron back into the fire

3:19(33:19)- removes iron from the fire

Used the head of another hammer as an anvil and the smaller hammer to hit the iron 39 times alternating using the other hammer and the anvil as a base

3:51(33:51)- places iron back into the fire

4:12(34:12)- removes iron from fire

Uses small chisel and tongs with medium hammer to remove a piece of iron from the handle end of the object

He hits the small chisel 4 times then uses the hammer to hit away the cut piece of iron, moving the object being forged back and forth so he is hitting the object on both sides back and forth. He hits the object 24 times before the cut iron falls away

4:42(34:42)- places the iron back into the fire

4:53(34:53)- adds two large handfuls of charcoal to the fire

5:19(35:19)- removes iron from the fire

Hits the iron 57 times

6:05(36:05)- places the iron into the fire

6:28(36:28)-removes iron from the fire

Hits the iron 41 times focusing on the handle area

(moving back to the blade and overall whole object)

Hits the iron 83 more times

Looks over the overall shape of the object

8:03(38:03)-places the iron back onto the fire

8:26(38:26)- adds a handful of charcoal to the fire

9:06(39:06)- adds another handful of charcoal to the fire

9:18(39:18)- removes iron from the fire

(working on the blade section)

Hits the iron 197 times checking the shape and straightness of the blade section of the object

11:41(41:41)- places the iron in the fire

12:20(42:20)- removes the iron from the fire

(working on the handle section)

Places a small bit of iron with a hole in it on the anvil. Places the handle section on top of the section with the hole and then uses an iron punch to make a hole in the handle of the object

Hits the iron punch 4 times to make the hole in the object

Takes the small hammer and hits the area around the hole 14 times

Changes to medium hammer and hits the iron 13 times

12:55(42:55)-places the iron back into the fire

13:08(43:08)- add handful of charcoal to the fire

14:19(44:19)- removes the iron from the fire and sets it next to the fire on the ground and begins to clear out some debris and charcoal from the fire

At this time the smith says that he wants to let the iron cool down before he begins to sharpen the blade

15:25(45:25)- Takes the medium hammer and hit the iron 91 times. Takes the smaller hammer and hits the iron 62 times. Takes the medium hammer and hits the iron 157 times. Changes to the smaller hammer again and hits the iron 152 times.

Takes two hammers to form a V shape to place the iron object against holding onto the hammers with his feet. Uses his toes to hold the iron object upright in place.

21:40(51:40)- begins to file the blunt side of the blade using a handheld file

Files 187 times alternating to different places on the iron object

23:55(53:55)- turns the object around to file on the other side of the iron, still on the blunt side of the blade

Files 155 times

25:53(55:53)-changes to a smaller file

Files 33 times

26:26(56:26)- picks up large file and begins filling on the handle

Files 109 times

28:23(58:53)- changes to small file and files 25 times

28:55(58:55)-positions the iron object so one side of the sharp section of the blade is facing him. Takes the big file

Files 122 times

(video starts where last ended)

00:22(1:00:22)- flips the blade over to file the other side

Files 137 times

2:15(1:02:15)-flips the blade over again

Files 28 times

2:40(1:02:40)- flips blade over again

Changes to small file and files 51 times

3:11(1:03:11)- flips the blade again

With the larger file he files 29 times

3:23(1:03:23)- flips blade again

Files 23 times

3:49(1:03:49)-flips the blade again

Flies 94 times

4:51(1:04:51)- flips blade again

Flies 100 times

5:57(1:05:57)- flips blade

Files 32 times

6:22(1:06:22)- flips blade

Files 51 times

7:01(1:07:01)-flips blade again

Files 25 times

7:18(1:07:18)-flips blade

Files 27 times

7:37(1:07:37)- flips blade

Switches to small file

Files 28 times

7:59(1:07:59)- flips blade

Files 21 times

Switches to big file

Files 35 times

8:38(1:08:38)-flips blade

Files 46 times

9:09(1:09:09)-flips blade

Picks up small file

Files slowly turning the blade back and forth each time. Files 42 times alternating sides

9:45(1:09:45)- very small file

Files section where the blade and handle meet 112 times

Files over blade a few times

Examines the blade and files a couple more times

Continues to do this alternating on both sides of the blade examining the filling

13:06(1:13:06)-finished with filling

(heat treating)

Starts to rekindle forge fire

13:30(1:13:30)- adds two large handfuls of charcoal to the fire

Waits for fire to get very hot

14:02(1:14:02)-places iron in the fire

14:28(1:14:28)- puts handful of charcoal on the fire

Starts to move the iron object in the fire. Directing the main point of heat to different parts of the sharpened part of the blade.

15:49(1:15:49)- removes iron from the fire

Slowly, blade first submerges part of the sharpened red-hot blade into water. Placing it in the water 3 quick times. Then takes the object and files the sharp section of the blade several times on both sides.

16:08(1:16:08)- takes a wet stick that was in the water trough and rubs this on the sharp side of the blade

16:10(1:16:10)-lays the iron on top of the forge fire, but not in the fire

16:14(1:16:14)- uses wet stick to again cool the sharp side of the blade

16:29(1:16:29)-hold the sharp part of the iron just over the fire

16:35(1:16:35)- removes from fire

Takes big hammer hits iron 22 times

Uses file to file the sharp side of blade 5 times

17:09(1:17:009)- holds iron object over the fire

17:10(1:17:10)- removes from the fire

17:18(1:17:18)- plunges the iron object in the water

17:32(1:17:32)- removes from water

Takes a cloth and wipes down the object looking carefully at it

(begins final sharpening and finishing)

Files the back of the blade section 64 times

Changes to a smaller file

Files back side of blade section 51 times

19:09(1:19:09)- Flips blade over to file the sharp cutting section

Changes to larger file

Files sharp section of the blade 28 times

19:37(1:19:37)- flips the iron object over to file again on the backside of the blade

Flies 36 times

Flips Iron over to file on the blade again

Files 4 times

Changes to a small file and files on section between blade and handle

Files 54 times

20:43(1:20:43)- Takes hole punch and hammer to make the holes in the handle more defined

Then takes small file and files the inside of the holes

Takes large files and flies the handle section 14 times

Files the backside of the blade section 38 times

Takes files and runs it caringly over the iron object, inspection the object

22:08(1:22:08)- Sets object on anvil and declares that he is finished.

Summary				
Total time iron was in fire		09 m	10 s	
Work time outside of fire		28 m	58 s	
Time spent heat treating		04 m	16 s	
Total forge time		51 m	40 s	
Total finishing and sharpening time		26 m	12 s	
Total time spent on object	1 h	22 m	08 s	
Total hammer strikes	1815			
Strikes with iron implement	51			
Total Strikes	1866			
File Strokes	1742			

B.5 Notes on Forging Object 6KS17

Notes on Forging of Object 6KS17 by Blacksmith 17 in Kollengode

Video begins with asking the ethics questions.

Smith lights the fire using hay then adding charcoal.

04:19- puts iron into fire

04:29- adds 4 handfuls of charcoal

07:00- removes iron from fire

Picks up extra-large hammer and stands

Hits the iron 20 times

Sits and picks up a medium hammer and hits the iron 24 times

07:58- puts iron into fire

08:05- adds 2 handfuls of charcoal

Uses bamboo broom to clean the anvil

08:59- adds handful of charcoal

09:58-removes iron from fire

Stands and uses extra-large hammer to hit the iron 16 times

Picks up medium hammer and hits the iron 37 times

10:57- puts iron into fire

11:11- adds handful of charcoal

Uses bamboo brush to clean anvil

11:59- removes iron from fire

Uses medium hammer to hit the iron 70 times

12:56- puts iron into fire

13:09- adds handful of charcoal

Uses bamboo to clean anvil

13:44- removes iron from fire

Uses medium hammer to hit the iron 54 times

14:27- puts iron back into fire

14:43- adds 2 handfuls of charcoal

Uses bamboo brush to clean anvil

15:47- removes iron from fire

Uses medium hammer to hit the iron 38 times

16:19- puts iron in fire

Uses bamboo to clean anvil

17:20- removes iron from fire

Stands and uses extra-large hammer to hit the iron 18 times

Uses medium hammer to hit the iron 22 times

Picks up large hammer and hits 50 times

18:47- puts iron in fire

19:06- adds 2 handfuls of charcoal

19:37- removes iron from fire

Picks up medium hammer and hits the iron 27 times

Uses large hammer to hit 32 times

20:17- puts iron in fire

Uses bamboo to clean anvil

20:36- removes iron from fire

Uses medium hammer and hits 25 times

Takes large hammer and hits 53 times

21:29- puts iron into fire

21:36- adds 2 handfuls of charcoal

22:17- removes iron from fire

Uses small hammer to hit 16 times

Picks up medium hammer and hits 37 times

22:53- puts iron in fire

23:13- removes iron from fire

Uses medium hammer to hit 37 times

Takes large hammer and hits 25 times

23:56- puts iron into fire

24:04- adds 2 handfuls of charcoal

25:14- removes iron from fire

Uses large hammer to hit 34 times

Picks up extra-large hammer and places it on the floor to use as an anvil

With large hammer hits 22 times then moves back to main anvil

Hits the iron 22 more times

26:36- puts iron in fire

26:40- adds handful of charcoal

27:22- removes iron from fire

Uses medium hammer and hits 27 times

27:54- puts iron in fire

28:09- adds 2 handfuls of charcoal

28:45- adds 2 handfuls of charcoal

29:04-removes iron from fire

Uses medium hammer to hit 4 times

Picks up large hammer and hits 64 times

Video stops at 30:00 and new one picks up

00:10(30:10)- puts iron into fire

Uses bamboo to clean anvil

00:37(30:37)- removes iron from fire

Takes small hammer and hits 49 times

Picks up medium hammer and hits 16 times

01:40(31:40)- puts iron in fire

01:51(31:51)- adds 2 handfuls of charcoal

02:47(32:47)- removes iron from fire

Uses small hammer to hit 35 times

Picks up medium hammer and hits 145 times

05:55(35:55)- plunges the iron into water

06:10(36:10)-End of forging and beginning of sharpening and finishing

Sets up extra- large anvil across floor to prop iron object against

Starts filing, files 670 strokes

He askes if we would like a hole in the handle and he is told to make one

He looks around the forge area for a tool, picks up a smaller file

Files 32 strokes

15:05(45:05)- finished with filing

Start of heat treating

15:06(45:06)- puts iron in fire

16:41(46:46)- removes iron from fire and plunges into water waits a few seconds then takes the iron out and runs a file over it

Says he is going to make the holes in the handle

Takes a small punch and places it on the handle, takes the small hammer and hits the punch 19 times

Then hits the iron handle section 25 times

Picks up the small punch again, places it on the handle and hits 14 times

Hits the handle 15 times

Runs the small file over the whole object a few times and checks the straightness of the object overall. Picks up small hammer and hits 15 times

20:36(50:36)- finished making the object

*Notes- Uses a variety of hammers that sit next to him the whole time he is forging. Forged blade then handle.

Summary	
Total time iron was in fire	17m 37s
Work time outside of fire	15m 54s
Time spent heat treating	01m 40s
Total forge time	33m 31s
Total finishing and sharpening time	08m 55s
Total time spent on object	50m 36s
Total hammer strikes	1083
File Strokes	702

B.6 Notes on Forging Object 7KS9

Notes on Forging of Object 7KS9 by Blacksmith 9 in Kollengode

Video begins with the ethics questions.

03:56- smith prepares fire to begin work

04:18- puts iron in fire

04:31- adds 2 handfuls of charcoal

05:02- adds 2 handfuls of charcoal

06:18- adds 2 handfuls of charcoal

Takes bamboo brush dipped in water and uses it to sprinkle water on the fire

08:23- removes iron from fire

Stands and uses large hammer to hit the iron 12 times

Sits and uses medium hammer to hit 21 times

08:56- puts iron in fire

09:03- adds 2 handfuls of charcoal

11:50- removes iron from the fire

Stands and uses large hammer hits the iron 14 times

Sits and uses medium hammer to hit 49 times

Uses bamboo brush to clean anvil

Picks up chisel and places on the iron

Hits the chisel 6 times

Takes medium hammer and hits the iron 2 times

Dips the piece that was cut by chisel into water

Uses medium hammer to hit the cut piece 2 times till the piece falls off

13:08- puts iron into fire

13:22- adds handful of charcoal

Uses bamboo to clean anvil

14:38- removes iron from fire

Used medium hammer to hit 45 times

15:21- puts iron into fire

15:34- adds 3 handfuls of charcoal

Uses bamboo to clean anvil

17:44- removes iron from fire

Stands and uses large hammer to hit 17 times

Uses medium hammer to hit 35 times

18:35- puts iron in fire

18:51- adds handful of charcoal

Uses bamboo to clean anvil

19:32- removes iron from fire

Uses medium hammer to hit 76 times

Picks up chisel and places it on the iron

Uses medium hammer to hit the chisel 2 times

20:33- puts iron in fire

20:52- adds handful of charcoal

Uses bamboo to clean anvil

21:48- removes iron from fire

Uses medium hammer to hit 51 times

22:25- puts iron into fire

Uses bamboo to clean anvil

23:13- removes iron from fire

Uses small hammer to hit 42 times

23:43- puts iron in fire

23:48- adds 2 handfuls of charcoal

Uses bamboo to clean anvil

25:06- removes iron from fire

Uses small hammer to hit 28 times

Pick up medium hammer and hits 22 times

Dumps hammer in water

Hits iron 52 times

26:22- puts iron in fire

26:32- adds 3 handfuls of charcoal

Dips end of bamboo brush into water and uses it to sprinkle water on fire

Adds handful of sawdust

28:33- adds handful of charcoal

29:46- removes iron from fire

Stands and uses large hammer to hit 17 times

Sits and uses medium hammer to hit 43 times

01:01(31:01)- puts iron into fire

01:13(31:13)- adds 3 handfuls of charcoal

Uses bamboo to clean anvil

Then dips bamboo in water and sprinkles water on fire

02:43(32:43)- removes iron from fire

Uses medium hammer to hit 69 times

Picks up chisel and places it on iron and hits the chisel 5 times

Uses small hammer to hit the section on the iron that has been cut with the chisel, hitting it 5 times until the piece falls off

03:51(33:51)- puts iron into fire

04:02(34:02)- adds handful of charcoal

Uses bamboo to clean anvil

05:13(35:13)- removes iron from fire

Uses medium hammer to hit 123 times

06:40(36:40)- puts iron into fire

06:49(36:49)- adds 2 handfuls of charcoal

Uses bamboo to clean anvil

08:16(38:16)- removes iron from fire

Medium hammer hits 102 times

09:28(39:28)- puts iron into fire

09:37(39:37)- adds handful of charcoal

Uses bamboo to clean anvil

11:05(41:05)- removes iron from fire

Picks up chisel and hits 23 times

Hits iron 5 times

Dips section cut with chisel into water

Hits iron 5 more times until piece cut falls off

12:11(42:11)- puts iron in fire

12:18(42:18)- adds 2 handfuls of charcoal

Uses bamboo to clean anvil

13:35(43:35)- adds handful of charcoal

14:06(44:06)- adds handful of charcoal

14:42(44:42)- removes iron from fire

Stands and uses large hammer to hit 19 times

Pick up medium hammer and hits 24 times

15:30(45:30)- puts iron in fire

Uses bamboo to clean anvil

16:56(46:56)- removes iron from fire

Stands and uses large hammer to hit 15 times

Sits and uses medium hammer to hit 27 times

17:37(47:37)- puts iron in fire

17:43(47:43)- adds 2 handfuls of iron

Uses bamboo to clean anvil

19:36(49:36)- removes iron from fire

Uses medium hammer to hit 77 times

20:34(50:34)- put iron in fire

20:46(50:46)- adds 2 handfuls of charcoal

Uses bamboo to clean anvil

22:20(52:20) – removes iron from fire

Uses medium hammer to hit 52 times

23:01(53:01)- puts iron into fire

Uses bamboo to clean anvil

23:46(53:46)- removes iron from fire

Uses medium hammer to hit 95 times

24:59(54:59)- puts iron in fire

25:16(55:16)- adds handful of charcoal

Uses bamboo to clean anvil

26:13(56:13)- removes iron from fire

Uses bamboo brush to clean off the iron object from top to bottom

Picks up medium hammer and hits 179 times

28:18(58:18)- done with forging

Sets up large hammer for the iron object to lean on

Smith takes a short break

00:09(01:00:09)- begins filing and sharpening

Files 1238 strokes

13:00(01:13:00)- finished with the filing

Finds a circular object with a hole in the middle, like a doughnut, and places it on the anvil. Picks up a punch and places the handle section of the iron over the doughnut object on the anvil. Places the punch on the iron and hits the punch 3 times. Moves the iron down so the doughnut is not under a different section of the tang then places the punch over the top and hits the punch with the medium hammer 5 times. Places the doughnut and punch in the middle of the two previous spots and hits the punch 4 times. This makes 3 holes in the tang of the object. He then turns the iron over and uses a hammer to hit the new holes to even out the iron hitting the iron 11 times. Using the punch, he then goes back to the holes to make them more defined hitting the punch 10 times. He then looks at the over all shape of the object and hits the iron 42 more times.

15:02(01:15:02)- puts iron into fire (starting heat treat)

15:13(01:15:13)- adds handful of charcoal

15:57(01:15:57)- removes iron from fire

Takes a large piece of rock salt dipped in water and rubs it up and down the sharp section of the blade

16:12(01:16:12)- puts iron into fire

16:16(01:16:16)- adds 2 handfuls of charcoal

16:31(01:16:31)- adds handful of charcoal

18:10(01:18:10)- adds 2 handfuls of charcoal

Uses bamboo to clean anvil

18:57(01:18:57)- adds handful of charcoal

19:52(01:19:52)- removes iron from fire

Plunges iron into water, removes then uses file to run up and down the sharp edge and overall looks at the object. Takes the bamboo brush and rubs it up and down the iron objects

20:39(01:20:39)- puts the iron into the fire

20:48(01:20:48)- removes iron from fire

Looks over the object, picks up the medium hammer and hits 10 times

21:36(01:21:36)- finished with object

*Notes- large amounts of hammer scale. Forged the blade first.

Summary	
Total time iron was in fire	39m 21s
Work time outside of fire	19m 23s
Time spent heat treating	05m 46s
Total forge time	58m 44s
Total finishing and sharpening time	12m 51s
Total time spent on object	01h 16m 40s
Total hammer strikes	1371
File Strokes	1238

B.7 Notes on Forging Object 8KS11

Notes on Forging of Object 8KS11 by Blacksmith 11 in Kollengode

Video begins with asking ethics questions.

02:12- puts iron into fire

02:26- adds 2 handfuls of charcoal

Dips hand in water and tosses it on the fire twice

Uses a bamboo brush to clean off anvil

03:39- adds handful of charcoal

04:30- adds handful of charcoal

05:13- adds handful of charcoal

07:03- removes iron from fire

Stands and uses large hammer to hit 27 times

Picks up medium hammer and hits 18 times

08:06- put iron into fire

08:12- adds 2 handfuls of charcoal

08:38- adds handful of charcoal

09:05- adds handful of charcoal

09:36- adds handful of charcoal

Dips hand in water and throws it on fire

10:00- adds handful of charcoal

11:35- removes iron from fire

Stands and uses the large hammer to hit 22 times

Picks up medium hammer and hits 12 times

12:20- puts iron in fire

12:33- adds handful of charcoal

Uses bamboo to clean anvil

14:23- removes iron from fire

Stands and uses large hammer to hit the iron 27 times

Picks up medium hammer and hits 5 times

15:13-puts iron in fire

Uses bamboo to clean anvil

15:38- adds handful of charcoal

15:56- adds handful of charcoal

Uses bamboo to clean anvil

16:45- adds handful of charcoal

17:08- removes iron from fire

Stands and uses large hammer to hit 20 times

Sits and uses medium hammer to hit 10 times

17:53- puts iron in fire

19:26- adds handful of charcoal

Uses bamboo to clean anvil

20:31- removes iron from fire

Stands and uses large hammer to hit 24 times

Sits and picks up medium hammer to hit 12 times

Picks up chisel and hits chisel 9 times

Hits iron 3 times then dunks cut part in water

Hits 11 times until cut piece falls off

22:16- puts iron in fire

22:19- adds handful of charcoal

22:32- adds handful of charcoal

Uses bamboo to clean anvil

23:23- adds handful of charcoal

24:05- removes iron from fire

Stands and uses large hammer to hit 24 times

Sits and uses medium hammer to hit 11 times

24:58- put iron in fire

26:09- removes iron from fire

Uses medium hammer to hit 12 times

Stands and uses large hammer to hit 20 times

Sits and uses medium hammer to hit 5 times

26:59- puts iron into fire

27:10- adds handful of charcoal

Uses bamboo to clean anvil

28:12- removes iron from fire

Stands and uses large hammer to hit 19 times

Sits and uses medium hammer to hit 16 times

29:04- puts iron in fire

Video ends and new starts

00:09(30:09)- removes iron from fire

Uses medium hammer to hit 8 times

Stands and uses large hammer to hit 13 times

Picks up medium hammer to hit 5 times

00:45(30:45)- puts iron into fire

01:30(31:30)- removes iron from fire

Hits iron 44 times with the medium hammer

02:07(32:07)- puts iron into fire

Uses bamboo to clean anvil

02:34(32:34)- removes iron from fire

Uses medium hammer to hit 45 times

03:26(33:26)- puts iron in fire

03:33(33:33)- adds 2 handfuls of charcoal

04:05(34:05)- adds handful of charcoal

05:49(35:49)- removes iron from fire

Stands and uses large hammer to hit iron 8 times

Sits and uses medium hammer to hit 1 time

Picks up chisel and places on iron hits chisel 23 times

Uses hammer to hit the cut piece 27 times until cut piece falls off

08:01(38:01)- puts iron in fire

08:12(38:12)- adds 2 handfuls of charcoal

09:06(39:06)- adds handful of charcoal

Dips hand in water and throws it on the fire

10:04(40:04)- removes iron from fire

Stands and uses large hammer to hit 22 times

Sits and uses medium hammer to hit 12 times

10:56(40:56)- puts iron in fire

12:10(42:10)- removes iron from fire

Stands and uses large hammer to hit 20 times

Sits and uses medium hammer to hit 6 times

12:47(42:47)- puts iron in fire

13:25(43:25)- removes iron from fire

Stands and uses large hammer to hit 13 times

Sits and uses medium hammer to hit 8 times

14:02(44:02)- puts iron in fire

14:07(44:04)- adds handful of charcoal

14:47(44:47)- removes iron from the fire

Uses medium hammer to hit 32 times

15:18(45:18)- puts iron in fire

16:49(46:49)- removes iron from fire

Stands and uses large hammer to hit 17 times

Sits and uses medium hammer to hit 9 times

17:33(47:33)- puts iron in fire

Uses bamboo to clean anvil

18:25(48:25)- removes iron from fire

Uses medium hammer to hit 49 time

19:11(49:11)- puts iron in fire

20:11(50:11)- removes iron from fire

Uses medium hammer to hit 24 time

20:41(50:41)- puts iron in fire

20:55(50:55)- adds 2 handfuls of charcoal

21:40(51:40)- removes iron from fire

Uses medium hammer to hit 22 times

22:03(52:03)- puts iron in fire

Uses bamboo to clean anvil

22:46(52:46)- removes iron from fire

Stands and uses large hammer to hit 8 times

Uses medium hammer to hit 25 times

23:24(53:24)- puts iron in fire

24:09(54:09)- removes iron from fire

Hits iron 27 times

24:44(54:44)- puts iron in fire

25:40(55:40)- removes iron from fire

Uses medium hammer to hit 60 times

26:58(56:58)- puts iron in fire

27:38(57:38)- removes iron from fire

Hits iron 130 times

Video stops and starts again

00:20(01:00:20)- puts iron in fire

01:49(01:01:49)- removes iron from fire

Hits iron 36 times

02:39(01:02:39)- puts iron in fire

02:47(01:02:47)- adds handful of charcoal

03:40(01:03:40)- removes iron from fire

Hits the iron 21 times

04:17(01:04:17)- puts iron in fire

04:47(01:04:47)- removes iron from fire

Hits the iron 9 times

Picks up small hammer and hits 7 times

Uses medium hammer to hit 5 times

05:19(01:05:19)- puts iron in fire

Uses bamboo to clean anvil

06:14(01:06:14)- removes iron from fire

Hits the iron 9 times

06:35(01:06:35)- puts iron in fire

07:22(01:07:22)- removes iron from fire

Hits iron 44 times

08:09(01:08:09)- puts iron in fire

08:42(01:08:42)- removes iron from fire

Hits the iron 35 times

09:34(01:09:34)- puts iron in fire

Uses a large section of train track placed on the ground as an anvil

10:25(01:10:25)- removes iron from fire

Hits the iron 15 times on the track anvil

Then moves back to the regular anvil and hits 41 times

Moves back to the track anvil and hits 2 times

Back on regular anvil hits 5 times

12:06(01:12:06)- puts iron in fire

12:39(01:12:39)- adds handful of charcoal

13:02(01:13:02)- removes iron from fire

Hits iron 276 times

17:42(01:17:42)- finished with forging

Smith moves to another section of his hut to prepare for filing and finishing

Using a stone to lean the iron against he begins filing

18:50(01:18:50) beings filing and sharpening

Files 1791 strokes

Video stops and starts again during filing

13:40(01:43:40)-finished with filing and sharpening

13:46(01:43:46)- starts fire back up to begin heat treating

13:47(01:43:47)- puts iron in fire

15:52(01:45:52)- removes iron from fire

Takes a rag soaked in water and dabs it up and down the sharp part of the blade

16:33(01:46:33)-puts iron back into fire

16:47(01:46:47)- adds handful of charcoal

18:27(01:48:27)- removes iron from fire

Plunges whole iron object into water

Runs the bamboo brush all over the iron

18:48(01:48:48)- hovers iron just over fire and the iron back and forth so the heat is directed to each part of the iron at different times

18:57(01:48:57)- removes iron from fire

Takes file and runs it up and down sharp part of the blade

Uses small hammer to hit 10 times

19:30(01:49:30)- finished with the object

*Notes- Lots of hammer scale. Forges blade then handle. Medium sized hammer was uses if not specified in notes

Summary	
Total time iron was in fire	47m 05s
Work time outside of fire	37m 11s
Time spent heat treating	05m 10s
Total forge time	01h 24m 16s
Total finishing and sharpening time	47m 50s
Total time spent on object	01h 47m 18s
Total hammer strikes	1363
File Strokes	1791

B.8 Notes on Forging Object SL2- from Bonnet's Research

*All notes in this section are taken from Bonnet (2014)

Billhook SL #2

9:00 Builds fire and picks metal for use

9:02 Places metal in fire

9:05 Begins shaping the metal into a unified form, flattens to make a rectangle shape

9:08 takes chisel and cuts off end of the part working to make the shape more even

9:09 uses hammer to elongate and shape the end more

9:12 places metal back into fire

9:16 forms the end of the rectangle into a loop, changes mind and straitens the metal back out

9:17 places metal back into fire

9:19 makes circle to form socket, just uses the hammer to do this. He then takes out a container with crushed glass and mixes this with water to form a paste.

9:21 stops to help other customers

Stop time

9:35 resumes by taking copper wire, from electrical cord, and cutting into ½ inch pieces. Then takes more glass and grinds it up on a rock and adds water to make paste.

9:50 dips metal being worked into water. He then takes the glass paste and applies it to the area of the socket to be wielded then adds pieces of the copper wire to the area to be wielded.

9:58 places the metal into the fire and heats till very hot then sets to the side to cool

10:02 plunges metal being worked into water then uses hammer to reshape weld area and remove excess debris

10:03 places metal back into fire

10:05 uses round metal bar inserted into socket to form the shape of the socket more

10:08 places metal back into fire

10:10 starts to elongate and shape area for the blade

10:15 places metal in fire

10:16 works more on the blade area

10:17 places metal back into fire

10:22 cuts end piece of iron off to help shape the end area of the blade

10:24 places metal back into fire

10:25 shapes the curve closest to the socket

10:26 places metal back into fire

10:27 shapes second curve

10:28 places metal back into fire

10:29 begins blade area on curve closest to the socket

10:30 places metal back into fire

10:31 works more on the blade area around the first curve

10:32 places metal back into fire

10:33 cuts more of the end of the blade area off with a chisel

10:34 places metal back into the fire

10:35 bends curve closest to the socket again

10:36 places back into fire

10:37 works more on the curve closest to the socket

10:38 places metal back into fire

10:39 works on blade and shape of second curve

10:40 places back into fire

10:41 works more on curve closest to the socket

10:42 places metal back into fire

10:43 works on second curve

10:44 places back into fire

10:45 works on second curve

10:46 places back into fire

10:47 starts to form blade on second curve

10:48 places back into fire

10:49 finish blade shape and form on both curves. Makes sure blade is strait.

10:51 places back into fire

10:52 places round rod back into the socket and hammers forge wield down

10:54 places metal back into fire

10:56 sets metal aside to cool

10:57 plunges metal into water

10:59 places more glass paste and copper wire pieces on weld area

11:05 places metal back into fire

11:10 places metal aside to cool

11:15 hammers lightly on the weld area

11:17 places more glass paste and copper on the weld area

11:23 places metal into fire

11:26 sets metal aside to cool

11:30 hammers lightly on weld area

11:32 plunges metal into water

11:34 uses hand grinder to polish area of weld

11:45 done with forge part of SL #2 (total forge time: 2h36m)

4:33 starts to sharpen blade using electrical hand grinder. Starts on one side with the blade secured in vice

4:36 flips blade over to sharpen other side

4:39 changes to other side to sharpen more

4:40 starts to sharpen with non-electric hand file

4:41 changes sides to sharpen more with hand file

4:45 done with sharpening

Total time spent on blade: 2h49m

Summary SL #2		
Total time iron was in fire		46m
Work time outside of fire	1h	50m
Time spent working on socket	1h	37m
Total forge time	2h	36m
Total finishing and sharpening time		12m
Total time spent	2h	49m

B.9 Notes on Forging Object SL3- from Bonnet's Research

Billhook SL #3

11:53 starts fire

11:55 puts metal into fire

11:57 elongates metal and shapes into a rectangle

12:07 puts metal into fire

12:15 uses chisel to cut through middle of the metal to form the socket

12:17 puts metal into fire

12:20 uses chisel to cut through other side of the metal to form the socket

12:23 places metal into fire

12:24 continues to use chisel to cut socket cuts all the way through the metal

12:25 places metal into fire

12:28 shapes socket more

12:29 places metal into fire

12:30 shapes socket more

12:32 places metal into fire

12:33 uses chisel to make socket bigger

12:34 places metal into fire

12:35 uses chisel to cut excess iron off back of socket

12:38 places metal into fire

12:39 uses short round metal bar placed inside socket to widen the socket and round off the edges of the outside of the socket

12:42 places metal back into fire

12:43 uses chisel to shape socket

12:44 places back into fire

12:45 shapes and widens socket

12:46 places metal into fire

12:47 shapes socket

12:48 places back into fire

12:49 flattening socket sides

12:51 places metal back into fire

12:52 shapes socket

12:53 places metal into fire

12:54 shapes socket

12:55 places metal into fire

12:56 shapes socket

1:02 decides to scrap the metal due to not liking the size of the socket. The socket was not wide enough. He decided after working unsuccessfully on other pieces of iron to return to this one and finish. (1h9m)

3:55 places metal into fire

3:56 shapes socket

3:58 places metal into fire

3:59 shapes blade side into rectangle

4:00 places metal into fire

4:01 forms curve by the socket

4:03 places metal into fire

4:04 shapes top curve and cuts off end of blade

4:05 places metal into fire

4:06 shapes top curve using round part of sledge hammer as base to curve the metal around

4:08 places metal into fire

4:09 flatten blade area

4:10 places metal into fire

4:11 elongates and flattening out of blade area

4:13 places metal into fire

4:14 shapes tip of blade

4:15 places metal into fire

4:16 shapes blade area

4:17 places metal into fire

4:18 shapes top curve more

4:20 places metal into fire

4:22 thinning and shaping of top curve

4:24 places metal into fire

4:25 works on outsides of socket

4:26 places metal into fire

4:27 shapes outside of socket

4:28 places metal into fire

4:30 works on curves and evening the blade

4:32 done with forge work (total forge time: 1h46m)

4:45 starts sharpening blade with electric hand grinder. Blade is held down in vice

4:43 flips sides

4:50 finished with SL # 3

Total time to make: 1h51m

Summary SL #3		
Total time iron was in fire		44m
Work time outside of fire	1h	7m
Time spent working on socket		53m
Total forge time	1h	46m
Total finishing and sharpening time		15m
Total time spent	1h	51m

B.10 Notes on the Forging of Knife Used from Jullef's Research

*These notes are from Gill Juleff's 1998 book, *Early Iron and Steel in Sri Lanka* (appendix B section 3, page 355). They are relevant to the interpretation of the sample set and data findings so are found in total here.

Forging the Mulgama bloom

Date: 1 December 1988

Location: Smithy of H.A. Seelappu brothers, Hatanpola

Recording: Tape 2, sides A and B

[When H.A. Elias was interviewed (interview 3) he had said he could make a knife using the iron bloom (Reg. 252) collected from Mulgama (SM 83). We returned early in the morning two days later with the bloom.]

8:30 a.m. The eldest brother (Seelappu) put the bloom into the hearth so that the bloom was on its side with its V-shape cut uppermost and the base of the V nearest the tuyere. It was covered with *damba* charcoal and a small boy worked the bellows continuously for about ten minutes by which time much of the bloom was read-hot. Throughout the whole operation the bellows were operated by the young boy who was about 12 years old. He received very little instruction for the blacksmiths and was clearly accustomed to the role. He watched the operation from start to finish.

The bloom was then moved to the anvil, using straight-ended tongs, and split into two through its hottest part, the base of the V-shaped cut. To do this the bloom was held firmly on the anvil with tongs, by one brother, while the eldest brother used a small cutting wedge (cf. Reg. 1133[1], [2], and [3], appendix D) held in the tongs, and the third brother used a large hammer to hit the wedge.

One half of the bloom was returned to the hearth and heated to red heat again. A small piece of iron was then cut from the bloom, by the same technique as used to split the bloom. It took three attempts to completely cut through the half-bloom. Between each attempt, the bloom was re-heated in the hearth. The cutting wedge also had to be re-tempered and quenched in water twice. The blacksmiths said the iron was very hard.

After separating the piece, it was forged, using a large hammer, into a solid rectangular billet. Again, the piece was twice re-heated until red-hot. This was done by one person, who held the red-hot iron with a pair of tongs with one hand, while using the hammer with the other. [Up to this point, all the work was done either solely, or was directed by the eldest brother.] The eldest brother left the smithy and the middle brother (Elias) took over the work. [No comment was made by either brother at this change] The billet was hammered into a thinner, elongated bar and the end held by the tongs was cut straight using the same wedge. The bar thus formed was then partially split longitudinally using a small cutting wedge so that its square cross-section had a deep V-shaped groove cut into it. Throughout the bar was periodically re-heated in the hearth until red-hot. The bar was always held at the same end, using long-handled tongs.

The split bar was put aside while a small piece of scrap steel [a lorry spring] was forged into a thin strip. The red-hot strip of steel was then placed in the groove in the forged bar, which had by then cooled. Muddy water was splashed over the top of the two pieces. [They say this will improve the weld. Any mud will suffice] The whole assemblage was returned to the hearth and buried in the charcoal while it was heated again.

The iron and steel were then heavily hammered together to close the groove, trapping the steel inside it. After forging, only a small piece of steel remained visible at the end of the bar. Having completely closed the split and reformed the bar, it was then forged into the shape of a *malu pihaya* [fish knife]. The small piece of protruding steel was cut off at an oblique angle which then formed the point of the knife. The end of the knife which had been held with the tongs was shaped into the tang of the knife and two holes were pierced for the attachment of the handle. This part of the knife had no steel in it. The knife was re-heated as and when necessary throughout the forging, to maintain it at red heat.

After the final shape of the knife had been formed it was heated again until red-hot and then the back of the blade was quenched in water. This was done by holding the knife by the blade and dipping only the back of the knife, very briefly, into water. The knife was then held in a vice and its surface filed clean. The filing was done by the youngest brother (Jamis) while the middle brother left the smithy.

The middle brother returned and heated the blade edge of the knife in charcoal to a red heat and immediately quenched it, first the blade and then the entire knife, in water. Finally, the knife was heated in the open flame of the hearth and quenched yet again.

The youngest brother then took over the work and the middle brother left the smithy again. Two rough pieces of wood were attached to either side of the tang, using two iron rivets supplied by the smithy. The wood was then hand-shaped and finished using a sharp knife and a file. Finally, the blade was sharpened by slow and careful filing of the blade. This completed the work and the two other brothers returned to the smithy to inspect the finished knife.

10:50 a.m. The opinion of the bothers was that although the knife was perfectly acceptable, it was not as good as the knives that they make from scrap steel. The iron had been hard to work, but not unduly so. The whole operation, from start to finish had taken less then 2.5 hours. The three brothers exchanged very few words while working and the division of the work between them was unstated, although very precise. The eldest brother directed the cutting and forging of the bloom. The middle brother shaped the knife and formed its blade by welding the steel insert. He also achieved the required hardness by tempering and quenching. The youngest brother attached the handle and finished the surface of the metal.

B.11 Fieldwork Notes Taken during Forge Work in Kerala

*All notes taken in the field by Tom Raisen during forge.

Blacksmith Notes – Kerala, India, 2017

Kollenkode

Date: 17/08/17

Location: 'Big Hut' – Kollenkode

Time Arrived: 10:10

Weather: Hot/humid. Very **HOT**

Start Time: 11:14:41
- Coconut Chopper

So – Blacksmith pumping the bellows to begin with
- One non-researcher watching inside
- two outside

Initial metal heating
- From 'raw' scrap
- Start at 11:14:42
- Out of fire/on anvil – 11:19:30
- Back in heat – 11:20:32
- Back out 11:24:28
  - Uses Larger Hammer a few times
  - Then back to smaller hammer
- Back in fire 11:24:50
- 11:26:30 – non-research people have all just left
- 11:26:46 - back out of fire
- 11:27:39 – back in fire
  - 11:28:37 – Checked length against an already finished coconut chopper
- 11:29:50 Out of fire
- 11:30:12 – Checked it
- 11:30:19 – Back in fire
- 11:31 – Adjusted temperature probe
- 11:33:20 – Back out of fire

- 11:34:32 – Cut off corner piece
- 11:34:45 – Back in fire
- 11:36:50 – Shape is beginning to form\at tip

[Note – Sometimes he will go for the water, then change his mind, all the time watching the fire closely]

[11:41:48 – the already finished coconut cutter is now nearer the fire to keep checking it more easily each time it is worked]

11:55:48 – Handle end starting to take shape
- being stretched out
- but no angle yet

[Always keeps anvil very clean, keeps brushing off hammer scale very quickly]

[Some fine edge shaping done while metal is not glowing hot]

[For the bend above the handle placed against finished piece, held hammer at point to bend, taken to anvil like this (held one above the other) and then started hammering]

Once while heating the iron and working bellows with one hand, he beats the anvil itself with a hammer in the other hand, to flatten out part of the anvil.

12:29 – Final shape is finished
- Piece is taken outside for sharpening
- Sharpening station

[Smith says - Although most people now use an electric grinder, he says by doing it all by hand a more uniform thickness and more even sharpness is possible]

12:56:17 – Back to forge for final tempering
- where blade is coated with salt
- then wetted with a plant when heated
- Blade then heated again and quenched in bucket of water
- then on anvil water is splashed over blade

Kollenkode – 18/08/17

Blacksmith – Vellappan, V.

Making – 'Small sickle'

Recording – Tom Raisen and Paul

Start Time – Recording – 10:30:30

Start time – Work – 10:35:00

Starting from 'scrap metal'

[Begins by forging the tip, while adding a slight curve already]

[So, beginning with the tip, he then moves to shaping the body, then flattening and spreading the piece

- Before going back for more fine tip shaping]

11:06 – Main forge finished

- Just grinding and tempering now

so, 11:06 – Grinding starts

- After cooling tip in water

Kollengode – 19/08/17

Blacksmith – 'Toddy Shop'

Making – Coffee knife

Recording Start Time – 10:03:45

Temp. record start time – 10:03:40

[Just as we were starting work, Smith received a visitor who gave him two tools for repair, and 500 rupee note. Smith kept heating metal, adding charcoal and working bellows the whole time]

[This smith is much more talkative as he works. Smiles a lot more too :)]

10:29 – Dips medium hammer in water while working tip edge

[Applied salt for tempering using salt water rag thing
- See photo 319]

11:56 – Started smithing small sickle – modern style
- Very loud generator, kind of fumey

All recording (camera and temperature) starts 11:55 for this piece

For this – Iron has been near fire all day – so didn't need long to heat up

Vypin – 22/08/17

Making – Big Knife

Start time recording – 15:26:23

Start time work – 15:32:00

[Have quite a few people around, two watching the work, plus one baby, and four people outside chatting
- all very social]

[15:40 – Most spectators have left, only one remains – people still outside chatting]

[15:46 – Older blacksmith pops in to collect some tools]

[15:45 – Blacksmith leaves – heads into store room at back – leaves iron in fire heating]

[15:47 – small power-cut
- Camera blacks out for a second – or maybe a min
- Turns out it's why the smith went out]

[15:48 – so many mosquitoes :( ]

[15:50 – Scrap piece seems quite thick, may take some time to flatten and spread]

[15:51 – Gained two more observers, but the guys chatting outside have left]

[15:52 – Someone comes in to drop off more work]

[15:53 - This is defo. a busy work space, lost of people come and go]

[16:15 – Blacksmith asks Paul what he is doing – first to do this]

[16:16 – Instigates a wider chat with other people watching about the project in general.
- First time I've noticed this
- two observers still chatting
- then one leaves]

[16:21 – Had to pause, a small piece of hto metal cut off and flew towards our power cables – minor panic there]

[16:21 – Blacksmith picks up hot piece that flew off in his *bare* hands
- Hands it to me casually
  - **OUCH!**
- Everybody laughs
  - Was kind of funny]

[The smith has had to spend much more time thinning out the blade section
- But was a thicker piece then was worked by other blacksmiths]

[16:31 – Smith Pauses for a quick bit of snuff before filing
- But is still heating the blade right now]

[Smith definitely seems to be using less charcoal – in smaller handfuls as well]

[16:33 – Smith rubs bull horn onto hot blade
- Says it will make the iron edge a little more mild, and so easier to file]

[16:36 – Smith prepares for filing – steps out for a min to go into his store room to get a small piece of metal – and leaves in the fire
- and takes another sniff of snuff]

Puts the Big Knife to one side to cool before filing – And start work on the next piece – which is in next section

17:28 – Moves back to filing and grinding the Big knife

17:30 – Grinding and sharpening begins

17:43 – Pauses as someone arrives, and heads to back store room

17:58 – Finished grinding big knife

18:25 – Big knife goes back into fire

18:29 – Out and right into the soil

18:36 – All finished

Vypin – 22/08/17

Smithing – Small Knife

Starts – 16:41

16:50 – Smith steps out to the store room again,

- Seems to like to move
- Returns 16:52 with scale
  - Didn't use scale for Big Knife

16:58 – Our longest observer leaves

17:00 – Smith and observer ask about the photo scales – sharing looks of interest

17:04 – They light some incense for the mosquitoes

17:12 – Power cuts again – Battery v. low on camera

- Have switched to recording on action camera

17:18 – Applied bull horn to this knife

17:28 – Power back in

- ready to start filming again

So – right now moves back to filing and grinding the Big Knife

17:58 - Back on Small knife – Start grinding

18:12 – Smith goes to store cupboard it get his glasses – only takes a few seconds

18:17 – Pauses as someone comes in, then goes again

Back to Big Knife again

18:36 – All Finished

For Photographs of tools

- All tools for both big and small knives are the same – so no duplicate photos
- **Except** – Small knife has a scale

Tirur – 23/08/17

Making – Knife

Recording start time – 14:56:10

Work start time 14:40

This smith uses a hand cranked bellows system – using a bicycle wheel with an assistant

Smith works very fast, very impressive

15:40 – Smith wants to wait for it to get cool – for 20 mins he says

- Does not want to cool with water in case it hardens

15:46 – Having said he would wait, he has been doing fine hammering since then as it cools

15:47 – Now the grinding begins

15:59 – While grinding/shaping blacksmith pauses a few times

- Bellows guy receives some cash which they split

16:09 – Grinding/sharpening finished

- Tempering begins

16:14 – tempering over – just a few final grinds

And – finished at 16:20

Vikom – 24/08/17

Making – elephant toe-nail cutter

Recording start time – 18:50

Work start time – 18:52

18:49 – Smith first cuts out rough shape with electric grinder

- as this is a modern one
- Katie is present – not recording
- Now doing ethics paperwork at 18:50

Grinding only took a minute, now its in the forge.

19:07 – Blacksmith heads out to change/refill his quenching water

19:20 – Electric cutter makes huge difference

- In time and working practice

This guy sure likes to cool his hammer – more than any other smith

19:36 – Started grinding, but changed his mind

- too hot to cut – from Paul

19:36 – This is the only blacksmith to not work barefoot. Wears sandals so does not/can not grip things with his toes

19:38 – Electric blower seems to get much hotter

- from colour of metal at least
- Was literally sparkling as it comes out of the fire

19:47 – Rubbed the piece with dry wood to soften it/make it mild – Smith says

- Like the bull horn use in Vypin

19:52 – Smith cuts off last portion of tang – Says he was thinking the wrong thing about the handle

Appendix C- Lab Analysis

C.1 Kerala Object X-Rays

C.2 Sri Lanka Object X-Rays

C.3 Kerala Lab Sheets

C.4 Sri Lanka Lab Sheets

C.5 Researcher One Sample Set 1 Findings

C.6 Researcher One Sample Set 2 Findings

C.7 Researcher One Micrographs

C.8 Researcher Two Sample Set 2 Findings

C.9 Researcher One Findings Overview Table

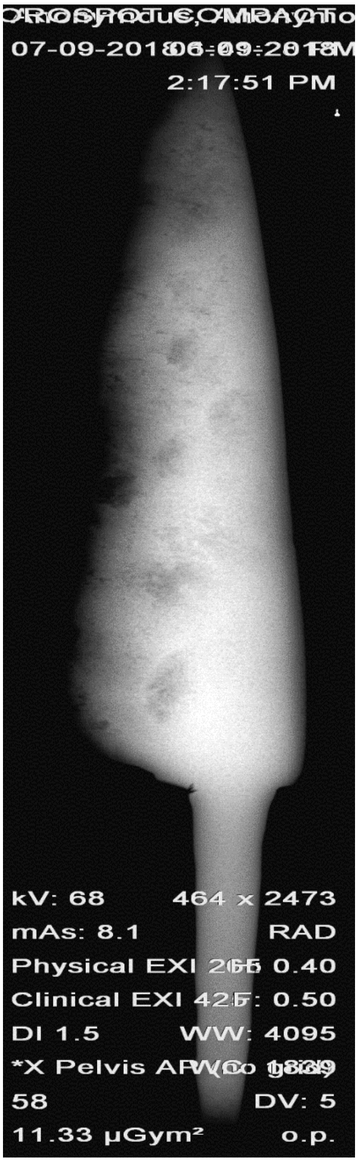
C.10 Researcher Two Findings Overview Table

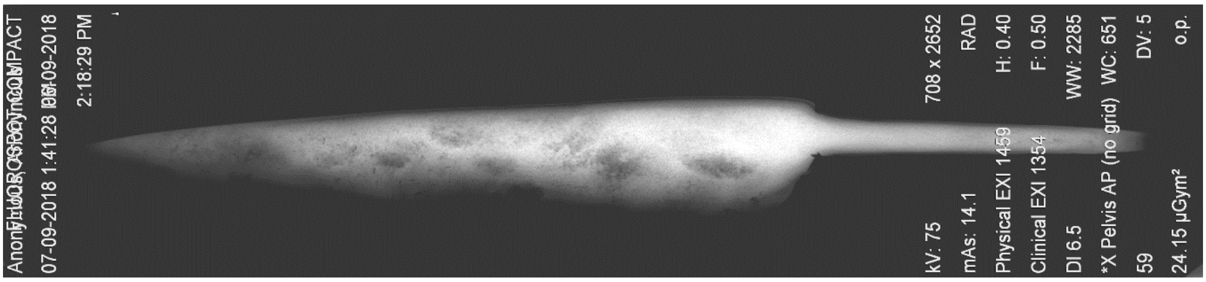
C .11 Analysis Selection Summary Table

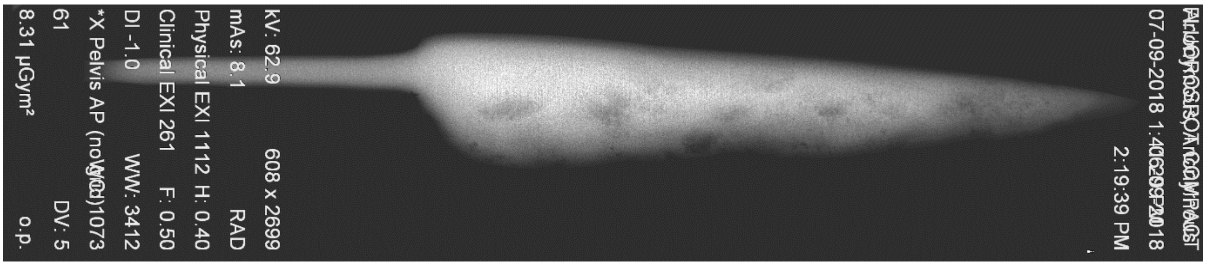
C. 12 Interview With David Scott

C.1 Kerala Object X-Rays

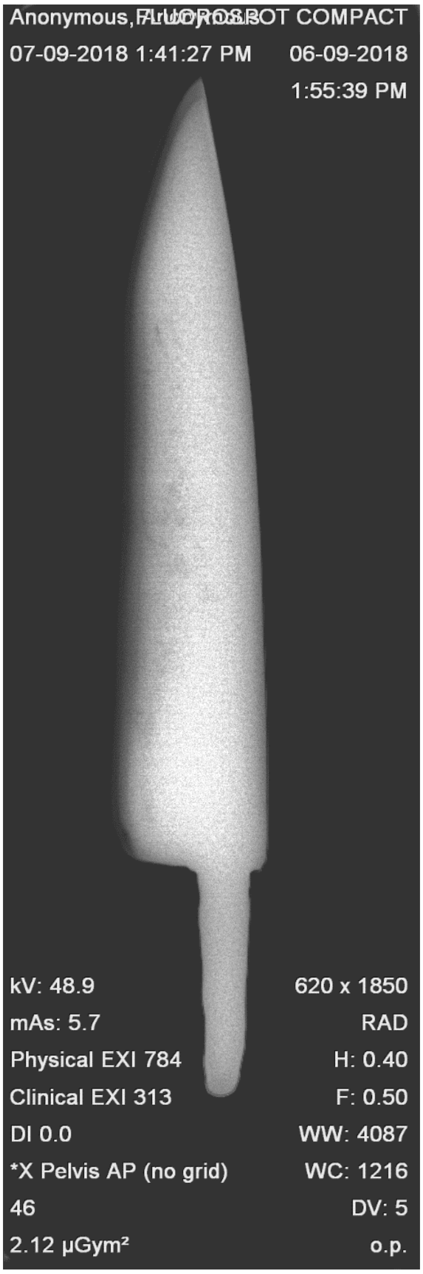
Object 1VS3

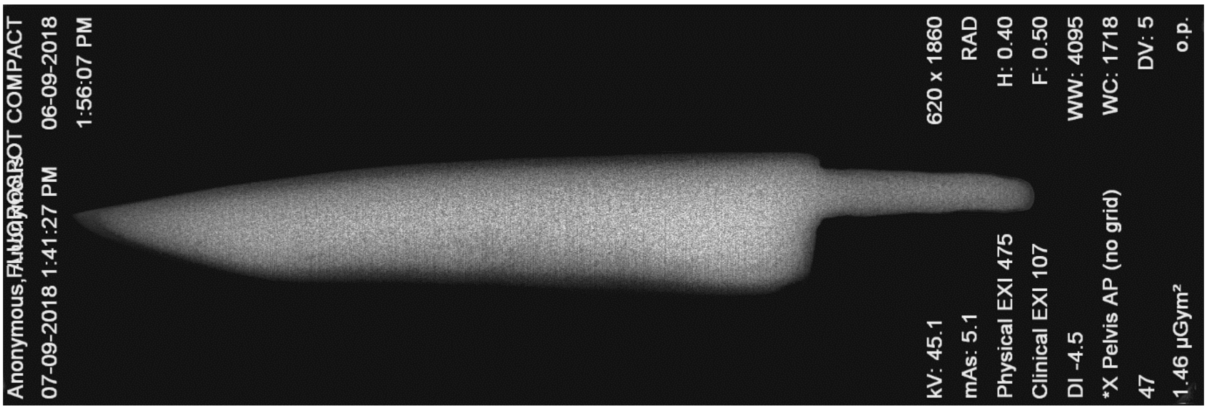




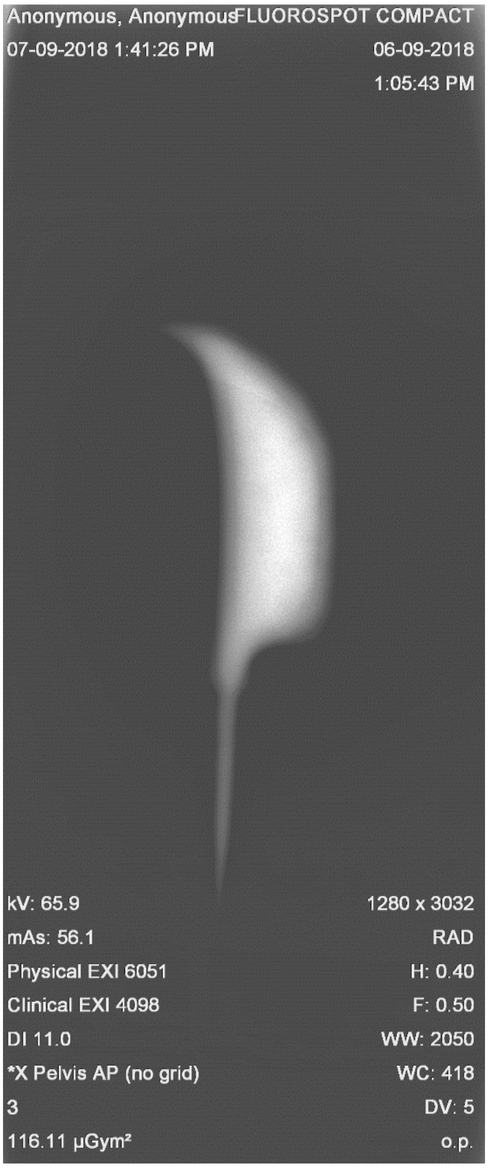


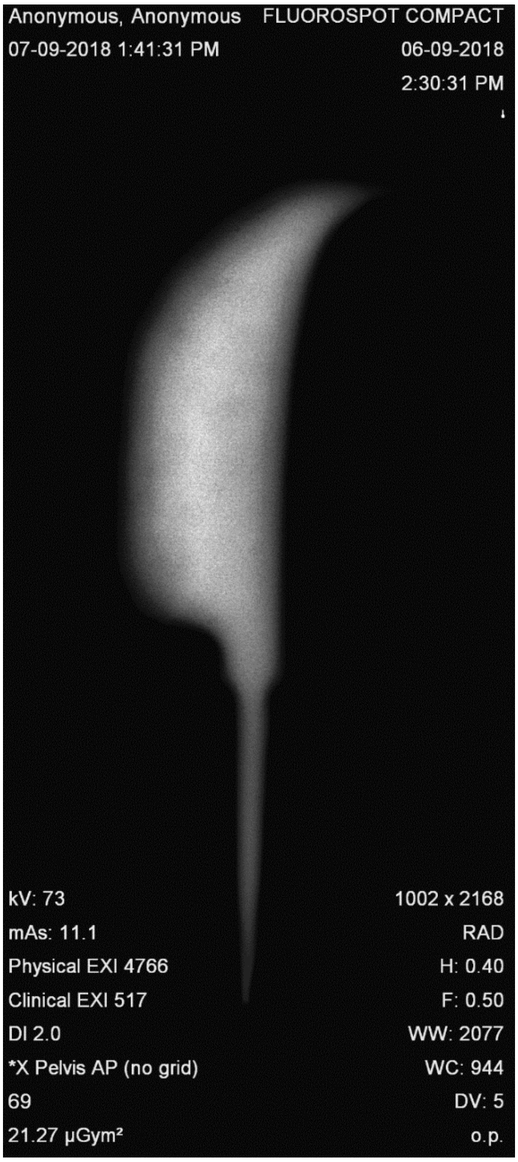
Object 2VS3

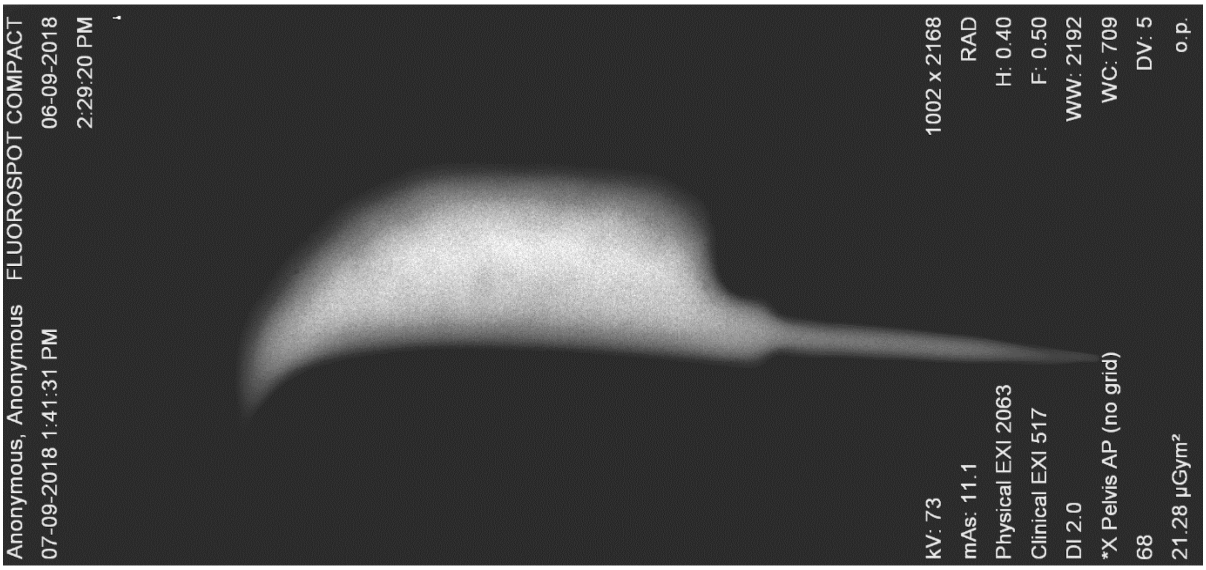

Anonymous,FLUOROSPOT COMPACT
07-09-2018 1:41:27 PM
06-09-2018
1:55:39 PM
kV: 48.9
mAs: 5.7
Physical EXI 784
Clinical EXI 313
DI 0.0
*X Pelvis AP (no grid)
46
2.12 µGym²
620 x 1850
RAD
H: 0.40
F: 0.50
WW: 4087
WC: 1216
DV: 5
o.p.


Anonymous,FLUOROSPOT COMPACT
07-09-2018 1:41:27 PM
06-09-2018
1:56:07 PM
620 x 1860
RAD
H: 0.40
F: 0.50
WW: 4095
WC: 1718
DV: 5
o.p.
kV: 45.1
mAs: 5.1
Physical EXI 475
Clinical EXI 107
DI -4.5
*X Pelvis AP (no grid)
47
1.46 µGym²

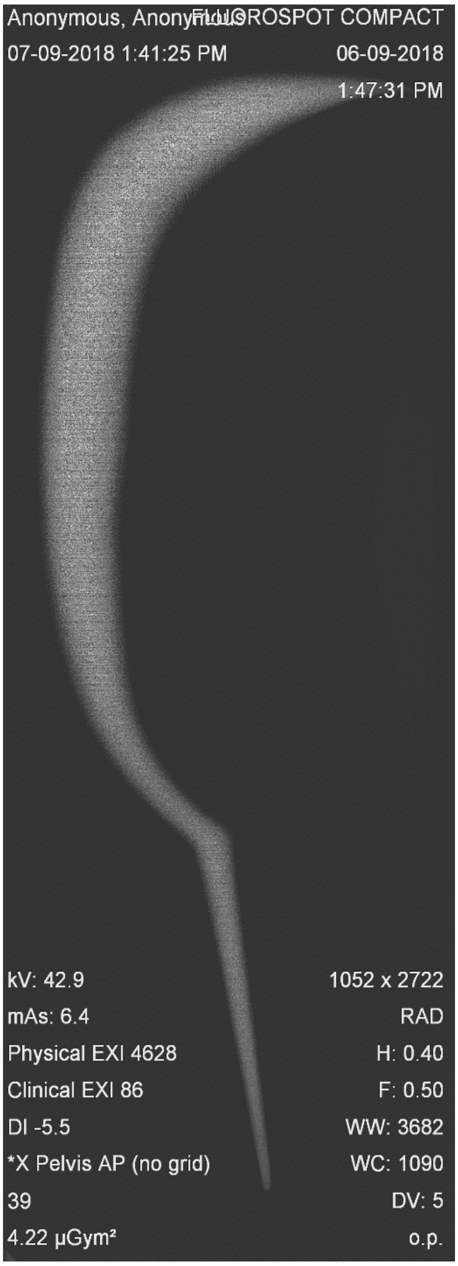
Object 3VS13







Object 4KS9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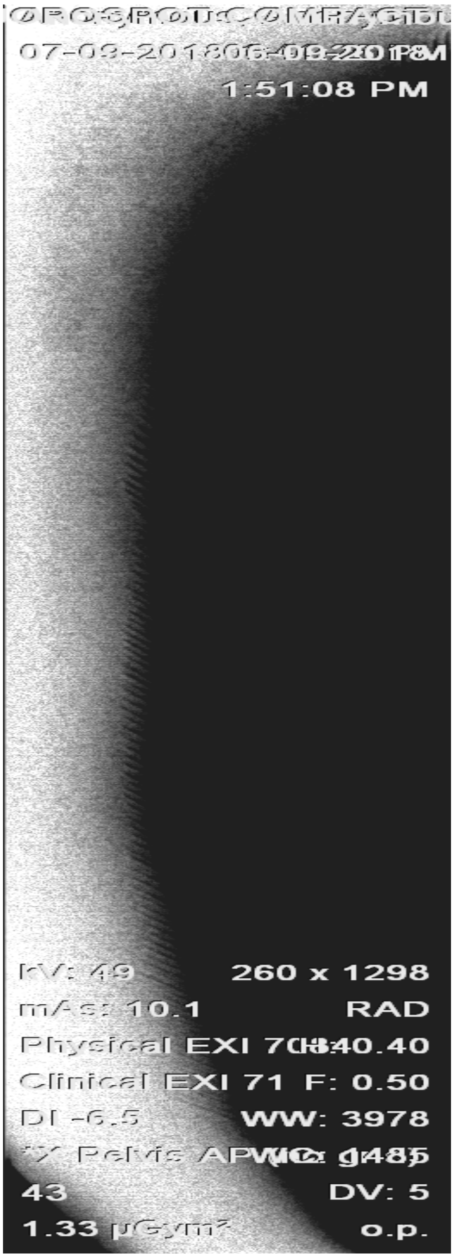
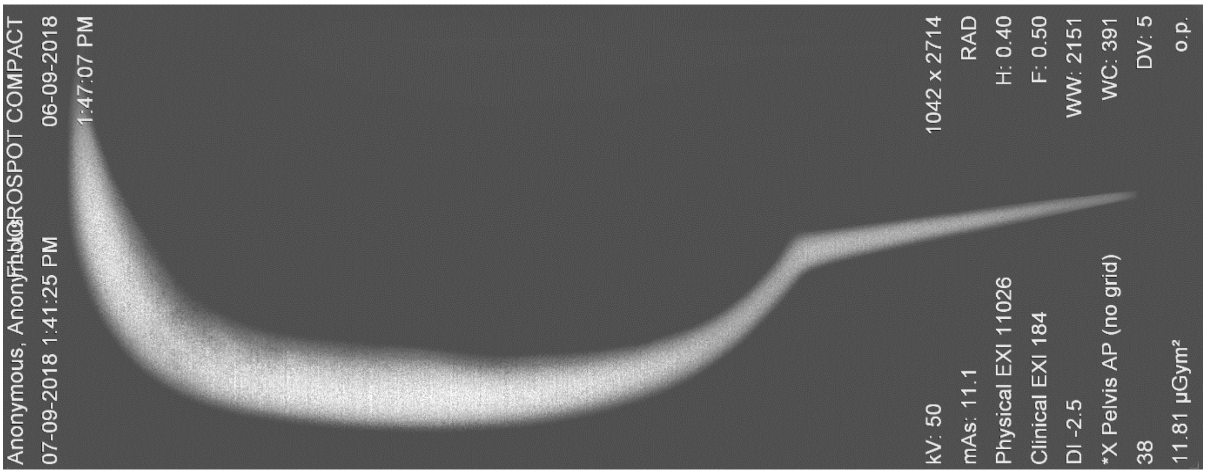
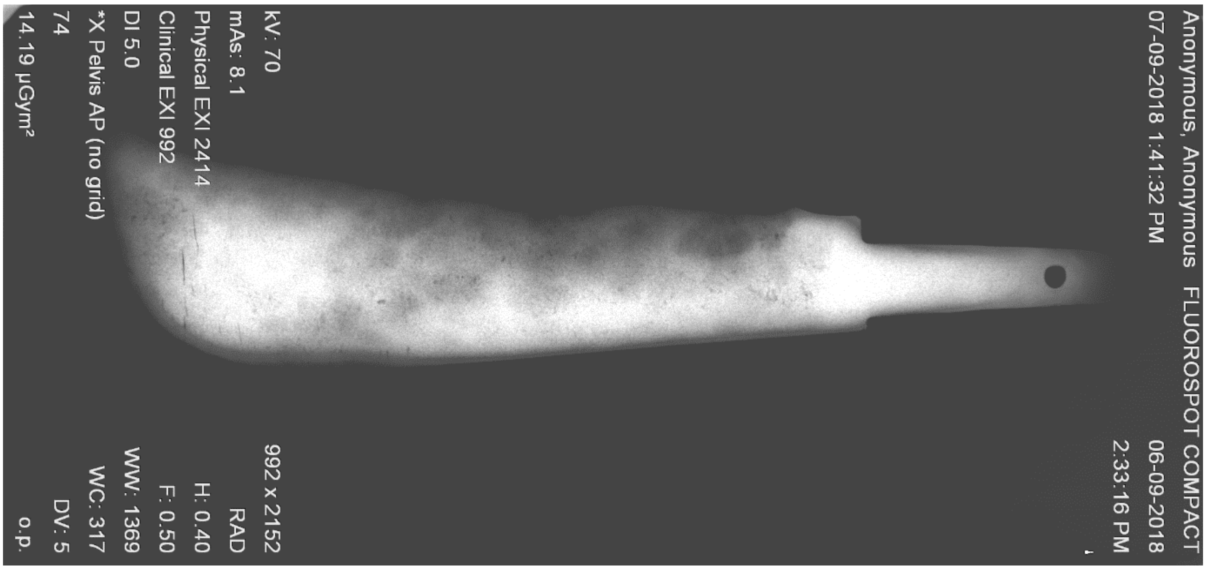
07-09-2018 1:41:25 PM
06-09-2018
1:47:31 PM
kV: 42.9
1052 x 2722
mAs: 6.4
RAD
Physical EXI 4628
H: 0.40
Clinical EXI 86
F: 0.50
DI -5.5
WW: 3682
*X Pelvis AP (no grid)
WC: 1090
39
DV: 5
4.22 µGym²
o.p.


1:51:08 PM
kV: 49
260 x 1298
mAs: 10.1
RAD
Clinical EXI 71
F: 0.50
DI -6.5
WW: 3978
43
DV: 5
1.33 µGym²
o.p.


07-09-2018 1:41:25 PM
06-09-2018
1:47:07 PM
1042 x 2714
RAD
H: 0.40
F: 0.50
WW: 2151
WC: 391
DV: 5
o.p.
kV: 50
mAs: 11.1
Physical EXI 11026
Clinical EXI 184
DI -2.5
*X Pelvis AP (no grid)
38
11.81 µGym²

Object 5TS5


Anonymous, Anonymous
07-09-2018 1:41:20 PM
FLUOROSPOT COMPACT
06-09-2018
1:22:36 PM
kV: 57
mAs: 7.2
Physical EXI 2510
Clinical EXI 240
DI -1.0
*X Pelvis AP (no grid)
13
11.27 µGym²
1272 x 2372
RAD
H: 0.40
F: 0.50
WW: 2248
WC: 420
DV: 5
o.p.


Anonymous, Anonymous
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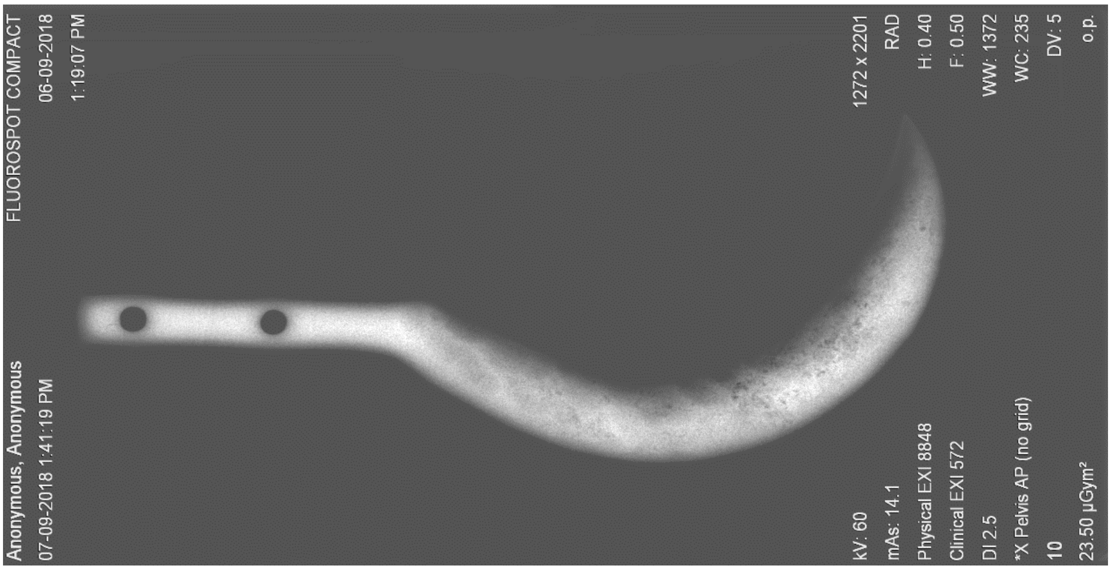
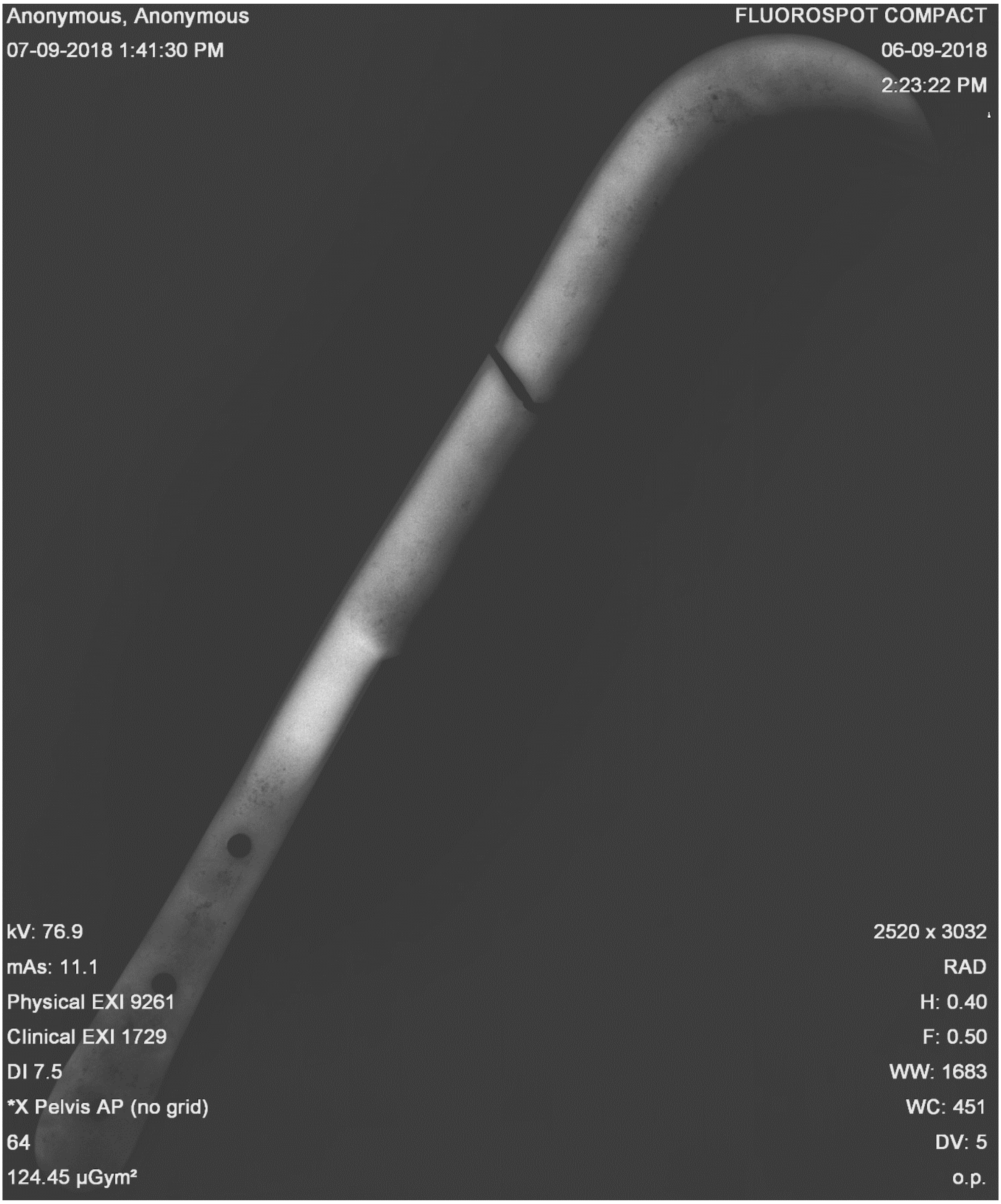
FLUOROSPOT COMPACT
06-09-2018
2:33:16 PM
kV: 70
mAs: 8.1
Physical EXI 2414
Clinical EXI 992
DI 5.0
*X Pelvis AP (no grid)
74
14.19 µGym²
992 x 2152
RAD
H: 0.40
F: 0.50
WW: 1369
WC: 317
DV: 5
o.p.

Object 6KS17



Object 7KS9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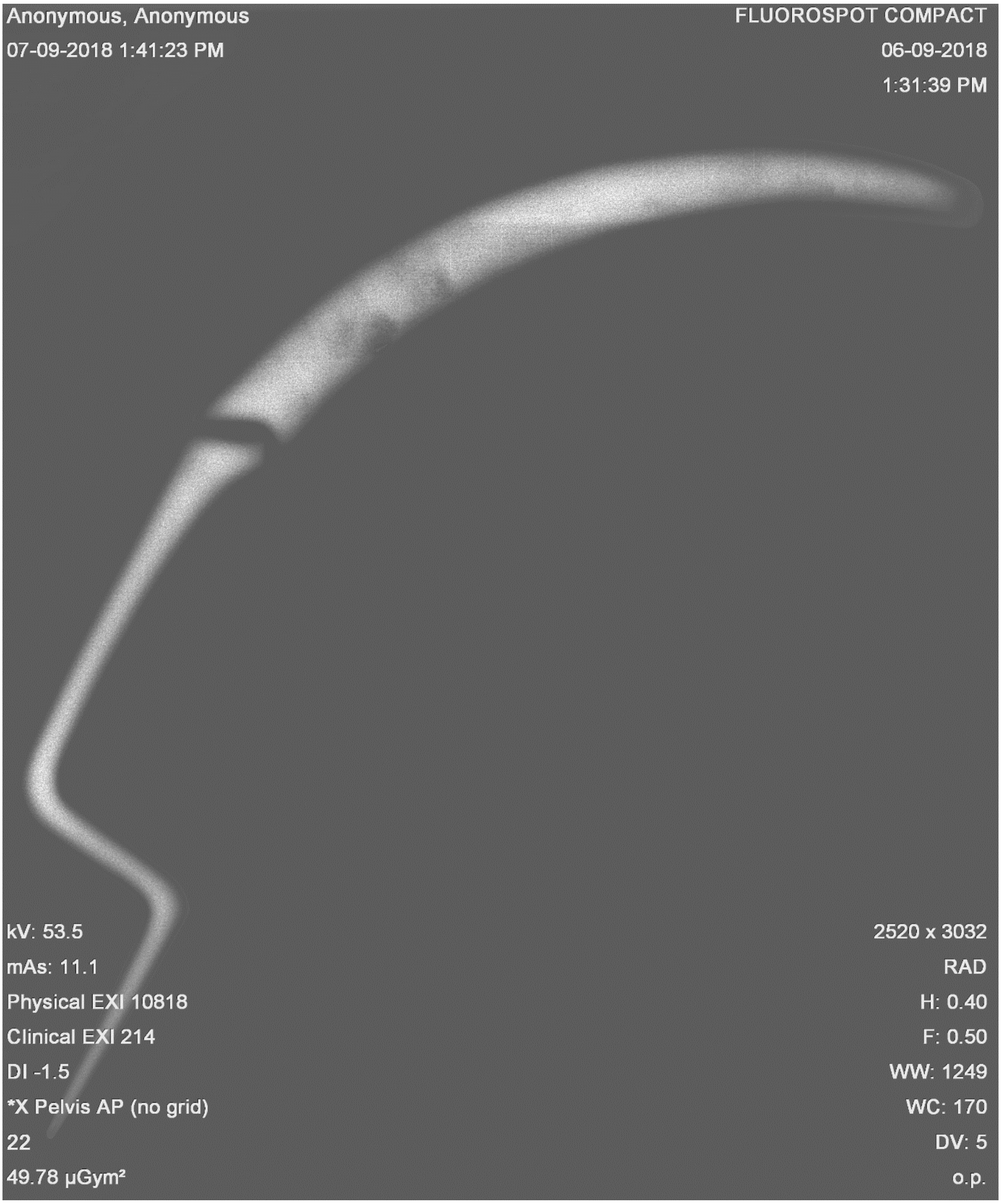
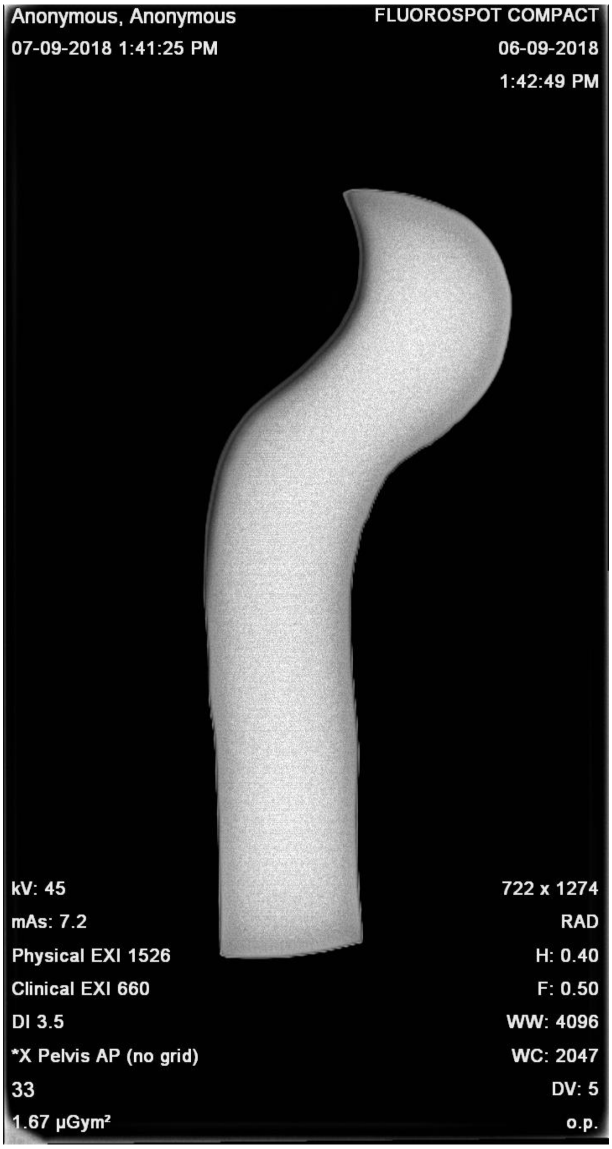
FLUOROSPOT COMPACT
06-09-2018
2:23:22 PM
kV: 76.9
mAs: 11.1
Physical EXI 9261
Clinical EXI 1729
DI 7.5
*X Pelvis AP (no grid)
64
124.45 µGym²
2520 x 3032
RAD
H: 0.40
F: 0.50
WW: 1683
WC: 451
DV: 5
o.p.

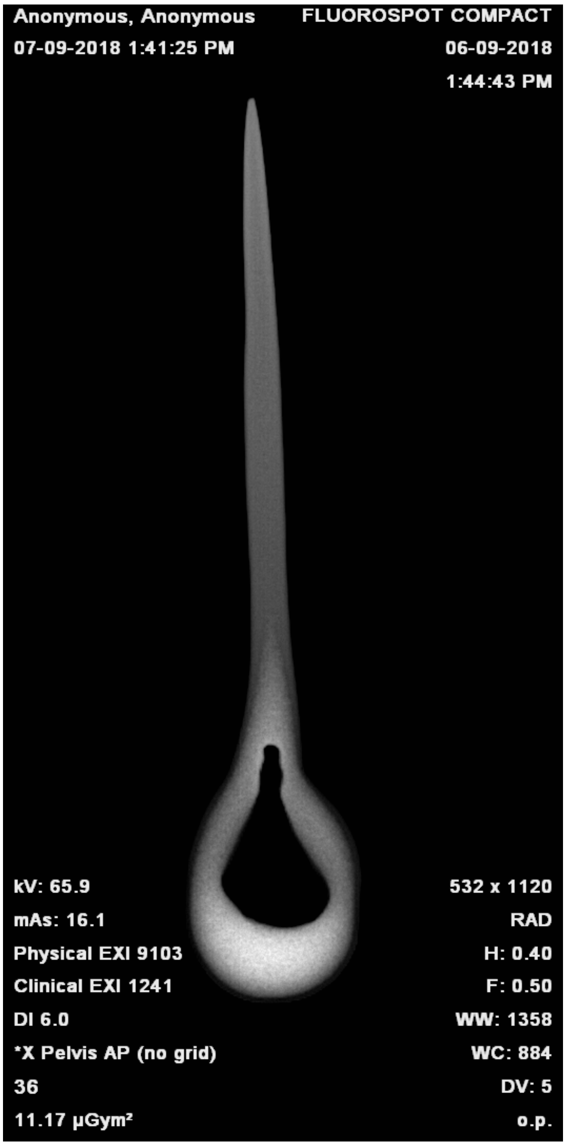
Object 8KS11



C.2 Sri Lanka Object X-Rays

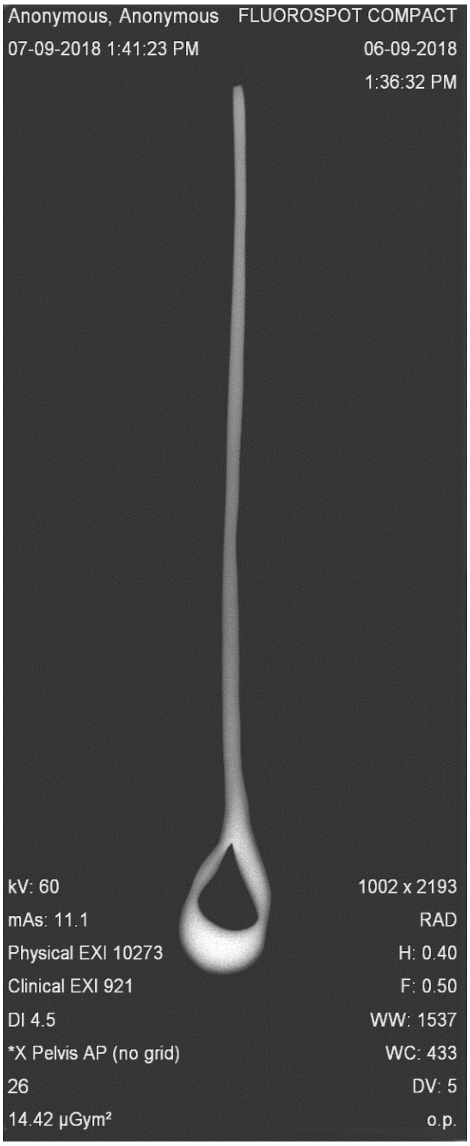
SL1

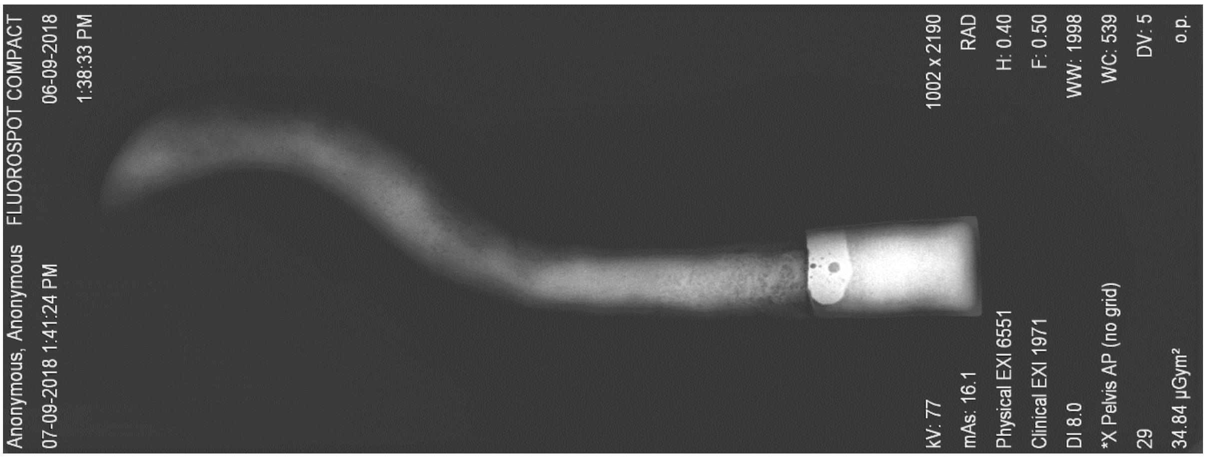




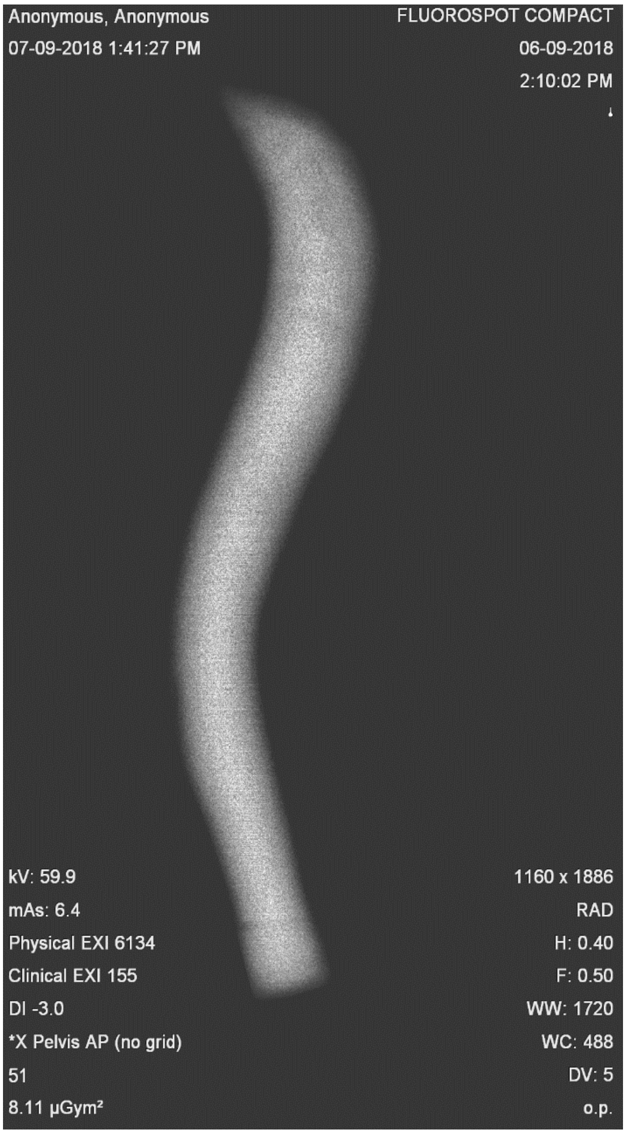
SL2


Anonymous, Anonymous
FLUOROSPOT COMPACT
07-09-2018 1:41:24 PM
06-09-2018
1:40:54 PM
kV: 72.9
582 x 1082
mAs: 16.1
RAD
Physical EXI 3759
H: 0.40
Clinical EXI 1089
F: 0.50
DI 5.5
WW: 2395
*X Pelvis AP (no grid)
WC: 1089
30
DV: 5
12.36 µGym²
o.p.


Anonymous, Anonymous
FLUOROSPOT COMPACT
07-09-2018 1:41:23 PM
06-09-2018
1:36:32 PM
kV: 60
1002 x 2193
mAs: 11.1
RAD
Physical EXI 10273
H: 0.40
Clinical EXI 921
F: 0.50
DI 4.5
WW: 1537
*X Pelvis AP (no grid)
WC: 433
26
DV: 5
14.42 µGym²
o.p.


Anonymous, Anonymous
FLUOROSPOT COMPACT
07-09-2018 1:41:24 PM
06-09-2018
1:38:33 PM
1002 x 2190
RAD
H: 0.40
F: 0.50
WW: 1998
WC: 539
DV: 5
o.p.
kV: 77
mAs: 16.1
Physical EXI 6551
Clinical EXI 1971
DI 8.0
*X Pelvis AP (no grid)
29
34.84 µGym²

SL3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FLUOROSPOT COMPACT
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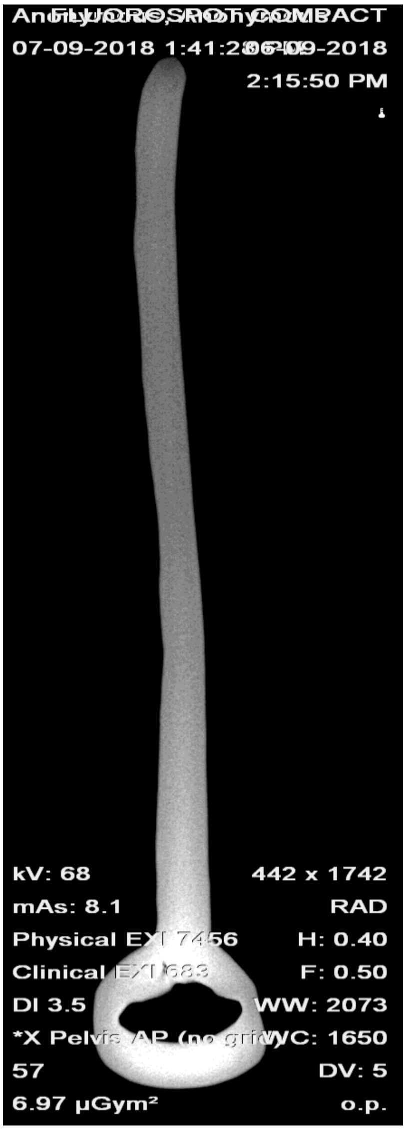
06-09-2018
2:10:02 PM
kV: 59.9
1160 x 1886
mAs: 6.4
RAD
Physical EXI 6134
H: 0.40
Clinical EXI 155
F: 0.50
DI -3.0
WW: 1720
*X Pelvis AP (no grid)
WC: 488
51
DV: 5
8.11 µGym²
o.p.


2:15:50 PM
kV: 68
442 x 1742
mAs: 8.1
RAD
H: 0.40
F: 0.50
DI 3.5
57
DV: 5
6.97 µGym²
o.p.


FLUOROSPOT COMPACT
06-09-2018
2:10:50 PM
934 x 1641
RAD
H: 0.40
F: 0.50
WW: 2527
WC: 814
DV: 5
o.p.
Anonymous, Anonymous
07-09-2018 1:41:28 PM
kV: 77
mAs: 8.1
Physical EXI 5290
Clinical EXI 785
DI 4.0
*X Pelvis AP (no grid)
53
17.13 µGym²

C.3 Kerala Lab Sheets

Kerala Iron Object 1

Local Name of Object: Kathi

Labelled as: 1VS3

Forged by: Premanath T.N. (BS 3)

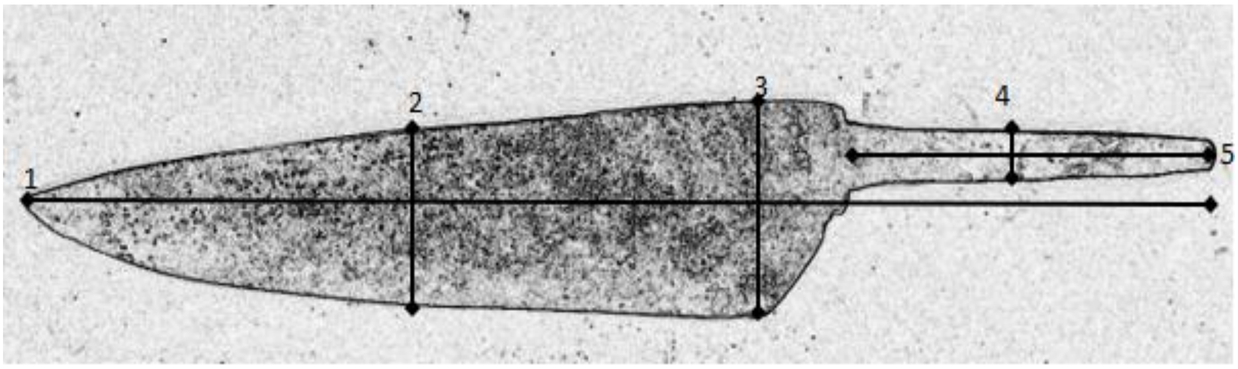
Location of Forge: Vypin

Date Forged: 22/08/2017

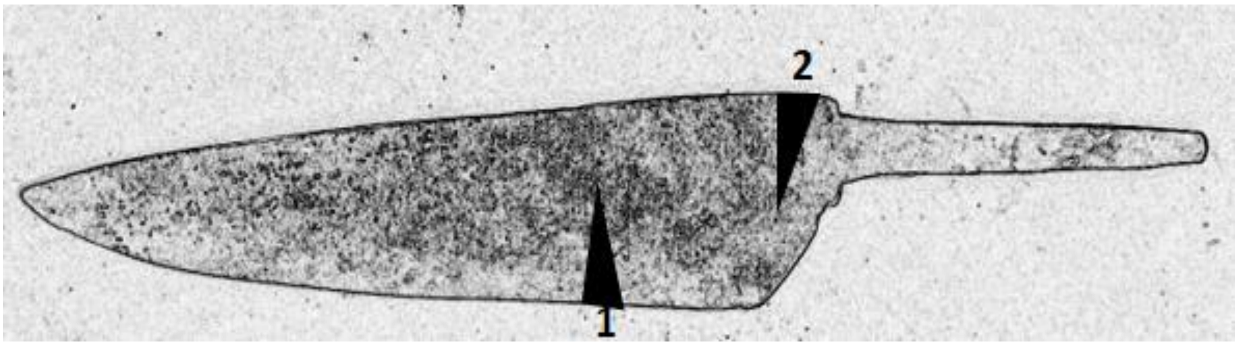
Weight: 316.3g

Dimensions:

1) 33.5cm 2) 4.3cm 3) 5.3cm 4) 1.3cm 5) 10.5cm



Sample Cut Locations



1. Sample mount ID 1VS3-1
2. Sample mount ID 1VS3-2

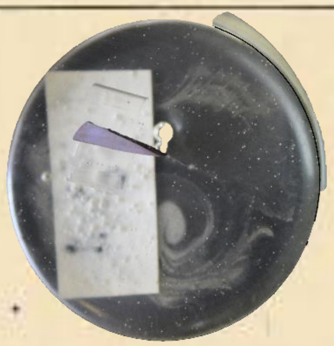
Mounting and Polishing Data Sheet

Mount ID: 1VS3-1

Material Information: Iron from lorry springs found in Kerala

Sample Information: Knife forged in Kerala locally known as a Kathi, forged by BS#3

Mount Information & Layout:



Other Notes:

Artifact ID#-1VS3

Procedure Details:
Samples Cut and mounted on 4/2/19
grinding 16/11/19 - 240
17/11/19 - 800, 1200, 2500

Name: Katie Bonnet	**Date Completed:** 24/11/19

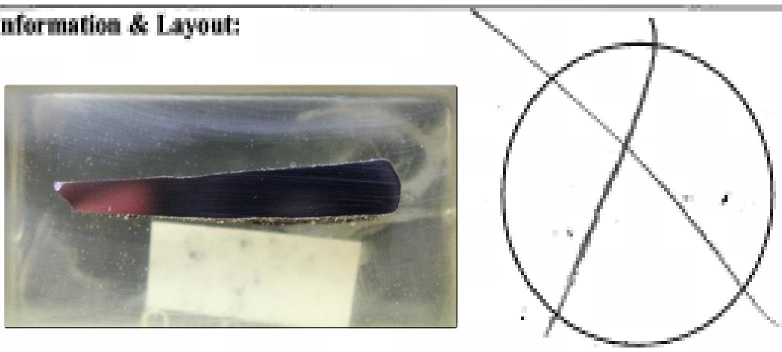
Mounting and Polishing Data Sheet

Mount ID: 1VS3-2

Material Information: Iron from lorry springs found in Kerala

Sample Information: Knife forged in Kerala locally known as a Kathi, forged by BS#3

Mount Information & Layout:



Other Notes:

Artifact ID # 1VS3

Procedure Details: Samples cut and mounted on 4/2/19

grinding 22/10
- 240
- 800
- 1200
- 2500

Polish 20/11/19

Name: Katie Bonnet	**Date Completed:** 24/11/19

Kerala Iron Object 2

Local Name of Object: Chiratta Kari/ Cheriya Kathi

Labelled as: 2VS3

Forged by: Premnath T.N. (BS 3)

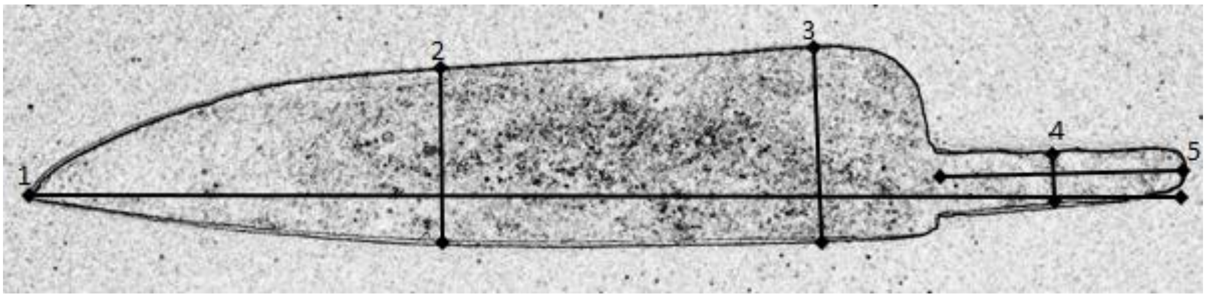
Location: Vypin

Date Forged: 22/08/2017

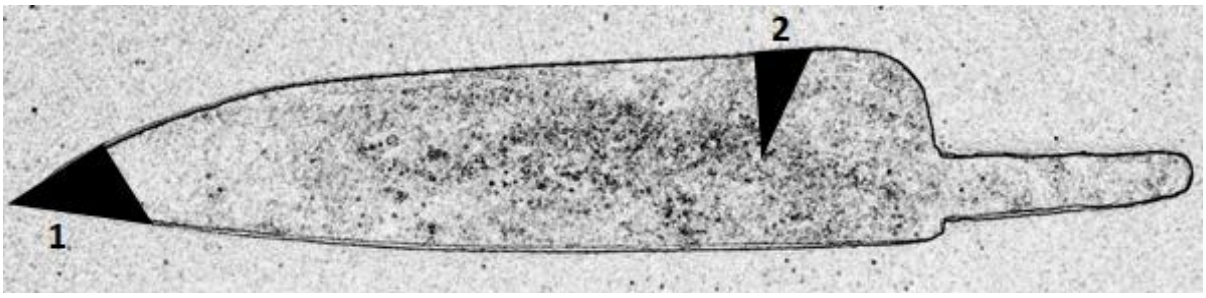
Weight:

Dimensions:

1)20.7 2) 2.7 3) 3.3 4) 1 5) 4.5



Sample Cut Locations



1. Sample mount ID 2VS3-1
2. Sample mount ID 2VS3-2

Mounting and Polishing Data Sheet

Mount ID: 2VS 3-1

Material Information: Iron from lorry springs found in Kerala	
Sample Information: Knife forged in Kerala (vypin) locally known as a Chiratta kari, forged by BS#3	
Mount Information & Layout: 	
Other Notes: Artifact ID# 2VS3	
Procedure Details: Samples cut and mounted on 4/2/19 grinding on 16/11/19 - 240 17/11/19 - 800, 1200, 2500	

Name: Katie Bonnet	**Date Completed:** 24/11/19

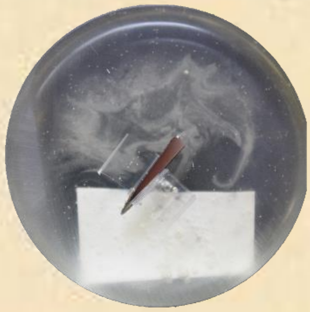
Mounting and Polishing Data Sheet

Mount ID: 2VS3-2

Material Information: Iron from lorry springs found in Kerala

Sample Information: Knife forged in Kerala (vipin) locally known as a Chiratta Kari, forged by BS#3

Mount Information & Layout:



Other Notes:

Artifact ID# 2VS3

Procedure Details: Samples cut and mounted on 4/2/19

grinding 12/11/19 - 240, 13/11/19 - 800, 1200, 2500

Polishing. 20/11/19

Name: Katie Bonnet	**Date Completed:** 24/11/19

Kerala Iron Object 3

Local Name of Object: Kollengode Kathi

Labelled as: 3VS13

Forged by: Chandran S. (BS 13)

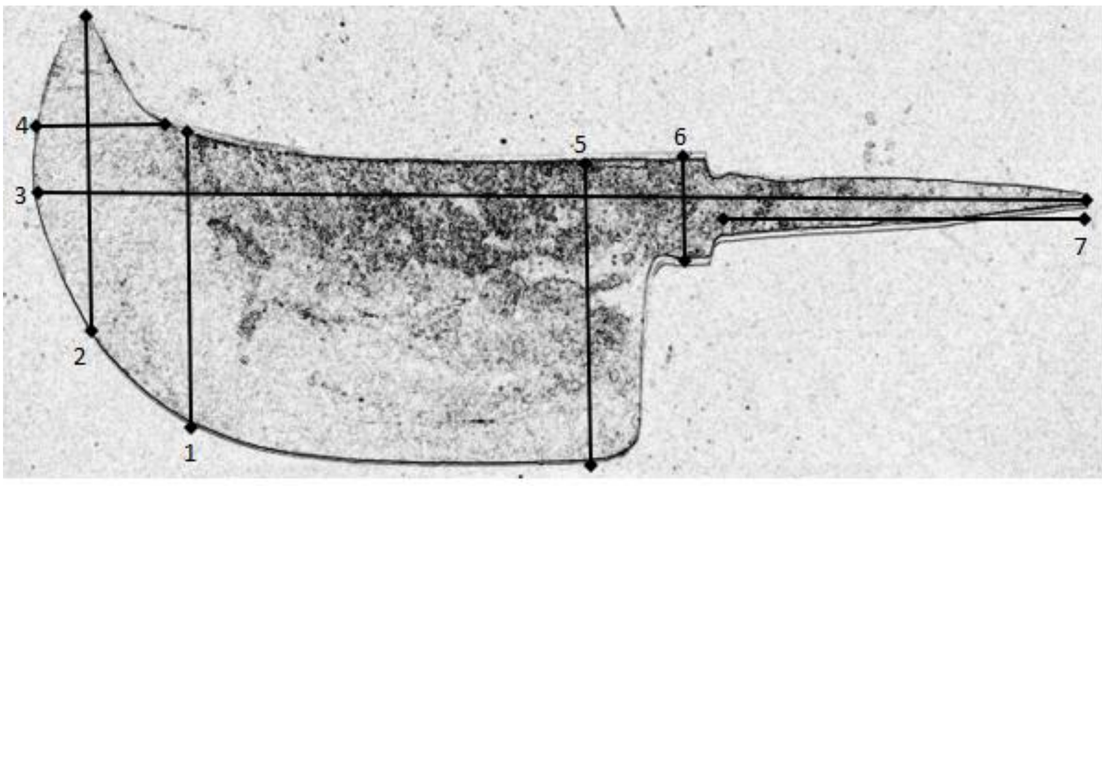
Location: Vaikum

Date Forged: 20/08/2017

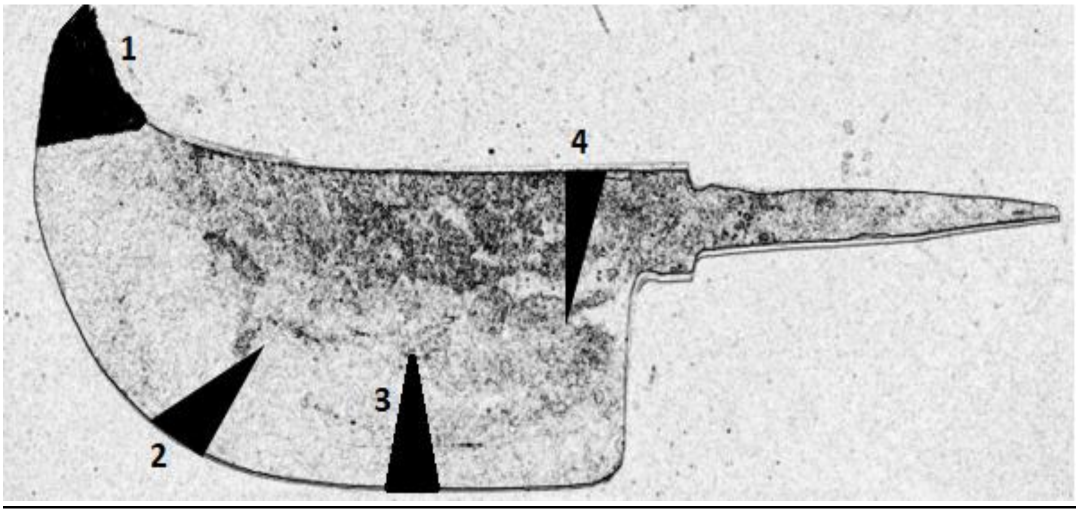
Weight: 365.1g

Dimensions:

1) 6 2) 6.5 3) 23.7 4) 2.5 5) 6.3 6)2.1 7)8.1



Sample Cut Locations



1. Sample mount ID 3VS13-1
2. Sample mount ID 3VS13-2
3. Sample mount ID 3VS13-3
4. Sample mount ID 3VS13-4

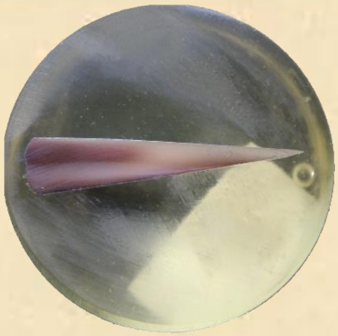
Mounting and Polishing Data Sheet

Mount ID: 3VS13 -1

Material Information: Iron from lorry springs found in Kerala

Sample Information: object forged by blacksmith #13 and is an elephant toenail clipper, locally called a Kollergode Kathi

Mount Information & Layout:



Other Notes:
Artifact id # 3VS13

Procedure Details:
Sample cut on 19/6/19
Mounted on 16/11/19
Grinding on 17/11/19 - 240, 800, 1200, 2500

Name: Kathryn Bennet | **Date Completed:** 24/11/19

Mounting and Polishing Data Sheet

Mount ID: 3VS13-2

Material Information: Iron from lorry springs found in Kerala.

Sample Information: Object forged by blacksmith #13 and is a elephant toenail clipper, locally called Kollungodi Kathi

Mount Information & Layout:

Other Notes:

Artifact id# 3VS13.

Procedure Details:

Sample cut on 19/6/19
Mounted on 16/11/19
grinding on 17/11/19 -240,800,1200,2500

Name: Kathryn Bonnet | **Date Completed:** 24/11/19

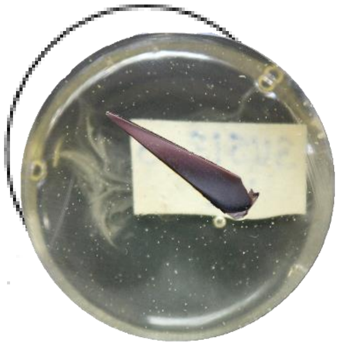
Mounting and Polishing Data Sheet

Mount ID: 31/513-3

Material Information: Iron from lorry springs found in Kerala

Sample Information: Object forged by blacksmith #13 and is a elephant toenail clipper. locally called a Kollergodle Kathi

Mount Information & Layout:



Other Notes:

Artifact id # 31/513.

Procedure Details: Samples cut and mounted on 6/6/19
grinding 27/10 · 240, 800, 1200, 2500
Polishing 20/11/19

Name: Katie Bonnet **Date Completed:** 29/11/19

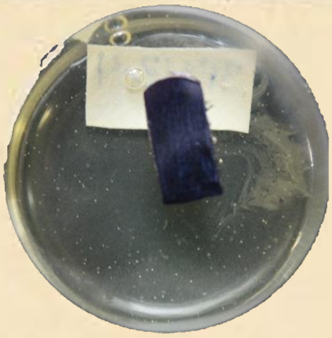
Mounting and Polishing Data Sheet

Mount ID: 3VS13-4

Material Information: Iron from lorry springs found in Kerala

Sample Information: Object forged by BS#13 and is a elephant toenail clipper, locally called a Kollengode Kathi

Mount Information & Layout:



Other Notes:

ArtifactID # 3VS13

Procedure Details:

Cut on 6/6/19
mounted on 6/6/19
grinding 13/11/19-240, 13/11/19-800,1200,2500
Polishing 20/11/19

Name: Kathryn Bonnet **Date Completed:** 24/11/19

Kerala Iron Object 4

Local Name of Object: Koythu Arival

Labelled as: 4KS9

Forged by: Prabhakaran C. (BS 9)

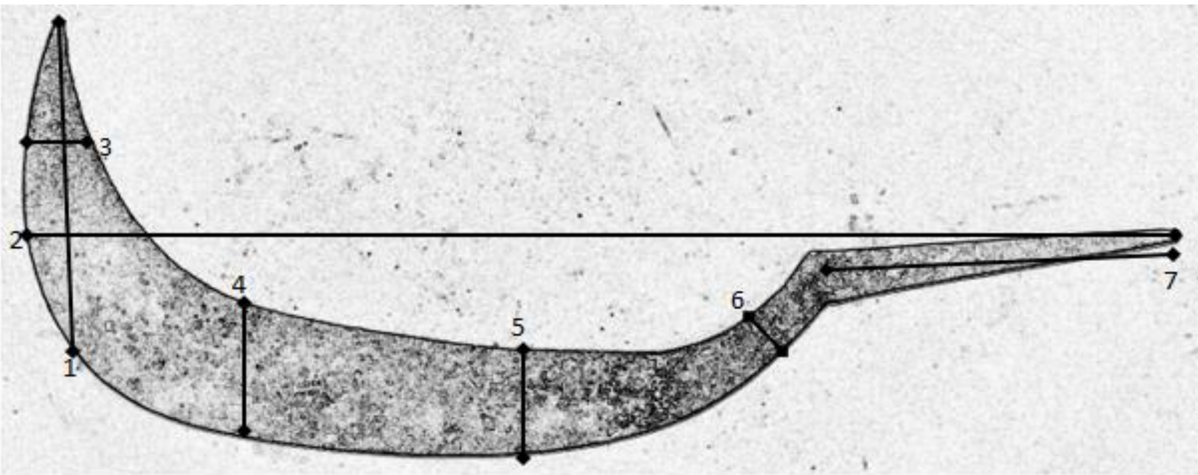
Location: Kollengode

Date Forged: 19/08/2017

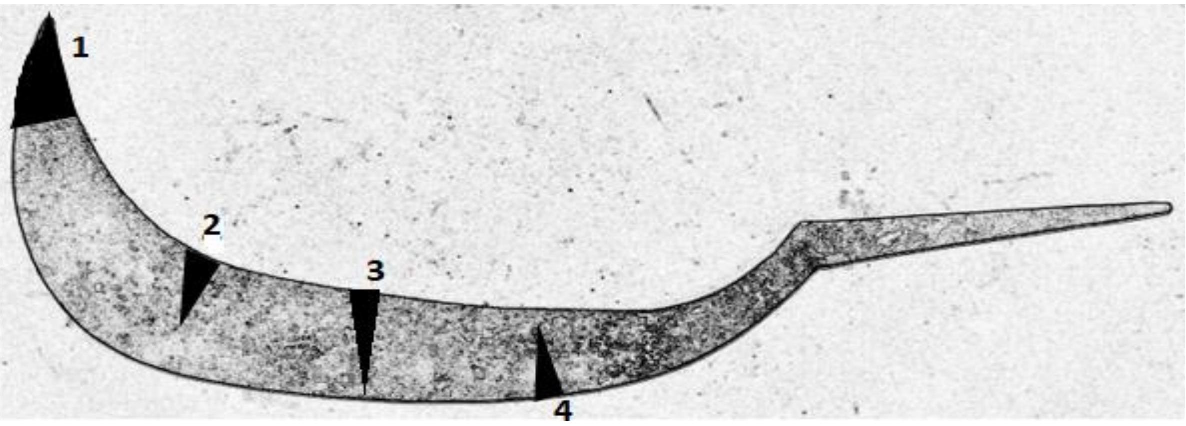
Weight: 208.7 g

Dimensions:

1) 9.5 2)34 3)2.3 4)4 5) 3.4 6) 1.4 7) 10.3



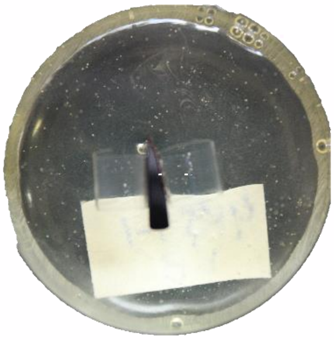
Sample Cut Locations



1. Sample mount ID 4KS9-1
2. Sample mount ID 4KS9-2
3. Sample mount ID 4KS9-3
4. Sample mount ID 4KS9-4

Mounting and Polishing Data Sheet

Mount ID: 4KS9-1

Material Information: Iron from lorry spring found in Kerala	
Sample Information: Object forged by BS#9 locally called a Koythu Arival	
Mount Information & Layout:	
Other Notes: Artifact id # 4KS9	
Procedure Details: Samples cut on 6/6/19 mounted on 6/6/19 grinding on 16/11/19 - 240 17/11/19 - 800, 1200, 2500	

Name: Katie Bonnet	**Date Completed:** 24/11/19

Mounting and Polishing Data Sheet

Mount ID: 4KS9-2

Material Information: Iron from lorry springs found in Kerala

Sample Information: Object forged By BS #9 and is locally called a Koythu Arival

Mount Information & Layout:

Other Notes:

Artifact ID # 4KS9

Procedure Details:

Sample cut on 6/6/19
Mounted on 6/6/19

Grinding - 4/11/19
240, 800, 1200, 2500
Polishing - 20/11/19

Name: Katie Bonnett	**Date Completed:** 24/11/19

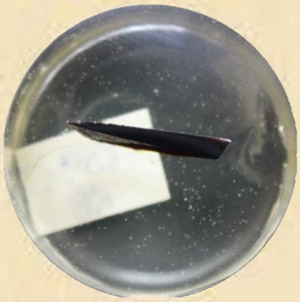
Mounting and Polishing Data Sheet

Mount ID: 4KS9-3

Material Information: Iron from brry Spring found in Kerala

Sample Information: Object forged by BS #9 locally called a Koythu Arival

Mount Information & Layout:



Other Notes:

Artifact ID # 4KS9

Procedure Details:

Sample cut on 6/6/9
mounted on 6/6/19
grinding on 16/11/19 - 240
17/11/19 - 800, 1200, 2500

Name: Katie Bonnet

Date Completed: 24/11/19

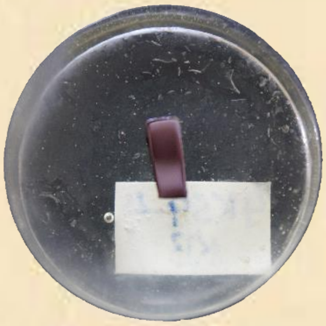
Mounting and Polishing Data Sheet

Mount ID: 4KS9-4

Material Information: Iron from lorry spring found in Kerala

Sample Information: object forged by BS#9 locally called a Koythu Arival

Mount Information & Layout:



Other Notes: Artifact ID # 4KS9

Procedure Details:
Cut and mounted on 6/6/19
grinding on 16/11/19 - 240
17/11/19 - 800, 1200, 2500

Name: Katie Bonnet **Date Completed:** 24/11/19

Kerala Iron Object 5

Local Name of Object: Vettu Kathi

Labelled as: 5TS5

Forged by: Velayudhan K.K (BS 5)/ Mani A.P. (bellows)

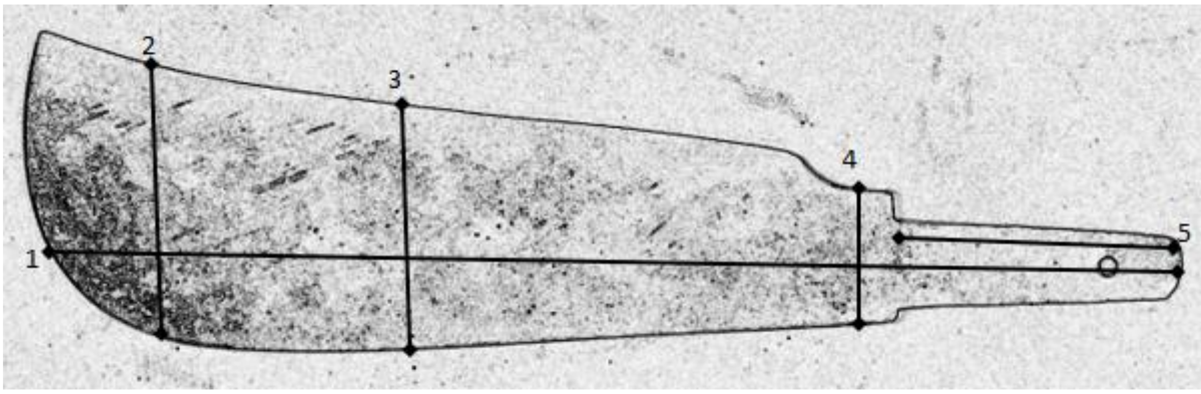
Location: Tirur

Date Forged: 23/08/2017

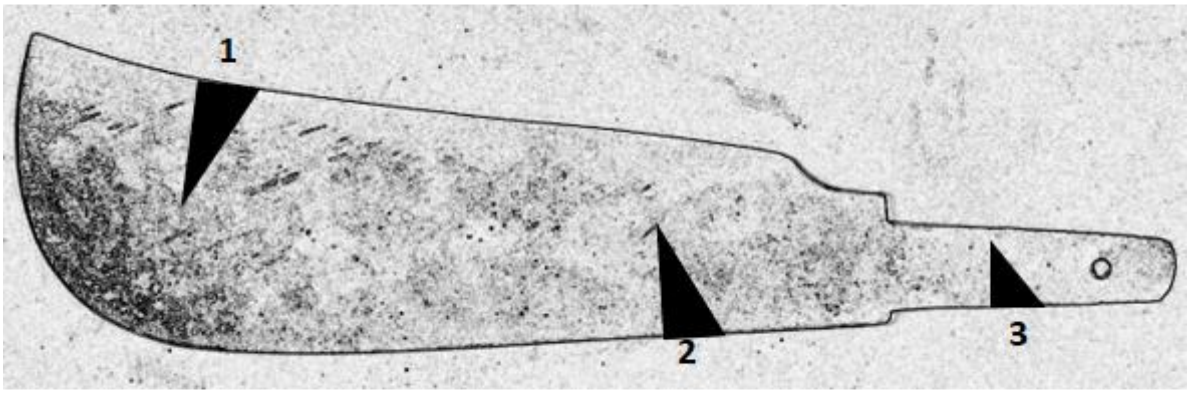
Weight: 212.4g

Dimensions:

1)25.2 2) 5.7 3) 5.3 4) 2.8 5) 6.3



Sample Cut Locations



1. Sample mount ID 5TS5-1
2. Sample mount ID 5TS5-2
3. Sample mount ID 5TS5-3

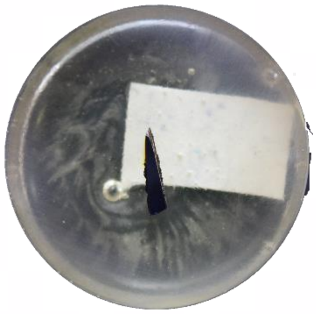
Mounting and Polishing Data Sheet

Mount ID: 5TS5-1

Material Information:

Sample Information:
Object forged by BS#5 locally called Vettu kathi

Mount Information & Layout:



Other Notes:
Artifact ID # 5TS5

Procedure Details:
Sample cut on 6/6/19
Mounted on 6/6/19
grinding on 16/11/19 - 240
17/11/19 - 800, 1200, 2500

Name: Katie Bennet | **Date Completed:** 24/11/19

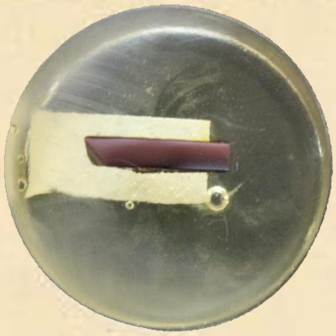
Mounting and Polishing Data Sheet

Mount ID: 5TS5-2

Material Information:

Sample Information:
object forged by BS#5 locally called Vettu Kathi

Mount Information & Layout:



Other Notes:
Artifact #5TS5

Procedure Details:
Sample Cut on 6/6/19
Mounted on 6/6/19
grinding on 16/11/19 - 240
17/11/19 - 800, 1200, 2500

Name: Katie Bonnet	**Date Completed:** 24/11/19

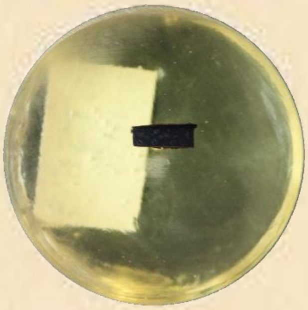
Mounting and Polishing Data Sheet

Mount ID: 5TS5-3

Material Information:

Sample Information:
Object forged by BS #5 locally called Vettu Kathi

Mount Information & Layout:



Other Notes:
Artifact ID # 5TS5

Procedure Details:
Sample cut on 6/6/19
Mounted on 6/6/19
grinding on 17/11/19 - 800, 1200, 2500

Name: Katie Bonnet | **Date Completed:** 24/11/19

Kerala Iron Object 6

Local Name of Object: Arival

Labelled as: 6KS17

Forged by: Vellappan V. (BS 17)

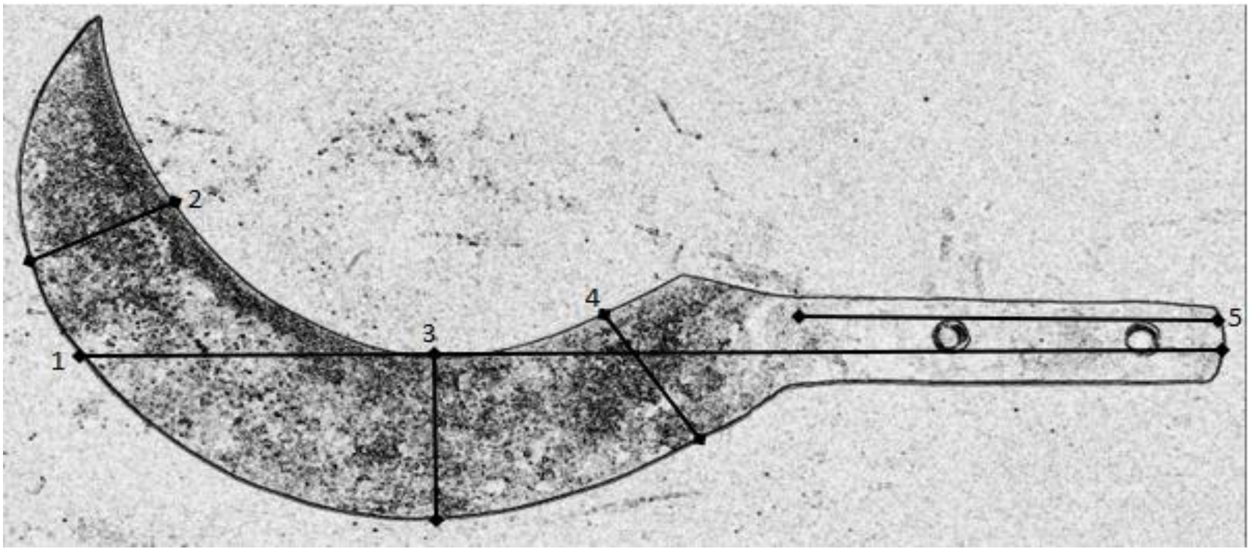
Location: Kollengode

Date Forged: 18/08/2017

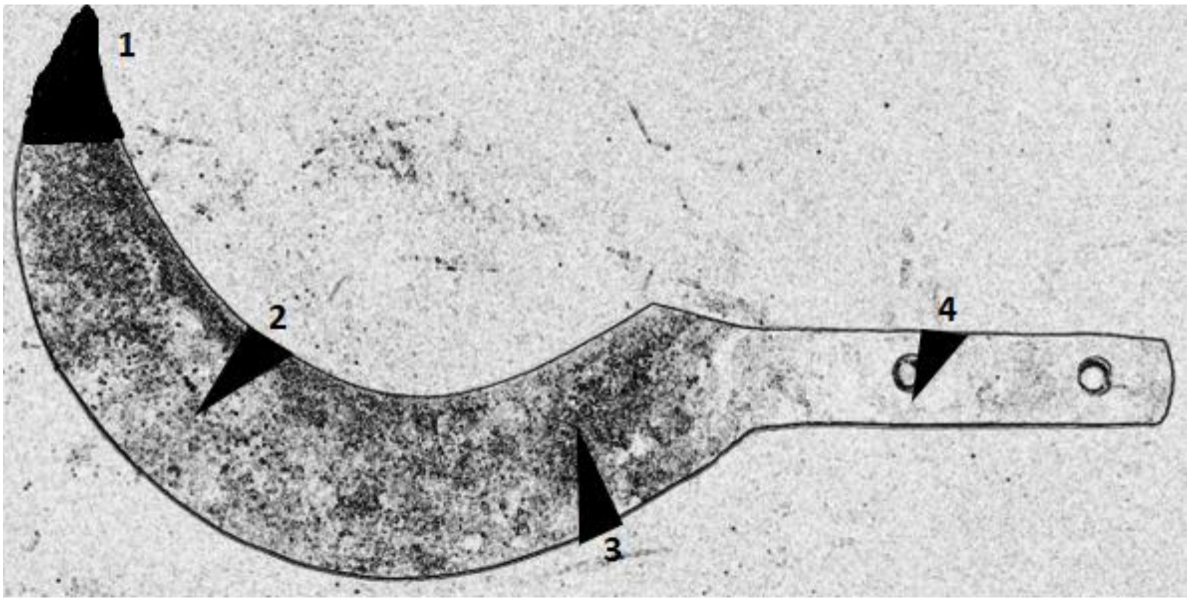
Weight: 185.8

Dimensions:

1) 23.5 2) 2.9 3) 3.8 4) 3.4 5) 8.7



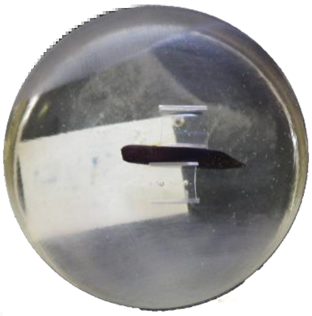
Sample Cut Locations



1. Sample mount ID 6KS17-1
2. Sample mount ID 6KS17-2
3. Sample mount ID 6KS17-3
4. Sample mount ID 6KS17-4

Mounting and Polishing Data Sheet

Mount ID: 6KS17 -1

Material Information:	
Sample Information: Object forged by BS#17 locally called a Arival	
Mount Information & Layout: 	
Other Notes: Artifact ID # 6KS17	
Procedure Details: Sample cut on 6/6/19 Mounted on 12/6/19 grinding on 16/11/19 - 240 17/11/19 - 800, 1200, 2500	

Name: Katie Bonnet	**Date Completed:** 24/11/19

Mounting and Polishing Data Sheet

Mount ID: 6KS17 -2

Material Information:

Sample Information: Object forged by BS#17 locally called a Arival

Mount Information & Layout:

Other Notes:

Artifact ID#6KS17

Procedure Details:

Sample Cut on 6/6/19
Mounted on 6/6/19
Grinding on 17/11/19 - 240, 800, 1200, 2500
Polishing - 20/11/19

Name: Katie Bonnet | **Date Completed:** 24/11/19

Mounting and Polishing Data Sheet

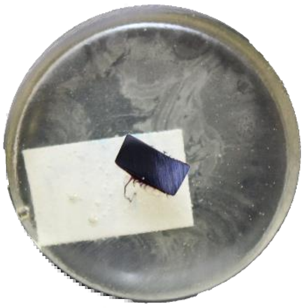
Mount ID: 6KS17-3

Material Information:	
Sample Information:	Object forged by BS #17 locally called a Arival
Mount Information & Layout:	
Other Notes:	Artifact ID #6KS17
Procedure Details:	Sample Cut on 6/6/19 Mounted on 6/6/19 grinding on 17/11/19 - 800, 1200, 2500

Name: Katie Bonnet	**Date Completed:** 24/11/19

Mounting and Polishing Data Sheet

Mount ID: 6KS17 - 4

Material Information:
Sample Information: Object forged by BS#17 locally called a Arival.
Mount Information & Layout: 
Other Notes: ArtifactID # 6KS17
Procedure Details: Sample cut on 6/6/19 Mounted on 6/6/19 grinding on 17/11/19 - 240, 800, 1200, 2500

Name: Katie Bonnet	Date Completed: 24/11/19

Kerala Iron Object 7

Local Name of Object: Kavath

Labelled as: 7KS9

Forged by: Prabhakaran C. (BS 9)

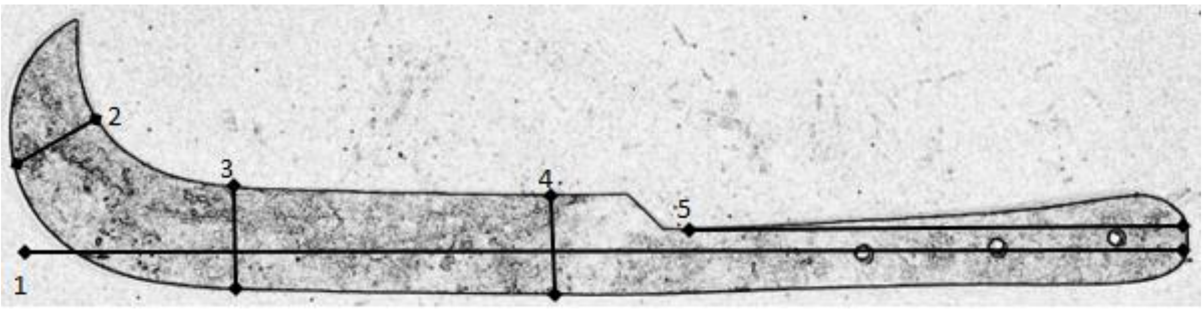
Location: Kollengode

Date Forged: 19/08/2017

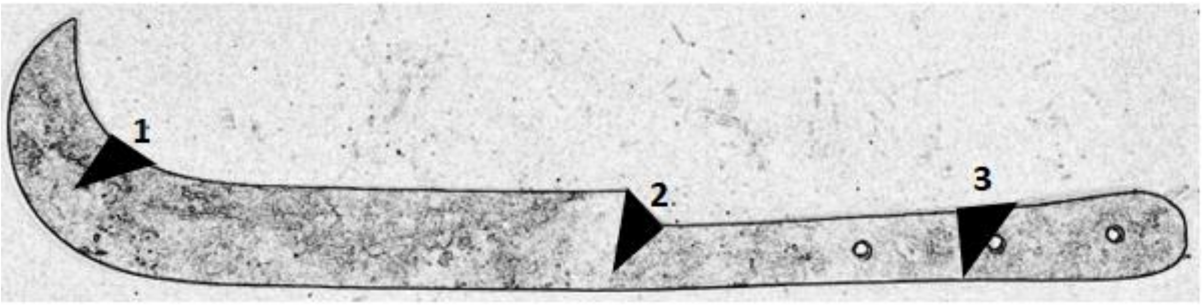
Weight: 509.6g

Dimensions:

1) 48 2) 4 3) 4.3 4) 4 5) 21



Sample Cut Locations



1. Sample mount ID 7KS9-1
2. Sample mount ID 7KS9-2
3. Sample mount ID 7KS9-3

Mounting and Polishing Data Sheet

Mount ID: 7KS9-1

Material Information:
Sample Information: Object forged by BS #9 and locally called a Kavath
Mount Information & Layout: 
Other Notes: Artifact ID # 7KS9
Procedure Details: Sample cut on 6/6/19 Mounted on 12/6/19 grinding on 17/11/19 - 800, 1200, 2500

Name: Katie Bonnet	**Date Completed:** 24/11/19

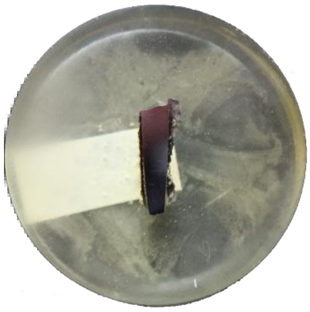
Mounting and Polishing Data Sheet

Mount ID: 7K59-2

Material Information:

Sample Information: object forged by BS #9 and locally called a Kavath

Mount Information & Layout:



Other Notes:

Artifact ID # 7K59

Procedure Details:

Sample cut on 6/6/19
mounted on 12/6/19
grinding 12/11/19- 240, 13/11/19-800, 1200, 2500
Polish 20/11/19

Name: Katie Bonnet | **Date Completed:** 24/11/19

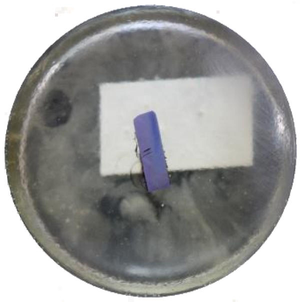
Mounting and Polishing Data Sheet

Mount ID: 7K59-3

Material Information:

Sample Information: object forged by BS#9 and locally called a Kavath

Mount Information & Layout:



Other Notes:

Artifact ID # 7K59

Procedure Details:

Sample Cut on 6/6/19
Mounted on 13/6/19
grinding on 17/11/19-800,1200,2500

Name: Katie Bonnet **Date Completed:** 24/11/19

Kerala Iron Object 8

Local Name of Object: Thengu Kayatta Karude Kathi

Labelled as: 8KS11

Forged by: Subramanian (BS 11)

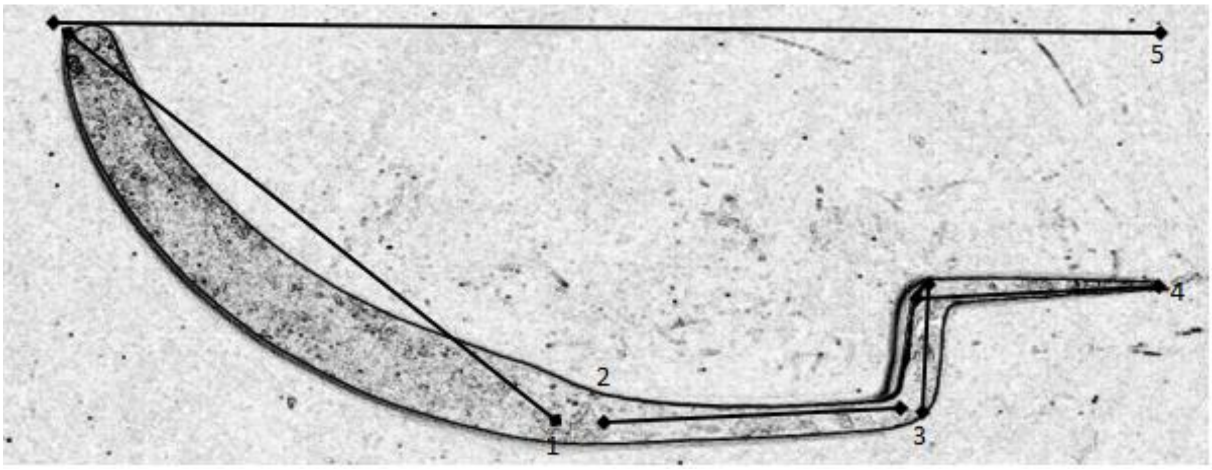
Location: Kollengode

Date Forged: 17/08/2017

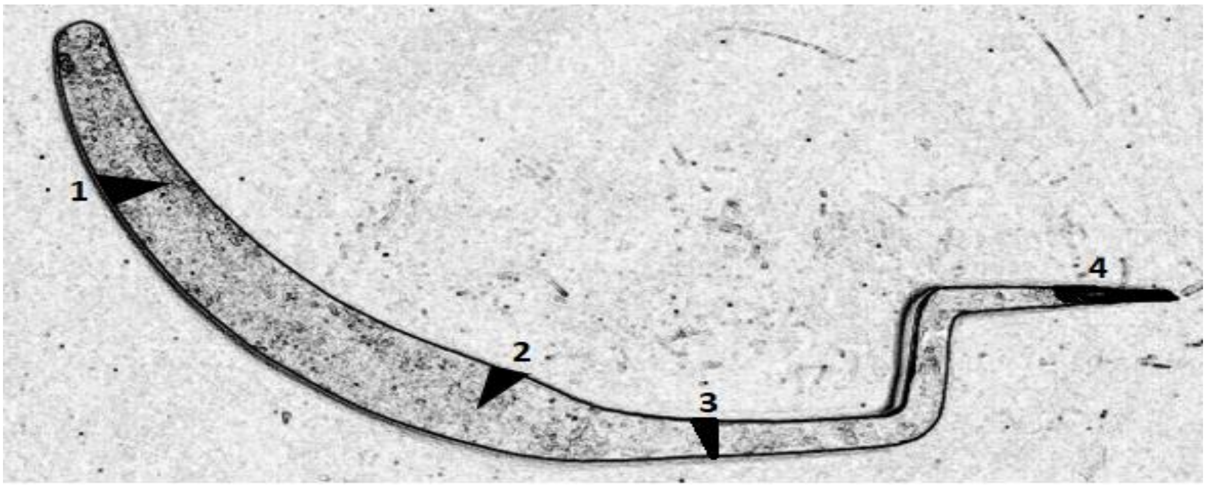
Weight: 364.3 g

Dimensions:

1) 27 2) 12.6 3) 7.3 4) 9.8 5) 45.8



Sample Cut Locations



1. Sample mount ID 8KS11-1
2. Sample mount ID 8KS11-2
3. Sample mount ID 8KS11-3
4. Sample mount ID 8KS11-4

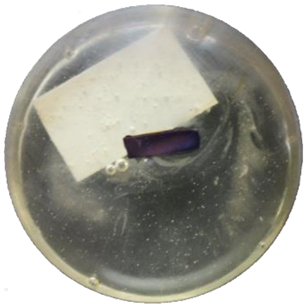
Mounting and Polishing Data Sheet

Mount ID: 8KS 11 - 1

Material Information:

Sample Information: Object forged by BS #11 and locally called a Thergu Kayatta Karude Kathi

Mount Information & Layout:



Other Notes:

Artifact #8KS 11

Procedure Details:

Sample Cut on 6/6/19
mounted on 12/6/19
grinding on 17/11/19 - 800, 1200, 2500

Name: Katie Bonnet | **Date Completed:** 24/11/19

Mounting and Polishing Data Sheet

Mount ID: 8KS11-2

Material Information:

Sample Information: object forged by BS#11 and locally called a Thengu Kayatta Karude Kathi

Mount Information & Layout:

Other Notes:

ArtifactID# 8KS11

Procedure Details:

Sample cut on 6/6/19
Mounted on 12/6/19
grinding 12/11/19-240, 13/11/19-800, 1200, 2500
Polish - 20/11/19

Name: Katie Bonnet | **Date Completed:** 24/11/19

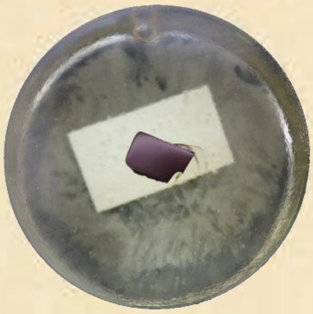
Mounting and Polishing Data Sheet

Mount ID: 8KS11-3

Material Information:

Sample Information: Object forged by BS#11 and locally called a Thengu Kaipatta Karudo Kathi

Mount Information & Layout:



Other Notes:

Artifact ID# 8SK11

Procedure Details:

Sample Cut on 6/6/19
mounted on 12/6/19
grinding on 16/11/19 - 240
17/11/19 - 800, 1200, 2500

Name: Katie Bonnet | **Date Completed:** 24/11/19

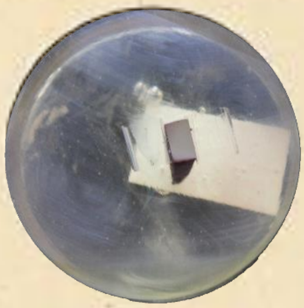
Mounting and Polishing Data Sheet

Mount ID: 8KS 11-4

Material Information:

Sample Information:

Mount Information & Layout:



Other Notes:

ArtiFact ID# 8KS11

Procedure Details:

Sample cut on 6/6/19
Mounted on 12/6/19
grinding 12/11/19 – 240, 13/11/19 - 800, 13/11/19 - 800, 1200, 2500
Polishing - 20/11/19

Name: Katie Bonnet | **Date Completed:** 24/11/19

C.4 Sri Lanka Lab Sheets

Mounting and Polishing Data Sheet

Mount ID: SL1-1

Material Information:

Sample Information: object forged in Sri Lanka, origianally labled as billhook

Mount Information & Layout:

Other Notes:

Artifact #SL1

Procedure Details:

Sample cut on 12/6/19
Mounted on 19/6/19
grinding on 17/11/19 - 800, 1200, 2500

Name: Katie Bonnet	**Date Completed:** 24/11/19

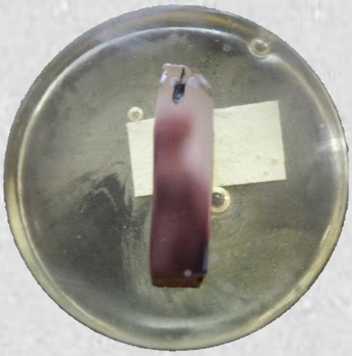
Mounting and Polishing Data Sheet

Mount ID: SL1-2

Material Information:

Sample Information: Object forged in Sri Lanka, origianally labled as billhook

Mount Information & Layout:



Other Notes:

ArtifactID #SL1

Procedure Details:

Sample Cut on 12/6/19

Mounted on 19/6/19

grinding 2/11/19

240, 800, 1200, 2500

Polishing 20/11/19

Name: Katie Bonnet	**Date Completed:** 24/11/19

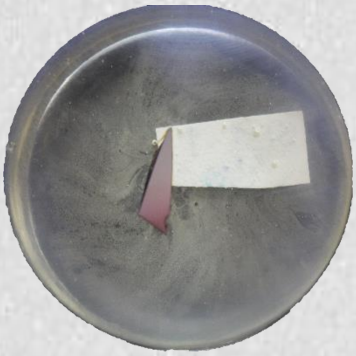
Mounting and Polishing Data Sheet

Mount ID: SL2-1

Material Information:

Sample Information:

Mount Information & Layout:



Other Notes:

Artifact #SL2

Procedure Details:

Sample Cut on 12/6/19
Mounted on 19/6/19
grinding 2/11/19
-240, 800, 1200, 2500
Polishing - 20/11/19

Name: Katie Bonnet	**Date Completed:** 24/11/19

Mounting and Polishing Data Sheet

Mount ID: SL2-2

Material Information:

Sample Information:

Mount Information & Layout:

Other Notes:

Artifact ID #SL2

Procedure Details:

Sample cut on 12/6/19
Mounted on 19/6/19
grinding 4/11/19
-240, 800, 1200, 2500

Name: Katie Bonnet	**Date Completed:** 24/11/19

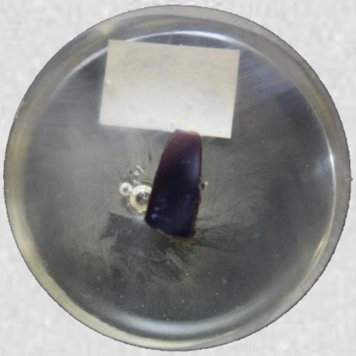
Mounting and Polishing Data Sheet

Mount ID: SL2-3

Material Information:

Sample Information:

Mount Information & Layout:



Other Notes:

Artifact ID# SL2

Procedure Details:

Sample cut on 12/6/19
Mounted on 19/6/19
grinding. 4/11/19
-200,800,1200,2500
Polishing 20/11/19

Name: Katie Bonnet	**Date Completed:** 24/11/19

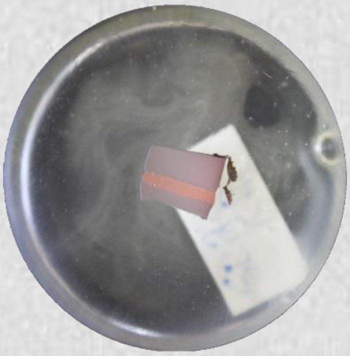
Mounting and Polishing Data Sheet

Mount ID: SL2-4

Material Information:

Sample Information:

Mount Information & Layout:



Other Notes:

Artifact ID #SL2

Procedure Details:

Sample Cut on 12/6/19
Mounted on 19/6/19
grinding on 16/11/19 - 240
17/11/19 - 800

Name: Kathryn Bonnett	**Date Completed:** 24/11/19

Mounting and Polishing Data Sheet

Mount ID: SL3-1

Material Information:

Sample Information:

Mount Information & Layout:

Other Notes:

Artifact #SL3

Procedure Details:

Sample cut on 12/6/19
Mounted on 19/6/19
grinding 4/11/19
240, 800, 1200, 2500
Polishing 20/11/19

Name:	**Date Completed:** 24/11/19

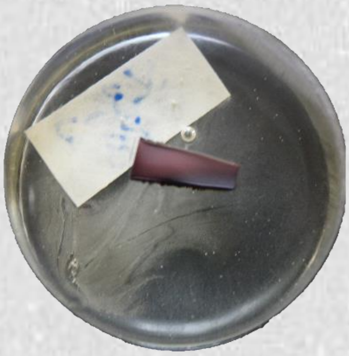
Mounting and Polishing Data Sheet

Mount ID: SL3-2

Material Information:

Sample Information:

Mount Information & Layout:



Other Notes:

Artifact ID #SL3

Procedure Details:

Sample Cut on 12/6/19
Mounted on 19/6/19
grinding 4/11/19
-240, 800, 1200, 2500
Polishing 20/11/19

Name: Kathryn Bonnet	**Date Completed:** 24/11/19

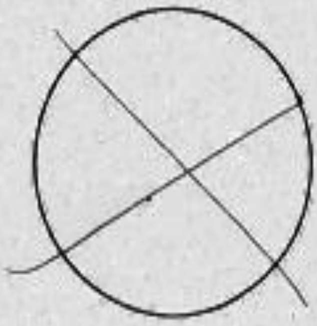
Mounting and Polishing Data Sheet

Mount ID: SL3-3

Material Information:

Sample Information:

Mount Information & Layout:



Other Notes:

Artifact ID # SL3

Procedure Details:

Sample Cut on 12/6/19
Mounted on 19/6/19
grinding 12/11/19 - 240, 13/11/19 - 800, 1200, 2500
Plolishing 20/11/19

Name: Kathryn Bennet	**Date Completed:** 24/11/19

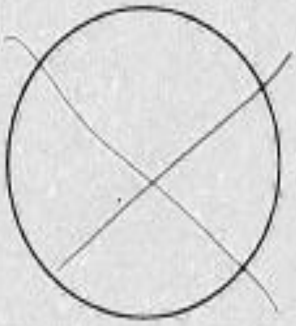
Mounting and Polishing Data Sheet

Mount ID: SL3-4

Material Information:

Sample Information:

Mount Information & Layout:



Other Notes:

Artifact ID # SL3

Procedure Details:

Sample cut on 12/6/19
Mounted on 19/6/19
Grinding 12/11/19 - 240, 13/11/19 - 800, 1200, 2500
Polishing - 20/11/19

Name: Kathryn Bonner	**Date Completed:** 24/11/19

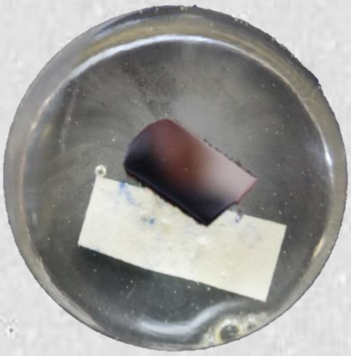
Mounting and Polishing Data Sheet

Mount ID: SSLS 1-1

Material Information:

Sample Information:

Mount Information & Layout:



Other Notes:

Artifact#SSLS1

Procedure Details:

Sample cut on 12/6/19
Mounted on 19/6/19
grinding on 16/11/19 - 240
17/11/19 - 800, 1200, 2500

Name: Kathryn Barnett **Date Completed:** 24/11/19

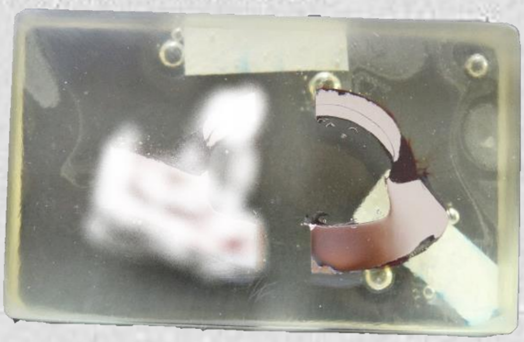
Mounting and Polishing Data Sheet

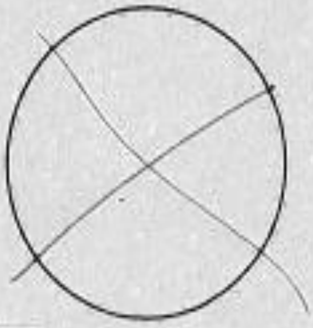
Mount ID: SSLS1-2

Material Information:

Sample Information:

Mount Information & Layout:





Other Notes:

Artifact# 5

Procedure Details:

Sample cut on 12/6/19
Mounted on 19/6/19
grinding 12/11/19 - 240, 13/11/19 - 800, 1200, 2500
Polish 20/11/19

Name: Kathryn Bonnet	Date Completed: 24/11/19

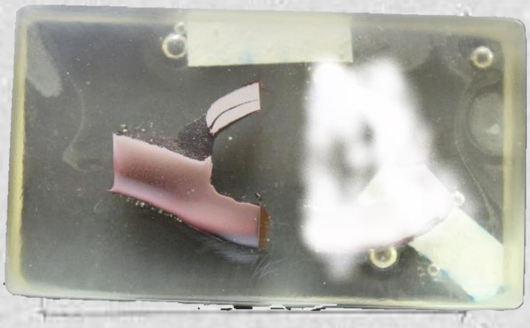
Mounting and Polishing Data Sheet

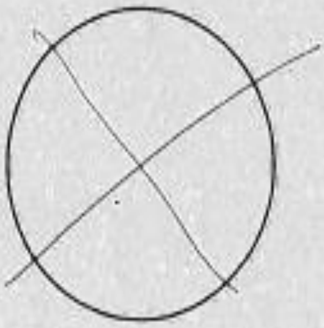
Mount ID: SSLS1-3

Material Information:

Sample Information:

Mount Information & Layout:





Other Notes:

Procedure Details:

Sample cut on 19/6/19
Mounted on 19/6/19
grinding 12/11/19 - 240, 13/11/19 - 800, 1200, 2500
Polish 20/11/19

Name: Katie Barrett	Date Completed: 24/11/19

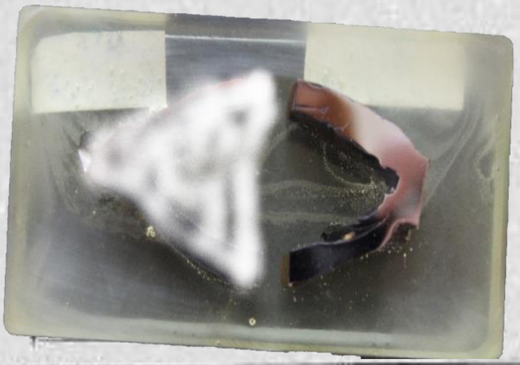
Mounting and Polishing Data Sheet

Mount ID: SSLS2-1

Material Information:

Sample Information:

Mount Information & Layout:



Other Notes:

Procedure Details:

Sample cut on 19/6/19
Mounted on 19/6/19
grinding 12/11/19 - 240, 13/11/19 - 800, 1200, 2500
Polish - 20/11/19

Name: Katie Bonnett **Date Completed:** 24/11/19

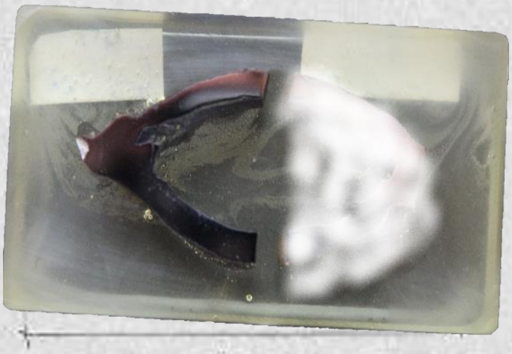
Mounting and Polishing Data Sheet

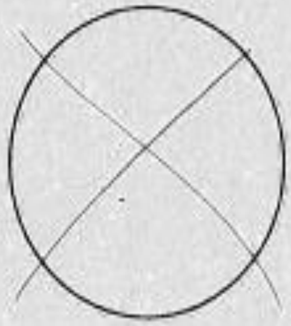
Mount ID: SSLS2 -2

Material Information:

Sample Information:

Mount Information & Layout:





Other Notes:

Procedure Details:

Sample cut on 19/6/19
mounted on 19/6/19
grinding 12/11/19 - 240, 13/11/19 - 800, 1200, 2500
Polish - 20/11/19

Name: Katie Bonnet	Date Completed: 24/11/19

Mounting and Polishing Data Sheet

Mount ID: SSLS3-1

Material Information: part of socket, brazed iron part of car spring, copper from electric wireing, glass from soda bottle

Sample Information:
forged in Sri Lanka, see masters for more info

Mount Information & Layout:

Other Notes:
Artifact ID# SSLS 3

Procedure Details:
Sample cut on 12/6/19
mounted on 19/6/19
grinding - 17/11/19
- 240, 800, 1200, 2500
Polishing 20/11/19

Name: Katie Bonnet **Date Completed:** 24/11/19

Mounting and Polishing Data Sheet

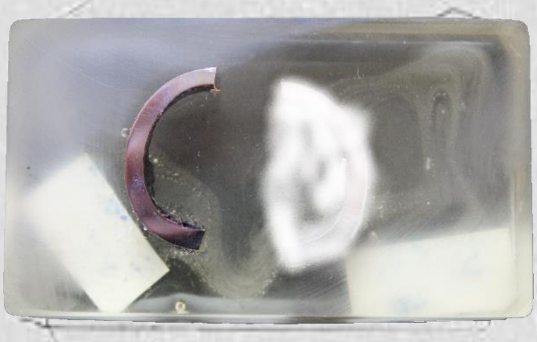
Mount ID: SSLS 3-2

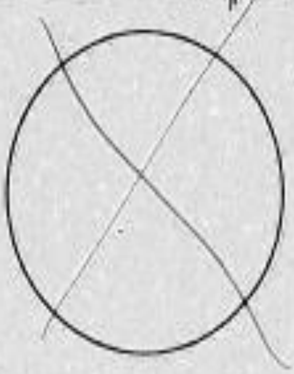
Material Information:

Sample Information:

two Samples one Mount

Mount Information & Layout:





Other Notes:

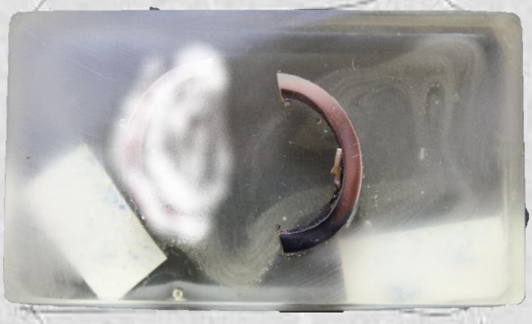
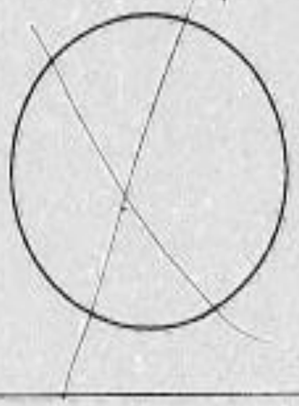
Procedure Details:

Sample cut on 19/6/19
Mounted on 12/6/19
grinding on 12/11/19 - 240, 13/11/19 - 800, 1200, 2500
Polish 20/11/19

Name: Katie Bonnet	**Date Completed:** 24/11/19

Mounting and Polishing Data Sheet

Mount ID: SSLS 3-3

Material Information:
Sample Information: two samples one mount
Mount Information & Layout:  
Other Notes:
Procedure Details: Sample cut on 19/6/19 mounted on 12/6/19 grinding on 12/11/19 - 240, 13/11/19 - 800, 1200, 2500 Polish 20/11/19

Name: Katie Bonnet	**Date Completed:** 24/11/19

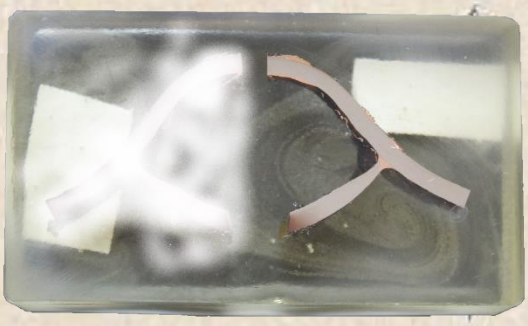
Mounting and Polishing Data Sheet

Mount ID: SSLS3-4

Material Information:

Sample Information:

Mount Information & Layout:



Other Notes:

Procedure Details:
sample cut on 12/6/19
mounted on 19/6/19
grinding 12/11/19 - 240, 13/11/19 - 800, 1200, 2500
Polish - 20/11/19

Name: Kathryn Bonnet	Date Completed: 24/11/19

Mounting and Polishing Data Sheet

Mount ID: SSLS3-5

Material Information:

Sample Information:

Mount Information & Layout:

Other Notes:

Procedure Details:

Sample cut on 12/6/19
mounted on 19/6/19
grinding 12/11/19 - 240, 13/11/19 - 800, 1200, 2500
Polish - 20/11/19

Name: Kathryn Bonnet	**Date Completed:** 24/11/19

C.5 Researcher One Sample Set 1 Findings

1. SSLS3-1 LOWER CARBON CONTENT THAN MANY IN THIS GROUP, HAS A DISTIRIBUTED WIDMANSTATTEN STRUCTURE WITH CARBON CONTENT AROUND 0.2- 0.3 PERCENT. SOME DECARBURIZATION TOWARDS SURFACE AND BRAZED JOIN AREA SEEMS TO HAVE LESS CARBON BUT HAS VERY CLEAN BRAZED INTERFACE WITH NO IRON MIGRATION INTO THE COPPER. VERY LITTLE SLAG CONTENT. TOWARDS THE SURFACE ISSL53-1 HAS LOWER CARBON CONTENT WITH BRAZED COPPER, HERE THE COPPER HAS BEEN EXPERTLY BRAZED WITH NO IRON CONTENT IN THE COPPER. THE CARBON CONTENT IS LOW WITH A WIDMANSTATTEN ASPECT. CARBON CONTENT ESTIMATED TO BE ABOUT 0.1-O.2% NOT QUENCHED.

2. SL2-3 GOOD BRAZED COPPER SURFACE WITH NO EXCESSIVE DIFFUSION OF IRON INTO THE COPPER. THE STEEL IS A LOWER CARBON STEEL WITH ABOUT 0.5-0.6% CARBON AND DARK ETCHING VERY FINE PEARLITE. THE GRAIN SIZE IS NOTICEABLY LARGER THAN SL3-2 OR SSL5-1. NOT QUENCHED.

3. SL1 -1 THE CUTTING EDGE IS ESSENTIALLY THE SAME IN COMPOSITION AS THE STEEL USED TO MAKE THE BLADE OR POINT. THERE IS SOME SURFACE DISTORTION IN THE PEARLITE AS A RESULT OF THE HAMMERING TO SHAPE THE CUTTING EDGE, BUT IT HAS NOT BEEN QUENCHED. THE CARBON CONTENT IS IN THE REGION OF 0.5-0.6% CARBON AND THE STRUCTURE SHOWS RIBBONS OF PEARLITE WITH AN INFILL OF DARK ETCHING FINE EUTECTOID OF FERRITE AND CEMENTITE. THERE IS LITTLE OR NO SLAG PRESENT. THERE IS A SMALL SLAG INCLUSION AWKWARDLY POSITIONED IN THE MICROSTRUCTURE WHICH IS A REGION OF WEAKNESS FOR THIS BLADE OR POINT. THE CARBON CONTENT APPEARS TO DECREASE TOWARDS THE AREA OF THE CUTTING EDGE THOUGH AS COMPARED WITH THE BULK AND HAS DROPPED PROBABLY AS A RESULT OF THE FORGING PROCESS.

4. SL1-2 THIS BLADE OR POINT HAS A PRONOUNCED DIRECTIONALITY TO THE STRUCTURE IN AN UNUSUAL CRISS-CROSS PATTERN AT LOW MAGNIFICATION WHICH SEEMS TO HAVE LITTLE TO DO WITH THE SHAPE OF THE FINISHED PRODUCT. THERE IS A BANDING TO THE WHITE PHASE, WHICH HERE LOOKS MORE LIKE CEMENTITE THAN PEARLITE. BETWEEN THE WHITE BANDED STRUCTURE THERE IS FINE PEARLITE. BUT ETCHING IN METHANOLIC PICRAL FAILED TO STAIN ANY OF THE WHITE PHASE, SHOWING THAT IT IS COMPOSED OF BLOCKY FERRITE RATHER THAN CEMENTITE. AT HIGH MAGNIFICATION SMALL SLAG INCLUSIONS CAN BE SEEN, ELONGATED ALONG THE LENTH OF THE SECTIONAL VIEW OF THE BLADE AS A RESULT OF WORKING AND FORGING TO SHAPE.

5. SL2-1 AT LOW MAGNIFICATION, SOME DECARBURIZATION HAS OCCURRED ON ONE EDGE, THERE IS A LAMINATION OR BANDED STRUCTURE OF FERRITE AND PEARLITE WHICH LOOKS TO BE UNRELATED TO THE DIRECTION OF WORKING OF A POINT OR BLADE EDGE. AT HIGHER MAGNIFICATION, THE RIBBONS OF FERRITE CAN BE SEEN TO HAVE SOME DIRECTIONALITY, WITH FINE EUTECTOID INFILL. VARBON CPNTENT ABOUT 0.4%. NO SLAG CONTENT AND NO QUENCHING.

6. SL2-2 AT LOW MAGNIFICATION A STRAITED APPEARANCE CAN BE SEEN RUNNING DIAGONALLY ACROSS THE BLADE. NO QUENCHING AND NO SLAG PRESENT. AT HIGHER MAGNIFICATION, THE STRUCTURE CAN BE SEEN TO INCLUDE A GREAT DEAL OF BLOCKY FERRITE WITH PEARLITE INFILL, CARBON CONTENT ABOUT O.3 – 0.4%.

7. SSLS3-5 LOW CARBON STEEL WITH GOOD BRAZED COPPER JOIN. THE MICROSTRUCTURE HAS A WIDMANSTATTEN ASPECT WITH A LOW CARBON CONTENT OF ABOUT 0.25% NO SLAG CONTENT. VERY LITTLE IRON CONTENT IN THE BRAZED JOIN ITSELF.

8. SSLS1-2 GOOD QUALITY EUTECTOID STEEL WITH NO SLAG CONTENT. SMALL EVEN GRAIN SIZE OF FINE PEARLITE. AT 100X THE PEARLITE STRUCTURE IS VERY FINELY SPACED.

9. SL3-2 GOOD QUALITY CARBON STEEL WITH LESS THAN 0.8% CARBON, THE CARBON CONTENT IS ABOUT 0.7%. NO SLAG CONTENT. AT X100 THE PEARLITE SPACING CAN BE SEEN IN SOME AREAS. CLEAN HYPOEUTECTOID STEEL. NO QUENCHING. X

10. SL3-3 CLEAN HYPOEUTECTOID STEEL WITH NO SLAG CONTENT. CARBON CONTENT ABOUT 0.6 – 0.7% CARBON.

11. SL3-4 GOOD HYPOEUTECTOID STEEL.

12. SSLS1-3 BANDED CARBON STEEL WITH THIN BANDES OF FERRITE BETWEEN PEARLITE GROUNDMASS.

13. SSLS3-4 INTERESTING BRAZED JOIN WITH EXTENSIVE IRON DENDRITIC STRUCTURES WITHIN THE COPPER DUE TO SOME DISSOLUTION. LARGE PORES PRESENT IN SOME OF THE JOINS. FEATHERY STRUCTURE BETWEEN THE FERRITE BOUNDARIES IS SUGGESTIVE OF BAINITE, SHOWING THAT THIS OBJECT COULD HAVE BEEN QUITE QUICKLY COOLED.

14. SSLS3-3 STEEL WITH ABOUT 0.7% CARBON WITH A WIDMANSTATTEN ASPECT. SOME OF THE DETAIL LOOKS LIKE BAINITE WITH A FEATHERY APPEARANCE AS IF IT MIGHT HAVE BEEN PARTIALLY QUENCHED.

15. SL2-4 BRAZED COPPER CENTRAL STRIP IN JOIN WITH IRON. DENDRITES OF IRON ARE VISIBLE IN THE COPPER. STEEL IS VERY DARK ETCHING WITH FERRITE AT FORMER AUSTENITE GRAIN BOUNDARIES. SOME DIFFUSION OF IRON INTO THE COPPER ALONG THE JOIN. PARTIALLY WIDMANSTATTEN MICROSTRUCTURE WITH ABOUT 0.6% CARBON. PERHAPS QUICKY COOLED.

16. SL3-1 HOMOGENEOUS CARBON STEEL. NOSLAG. VERY EVEN GRAINED. AT HIGH MAGNIFICATION CAN SEE FERRITE AT GRAIN BOUNDARIES WITH FINE PEARLITE INFILL. CARBON CONTENT ABOUT 0.7%. NO QUENCHING.

17. SSLS1-1 HOMOGENEOUS CARBON STEEL, LOOKS SLIGHTLY COARSER THAN SL3-1 BUT AT HIGH MAGNIFICATION THERE IS NO FERRITE REALLY, HENCE THIS IS A EUTECTOID STEEL WITH 0.8% CARBON AS THE STRUCTURE IS ALL PEARLITE.

18. SSLS2-1 AND SSLS 2-2 STRIATED BANDED STRUCTURE AT LOW MAGNIFICATION. AT HIGHER MAGNIFICATION ONE CAN SEE THAT THE STRUCTURE CONSISTS MOSTLY OF FERRITE WITH SOME PEARLITE BETWEEN THE BANDS. CARBON CONTENT IS LOW COMPARED WITH MOST OTHERS HERE, ABOUT 0.4% CARBON.

19. SSLS3-2 INTERESTING FINE STRUCTURE OF LARGE GRAINS WITH SOME WIDMANSTATTEN FERRITE AT GRAIN BOUNDARIES WITH PARTIALLY QUENCHED INTERIOR OF WHAT MIGHT BE BAINITE OR VERY FINE FEATHERY PEARLITE. AT LOW MAGNIFICATION HIGH CONTRAST BETWEEN FERRITE GRAIN BOUNDARIES AND DARK ETCHING GRAIN INTERIORS. BRAZED COPPER SURFACE WITH IRON DROPLETS AT BRAZED SURFACE.

20. GJ-36 NICELY TEXTURED WIDMANSTATTED HYPOEUTECTIC STEEL WITH ABOUT 0.4 – 0.3% CARBON. ASA RESULT OF FORGING THERE HAS BEEN SOME

DECARBURIZATION OF THE STEEL ALONG THE EDGES. THE STRUCTURE IS THAT OF GRAIN BOUNDARY FERRITE AND CROSS-HATCHED PEARLITE, SHOWING QUITE N ACICULAR STRUCTURE WHICH MIGHT HAVE FORMED THROUGH COOLING QUICKY IN THE FINAL STAGE OF FABRICATION, BUT NOT QUENCHED TO GET MARTENSITE.

21. GJ-38 AT LOW MAGNIFICATION THIS LOOKS LIKE A EUTECTOID STEEL WHICH HAS PROBABLY BEEN HEAT-TREATED. THE STRUCTURE CONSISTS OF A MASS OF INTERLOCKING NEEDLES, MARTENSITIC IN EFFECT. PROBABLY 0.8% CARBON STEEL QUENCHED.

22. GJR 312 A CLASSIC SWORD OR BLADE WITH A HIGH CARBON STEEL CENTRAL CORE. TOWARDS THE CUTTING EDGE THIS SECTION GOES DOWN TO A HIGH CARBON EDGE AND ONE LOW-CARBON SIDE, WHILE IN THE CENTRAL REGION THE HIGH-CARBON STEEL STRIP IS SANDWICHED BETWEEN THE TWO LOW CARBON SIDES. THE OUTER, LOW CARBON OUTER SURFACES ARE TYPICAL WROUGHT IRON WITH SLAG STRINGERS, HAS NO CARBON CONTENT AND IS VERY SOFT. THERE APPEARS TO HAVE BEEN SOME DIFFUSION FROM THE HIGHER CARBON CENTRAL STRIP AS A LITTLE PEARLITE CAN BE SEEN IN THE AREA OF THE WELD. THERE IS A WELD LINE PASSING ALONG THE JOIN WHICH MAY BE DUE TO SOME SEGREGATION DURING THE HEATING AND JOINING OF THE COMPONENTS. THE INNER STEEL CORE ETCHES VERY FAST TOWARDS THE CUTTING EDGE SHOWING THAT IT HAS BEEN HEAT TREATED IN THIS AREA AND HAS A MARTENSITIC ASPECT. FURTHER BACK FROM THIS EDGE, FERRITE BEGINGS TO APPEAR IN THIS CORE AND THE CARBON CONTENT IS ABOUT 0.5 – 0.6%. SO IN THE MANUFACTURE, A WROUGHT IRON WITH TYPICAL SLAG CONTENT HAS BEEN WELDED TO A MEDIUM CARBON STEEL CENTRAL STRIP, WITH VERY LITTLE SLAG CONTENT, SHOWING THAT THE FABRICATION TECHNOLOGY OF THESE TWO COMPONENTS IS QUITE DIFFERENT.

C.6 Researcher One Sample Set 2 Findings

General Observations

These samples are in general very unlike ancient iron samples from swords or other wrought products. Firstly, they are all too clean. No slag or corrosion. Secondly, the microstructure of the samples is far too regular: very unlike ancient examples. Thirdly, the pearlitic microstructures are too fine. In many cases far too fine. Most ancient examples do not have this degree of modern low-carbon or medium carbon uniformity, and some of the structures here need more work since the amount of time devoted to this many samples is clearly a little excessive in terms of microhardness, pearlite distribution, cell size etc..

I would say that the trouble with looking at this many samples without a huge amount of variation is that they become too monotonous to really provide a good field view of the possible variations in working of ancient or historic samples of iron and steel.

I would think that a better range of results would be possible if the metalsmiths were provided with hand-made steel, i.e. steel made in a traditional method, such as some of those used by American wootz makers today. ie Bits of wrought iron, placed in modern crucibles with carbon and heated up to make small steel ingots, then they could be worked up in various ways.

3VS13-3KB

The low magnification view shows a partially heat-treated edge with blue-etching possible martensite or very fine pearlite. Higher magnification shows patches of pearlite surrounded by lower carbon areas. At the areas between the different constituents, the areas look as if they have variable carbon content, but not especially high.

5TS5-1KB

This sample looks as if heat-treated with exceptionally fine dark etching pearlitic structure and meeting up with a transitional zone of possibly high carbon steel. Certainly, these components have been heat-treated to create this microstructure.

6KS17-1KB

Good cutting edge produced with the welding on of an external strip around the core of the lower carbon steel. At higher magnification the join between these two areas can be clearly seen. Like all of these samples so far the microstructure is unlike ancient examples, totally clean and no slag content.

The external layer of the blade does not look too different from the underlying steel, but has a slightly higher carbon content. Towards the butt end, the slightly higher carbon content component moves around the back to some extent suggesting that this piece has been made by the welding together of two slightly different carbon steels, the outer edge one being perhaps 0.65% and the internal 0.5% carbon.

1VS3-1KB

The cutting tip looks like it is not quenched but just rather fine pearlite. The structure further back from this is a very uniform pearlite and ferrite microstructure with more about 0.5% carbon content. It is a good modern steel. Seems to have some directionality to the structure along the length of the section.

2VS3-1KB

The cutting tip looks very similar to 1VS3-1KB and has a similar carbon content and microstructure. It appears to be mostly fine pearlite, back from the cutting tip the microstructure is of ferrite and pearlite with about 0.5% carbon content. Appears very uniform in microstructure.

4KS9-2KB

On etching this sample, the edges have etched quicker than the interior, and looks as if it has a higher carbon content than the interior. The microstructure at high magnification looks acicular as if the material has been heat-treated to some extent. But there is no martensite. Fine acicular pearlitic microstructure.

4KS9-3KB

This sample is of a fine pearlitic steel with about 0.6-0.7% carbon in fine microstructure which looks very uniform throughout as a fine mixture of ferrite and pearlite.

5TS5-2KB

Fine, slightly coarser microstructure that 4KS9-3KB, has a slight directionality and a fine pearlitic microstructure with larger areas of pearlite which, like many of the samples here cannot be resolved using the eyepiece camera.

7KS9-3KB

Very similar to many other examples here with fine pearlitic microstructure. Small grain size. Typical modern steel.

1VS3-2KB

Fine pearlitic microstructure. Small grain size. Typical modern steel. Carbon content about 0-6-0.7%. The exterior can be seen to be a little decarburized from working or forging while the interior etches to a fine pearlitic structure with about 0.7% carbon content.

4KS9-4KB

Almost a eutectoid steel. At x100 the steel has an acicular texture. At x20 the steel has a fine eutectoid microstructure, very even grains, very fine modern steel structure.

6KS17-2KB

Fine eutectoid steel with very even grain structure.

7KS9-1KB

Looks worked to shape, with variable threads of ferrite running through the structure, which is of a carbon steel with about 0.6% carbon content.

7KS9-2KB

Fine microstructure close to the eutectoid at low magnification, while at higher magnifications, the structure can be seen to be a little lower than the 0,8% level, probably in the region of 0.7% carbon steel. Structure has a directionality to it from the forging process.

8KS11-2KB

A gradient in carbon content may exist between the outer surface and the interior. At least this is the result on the first etching. The interior has a carbon content of about 0.5%- 0.6% while the surface microstructure shows a higher carbon content in the region of 0.7%

8KS11-3KB

This sample appears to be of slightly lower carbon content than some of the others in this group. The structure is very fine, even, pearlitic, with about 0.6% carbon.

8KS11-4KB

This sample appears to be slightly decarburized towards the edge of the sample and has a slightly coarser microstructure than some of the other samples examined here. It is a pearlitic steel with about 0.6% carbon content.

G3-39

This sword blade is made of a eutectoid steel, very fine microstructure which looks very much like an 0.8% steel. Very even throughout with not much variation apparent.

3VS13-4KB

A decarburized surface zone is quite thick here. The interior is practically a eutectoid steel. The carbon content drops off a lot to the outer surface here, becoming principally ferrite.

4KS9-1KB

Very fine-textured eutectoid steel.

5TS5-3KB

Some decarburization along the edge of the sample. The interior is a fine pearlitic steel with about 0,6% carbon content.

6KS17-3KB

Lower carbon steel with about 0.3% carbon content, otherwise similar to other examples here.

3VS13-1KB

Very fine structured eutectoid steel blade. Practically 0.8% carbon.

8KS11-1

This is a fine textured sample, almost of eutectic composition. very fine grained, no slag content. a good modern carbon steel

6KS17-4

Different from most other samples, this one is principally ferrite. at high magnification, a little slag can be seen together with a trace of carbide. very close to being a pure wrought iron of ferrite.

3VS13-2

Differential structure with the cutting tip being apparently unquenched here ?)...while the rest of the structure is fine ferrite and pearlite. the structure in part may be quenched to produce very fine pearlite microstructure. directionality is evident in the way the ribbons of the unquenched part of the structure meets up the very fine-grained structure.

2VS3-2

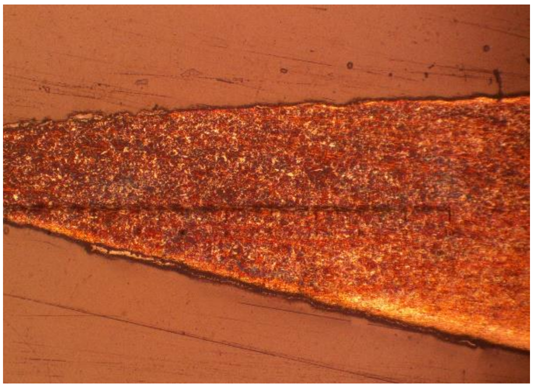
A strange rather porous-looking structure with patches of white, which may be ferrite and a fine-grained phase which is possibly pearlite, but the structure is rather odd and looks as if the pores are filled or partially filled with a mineral phase.

C.7 Researcher One Micrographs

Object 1VS3

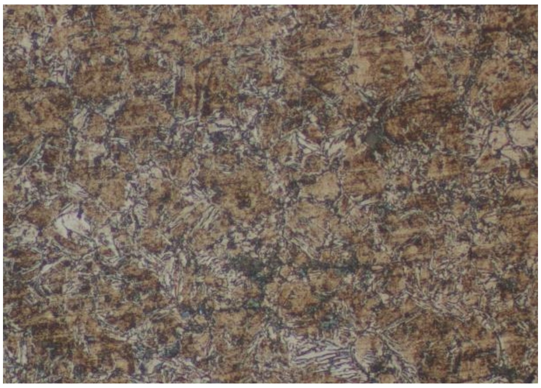
Sample 1

X10



X20

X40

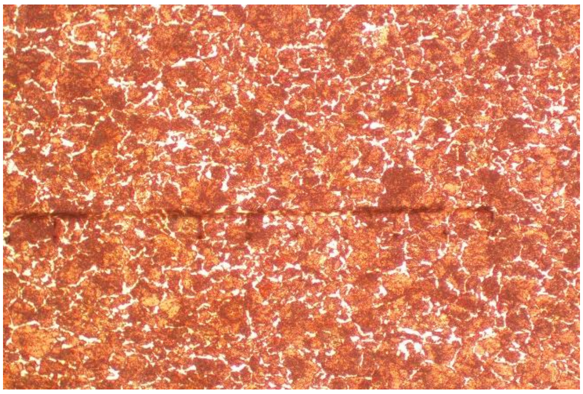


X100

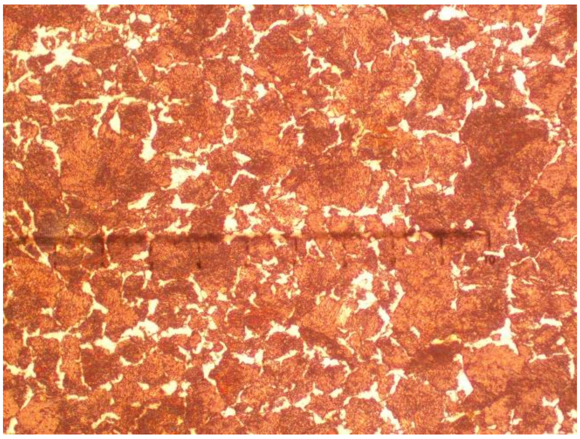
Sample 2

X10

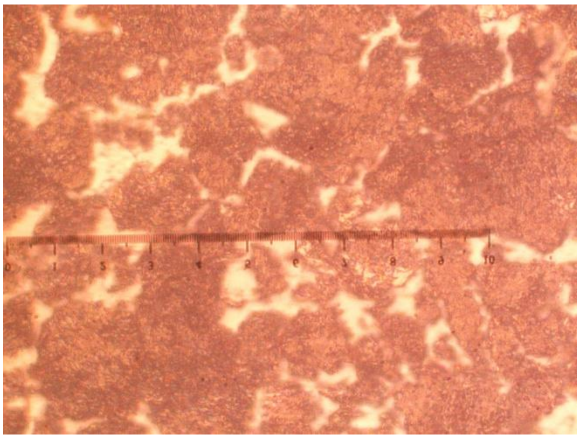
X20



X40



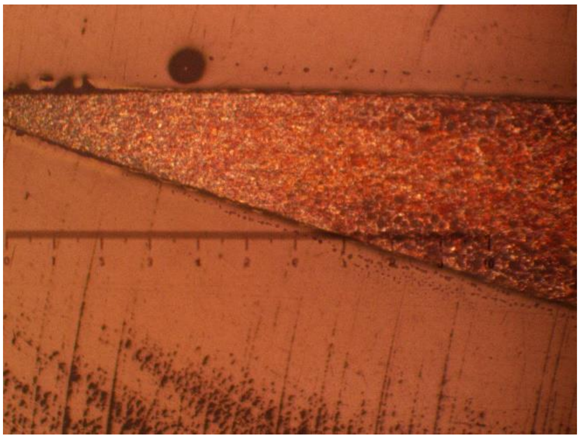
X100



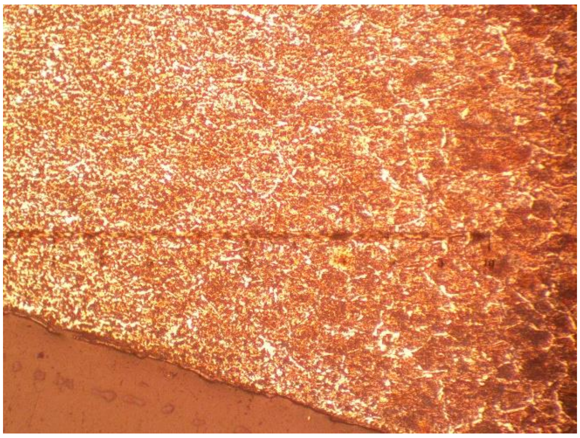
Object 2VS3

Sample 1 X10

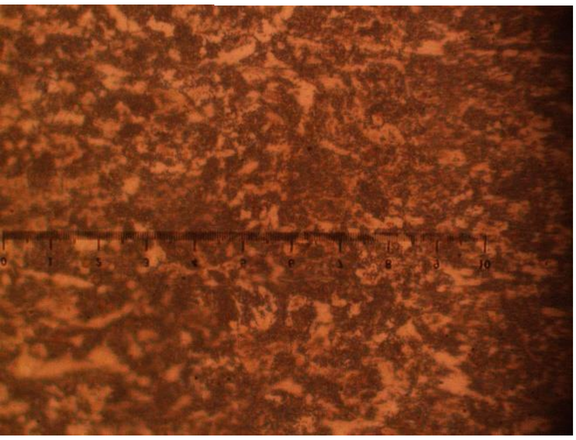
X10



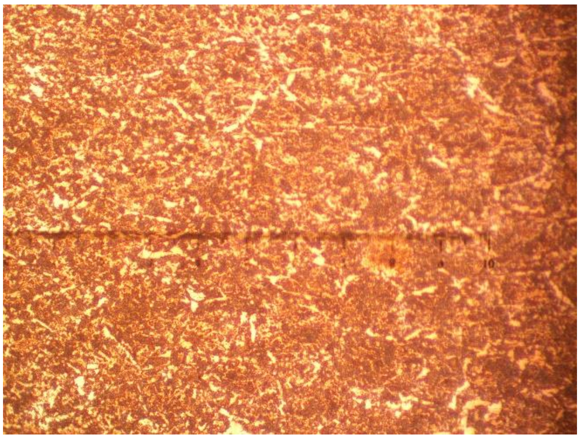
X20

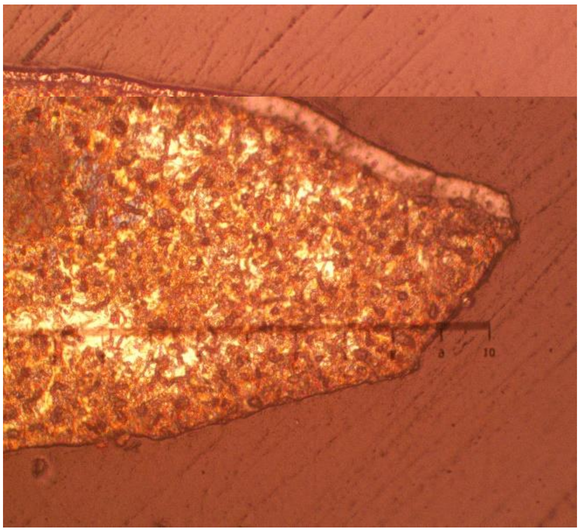


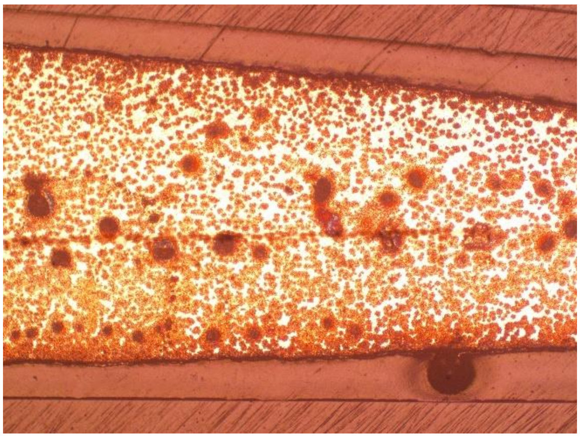
X100



Sample 2
x10
x20

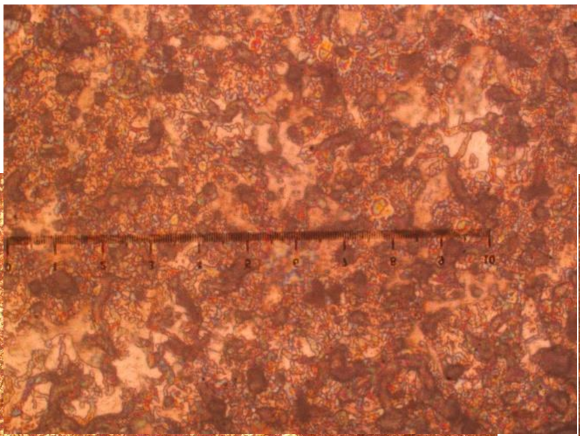






X40

X100



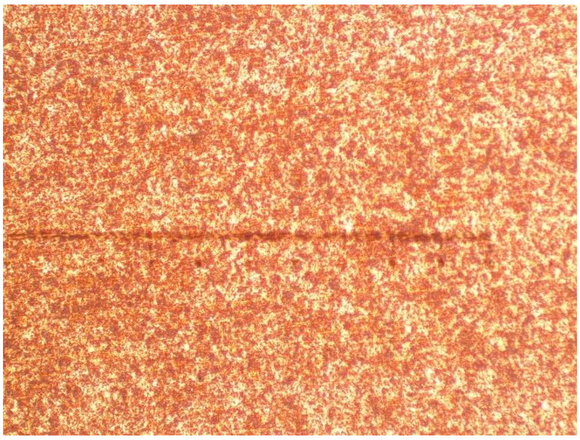
Object 3VS13

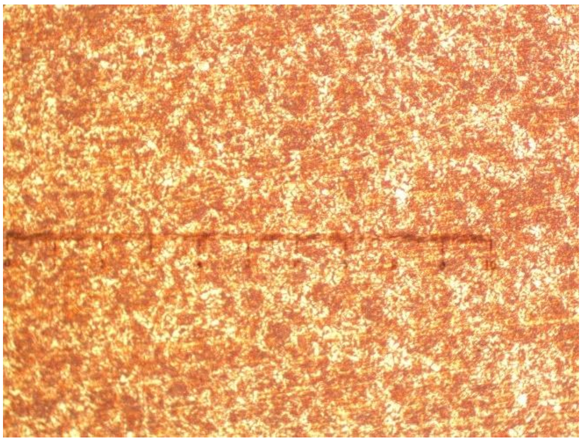
Sample 1 X20

X40

Sample 2

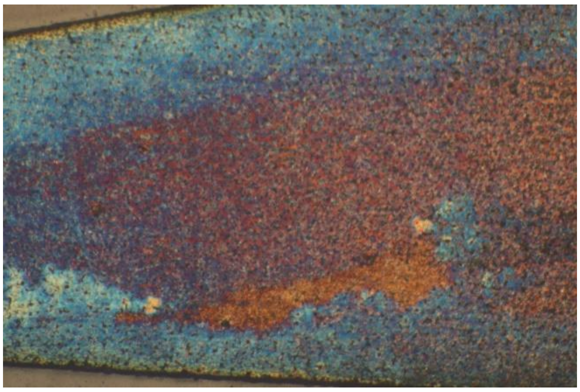
X20 X40

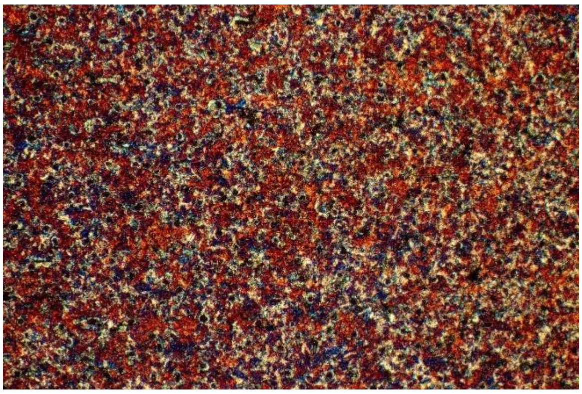




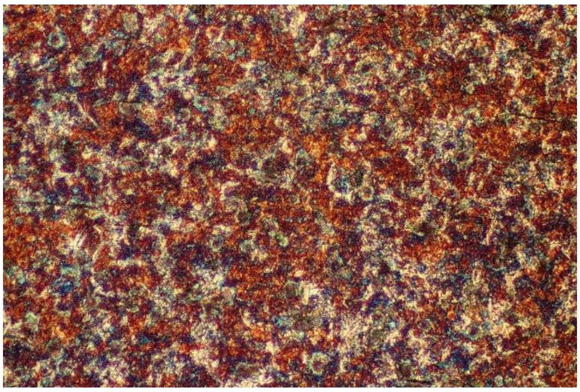
X100

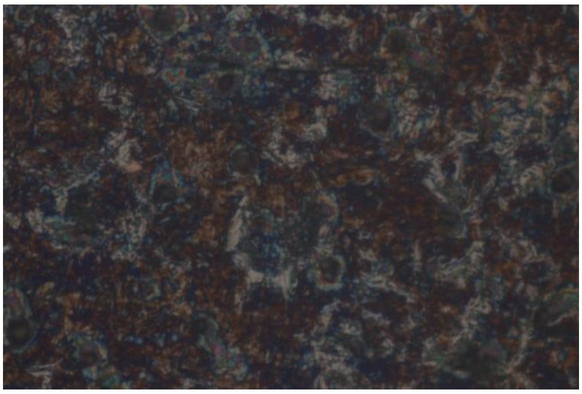
Sample 3 X10 X20



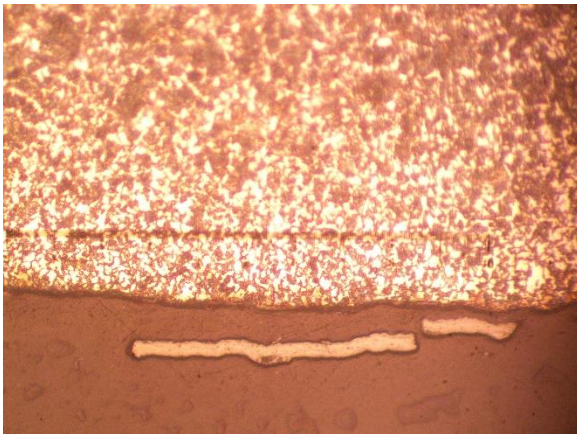


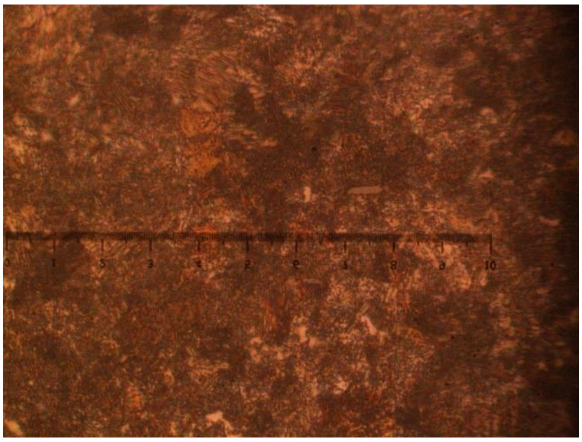
X40 X100





Sample 4 X20 X40

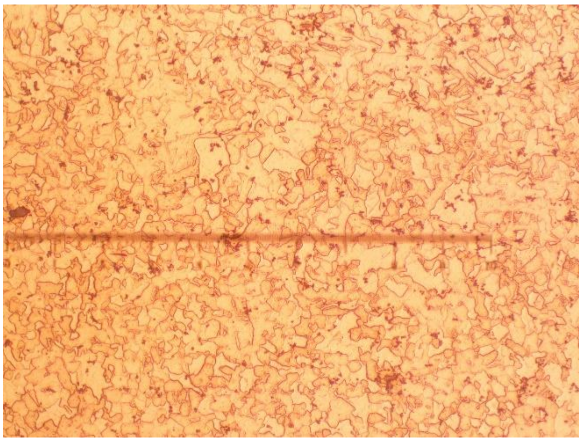




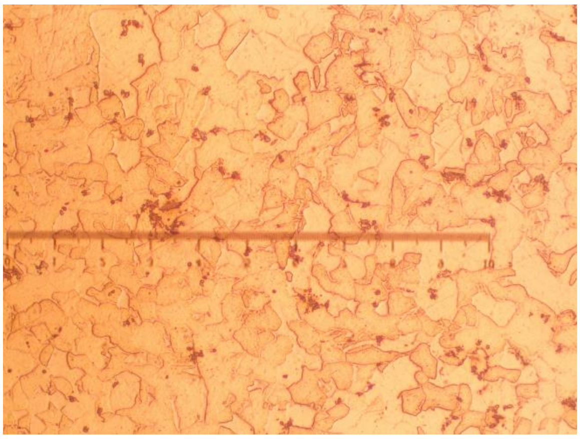
4KS9

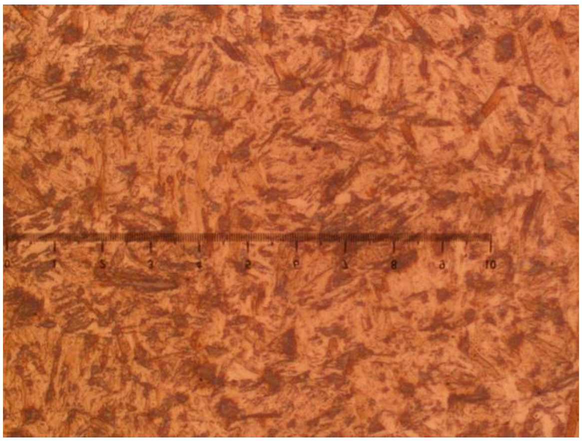
Sample 1

X10 X20



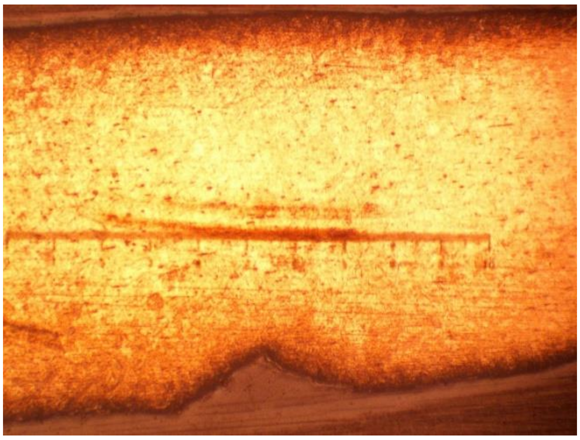
X40 X100

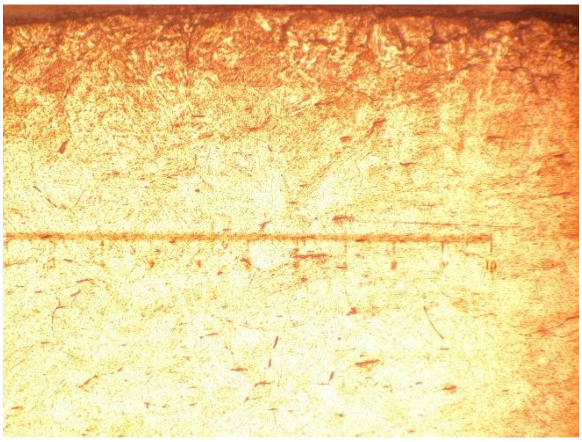




Sample 2 X10

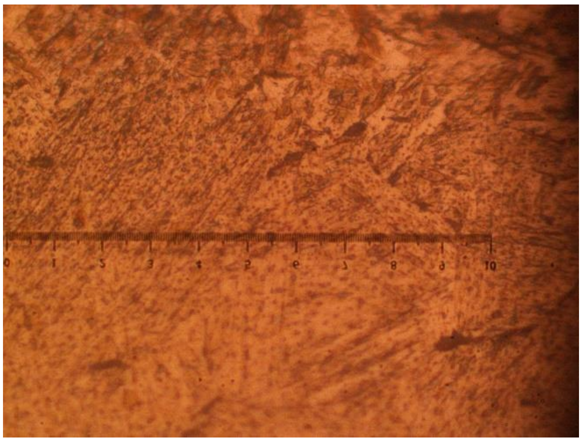
X20



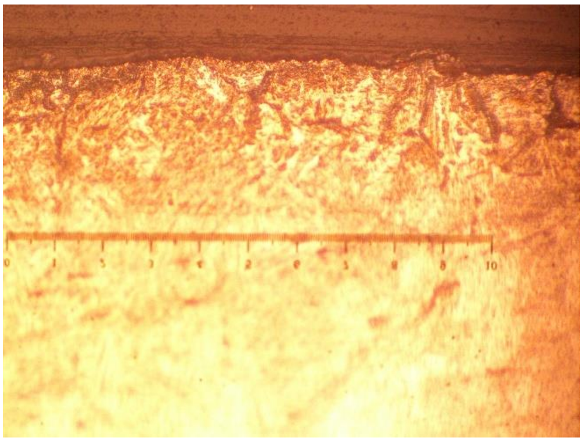


X40

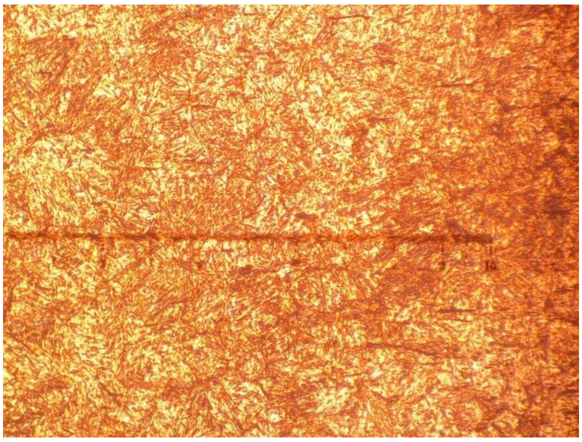
X100



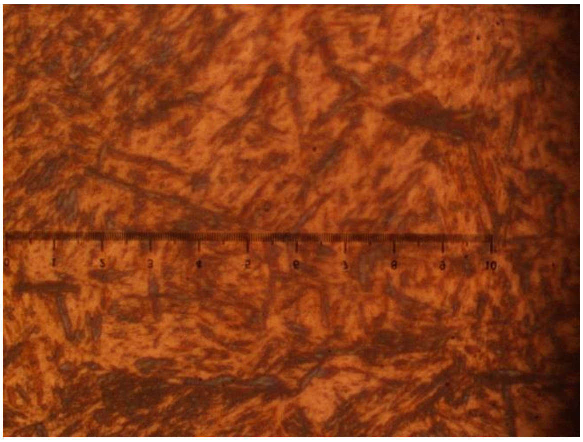
X 400



Sample 3 X10 X200

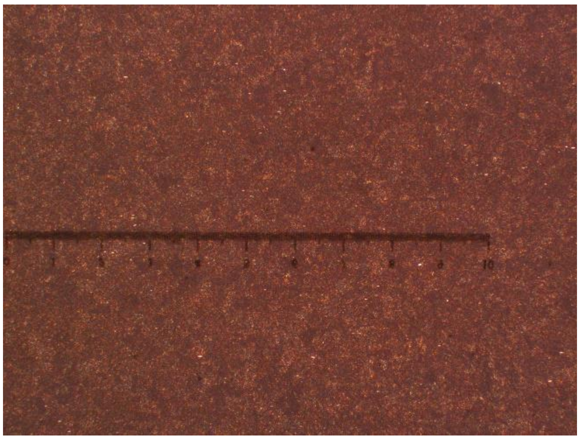


X 1000

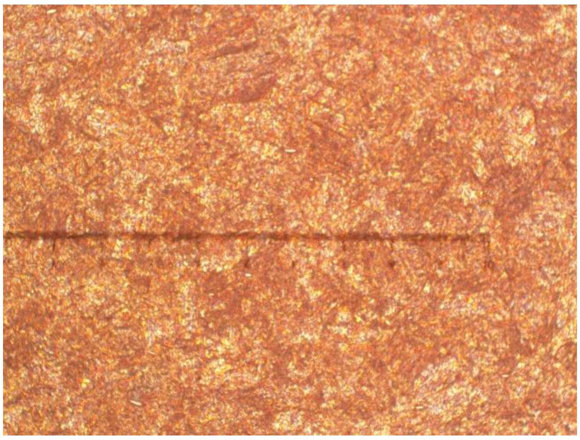


Sample 4

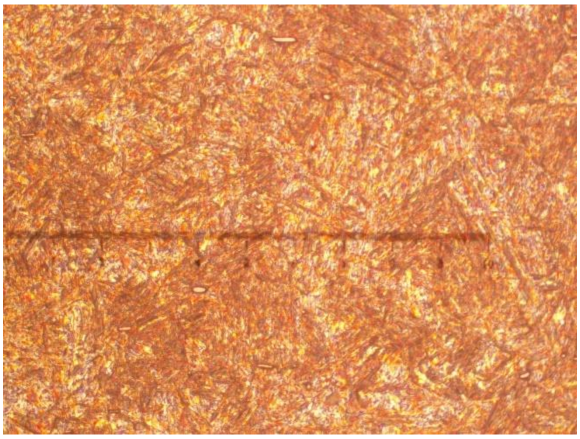
X10



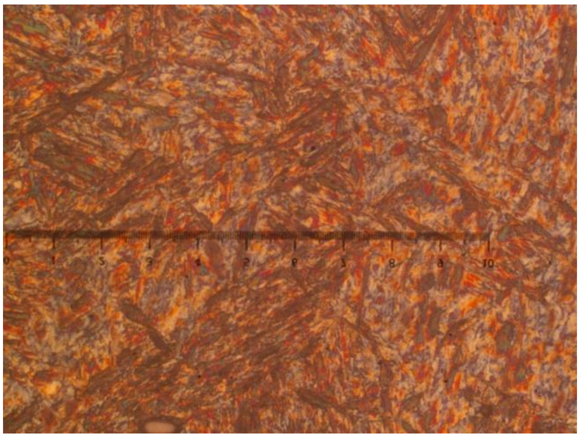
X20



X40



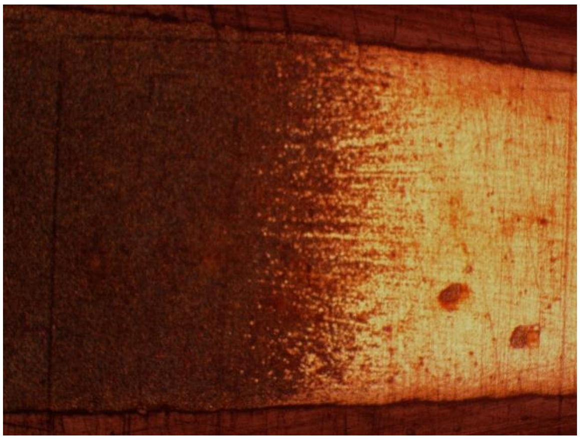
X100



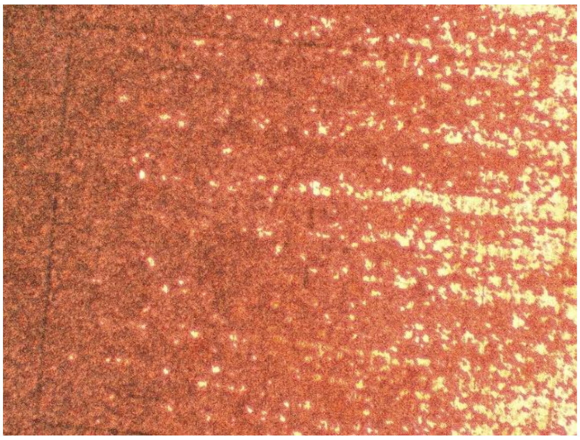
Object 5TS5

Sample 1

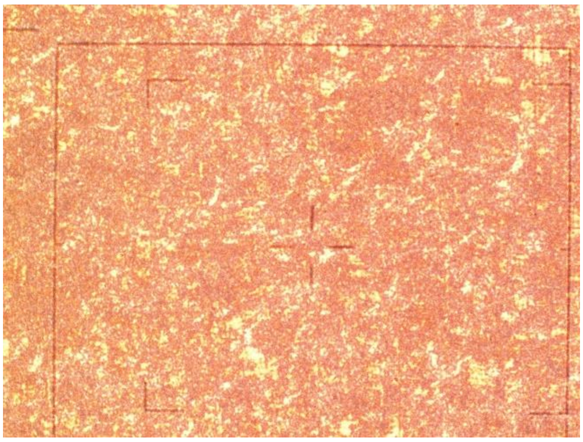
X10



X20

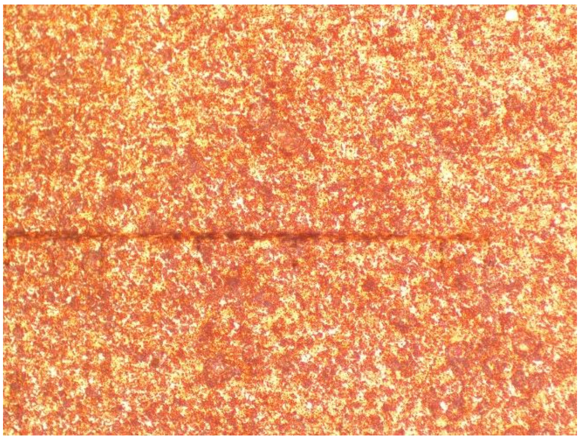


X40

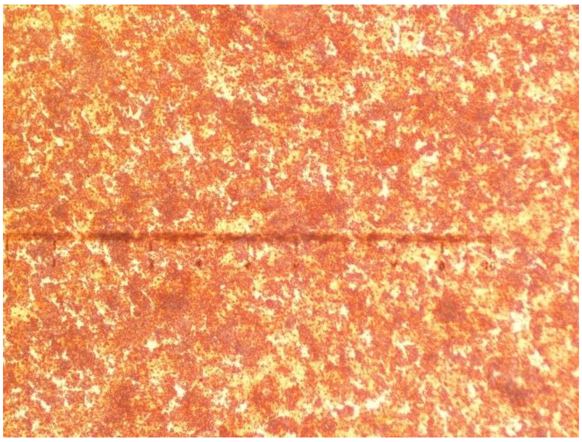


Sample 2

X20

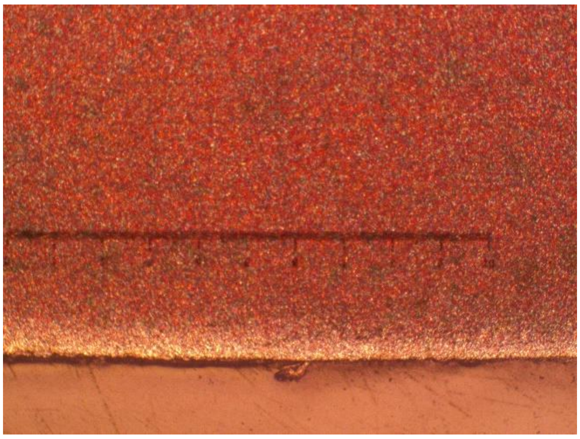


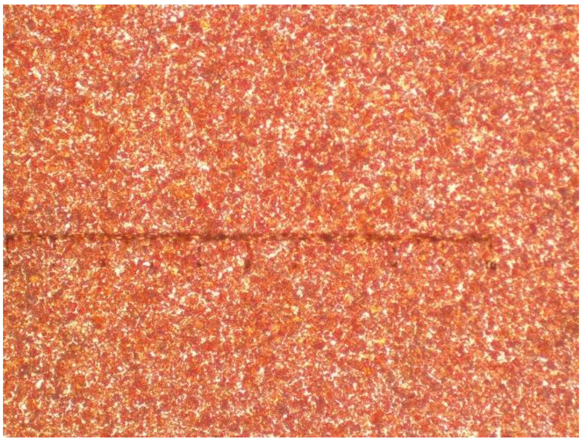
X40



Sample 3 X10

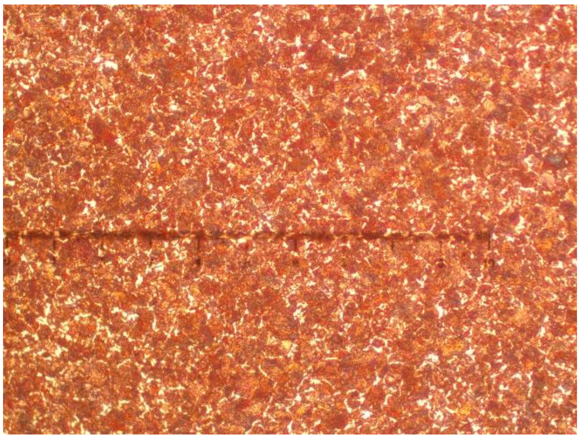
X20





X 40

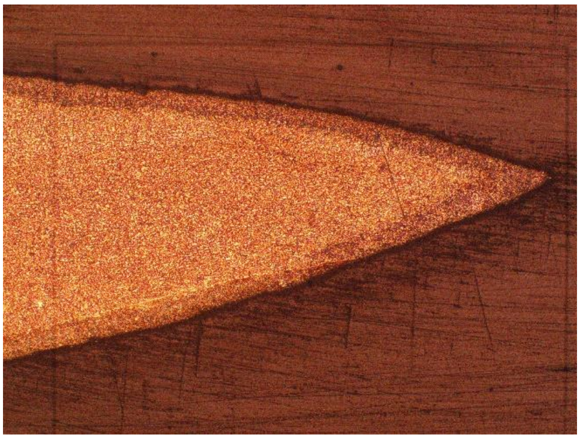
X 100

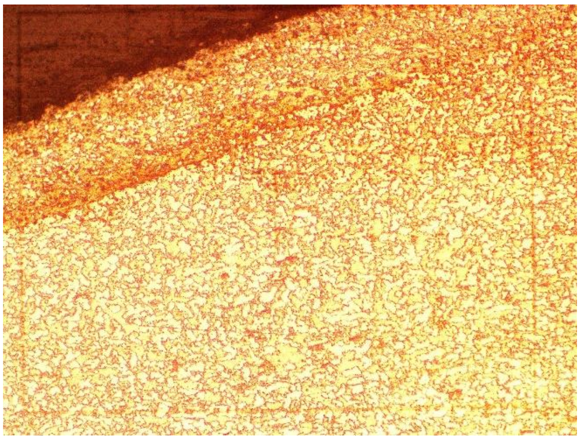


Object 6KS17

Sample 1 X10

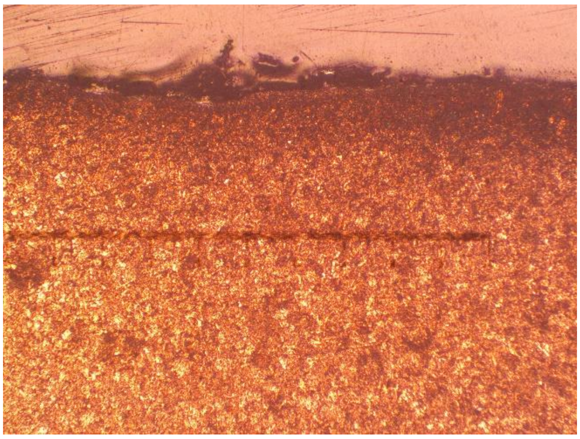
X20

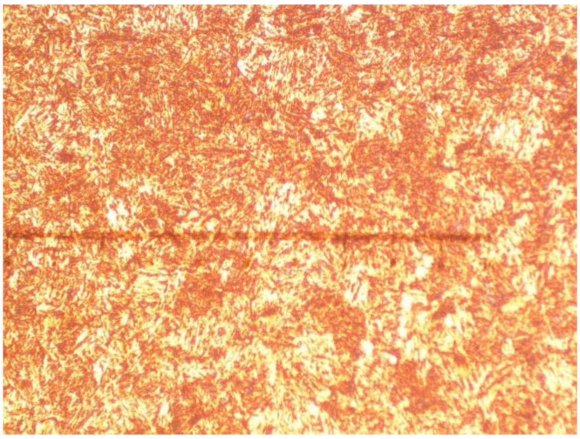




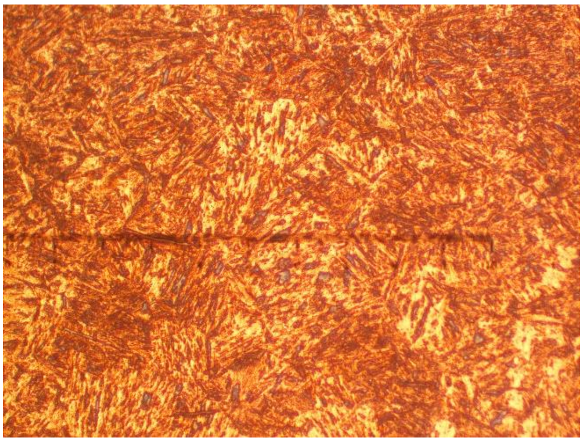
Sample 2 X10

X20



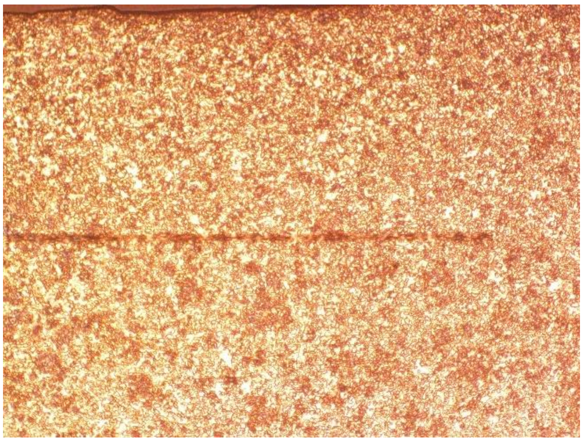


X 40



Sample 3

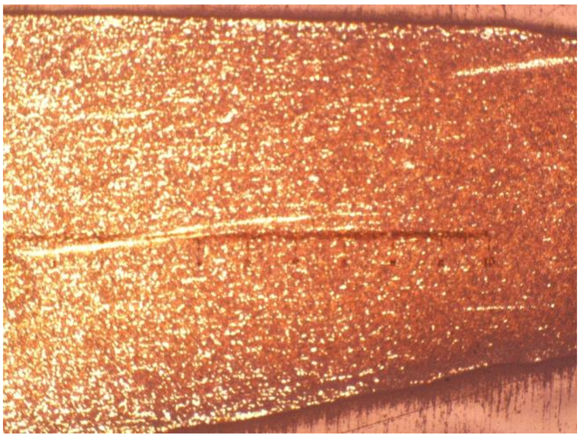
X 20

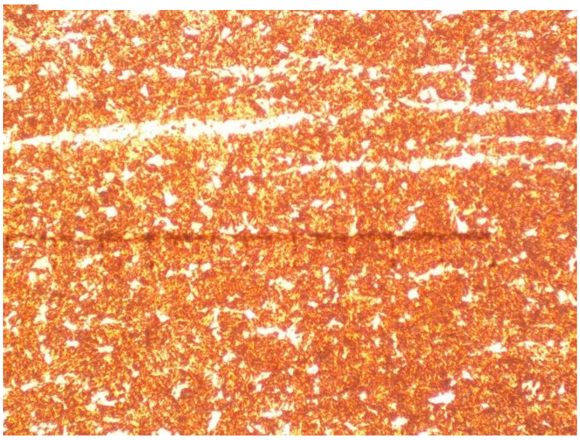


Object 7KS9

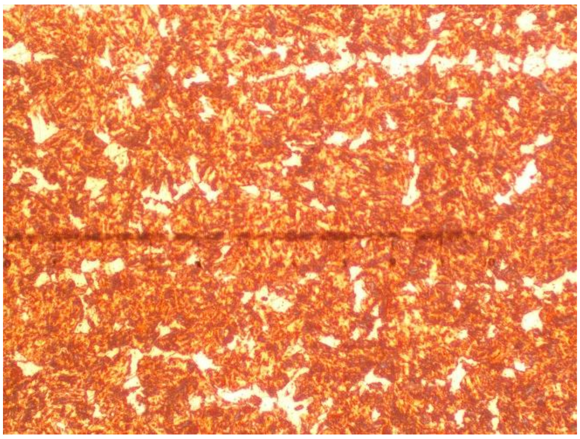
Sample 1 X10
X20

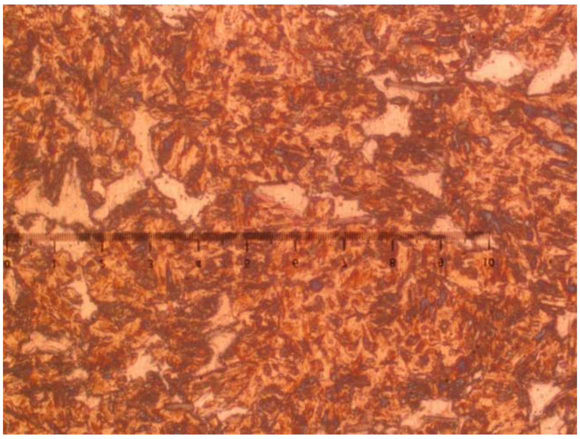
X100





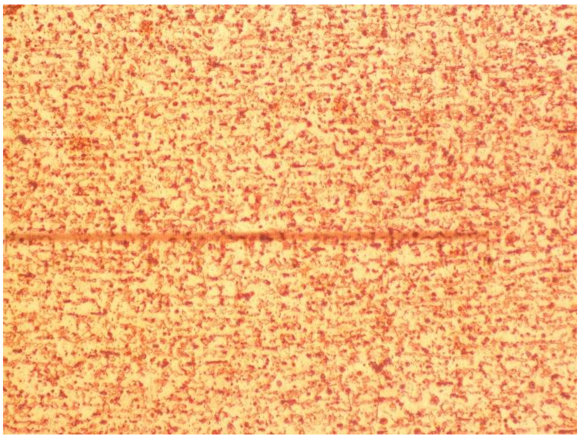
X40





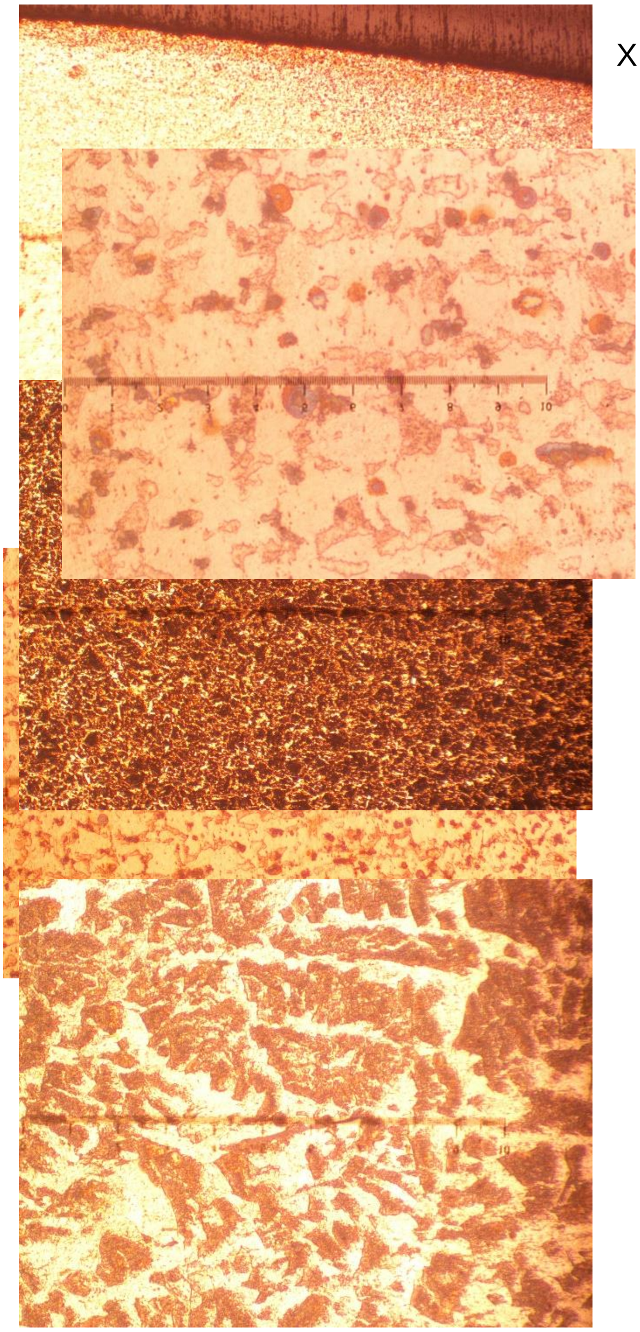
Sample 2 X10

X20



X40

X100

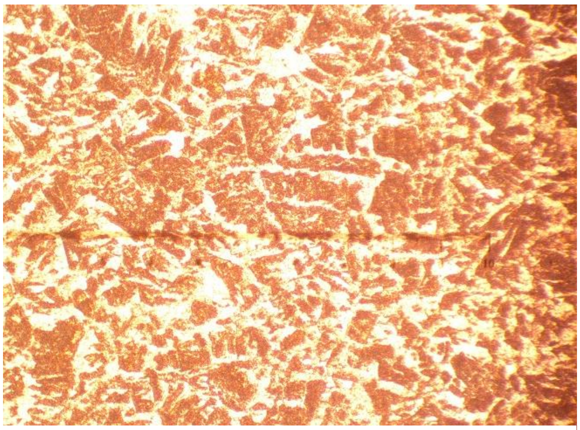


Sample 3

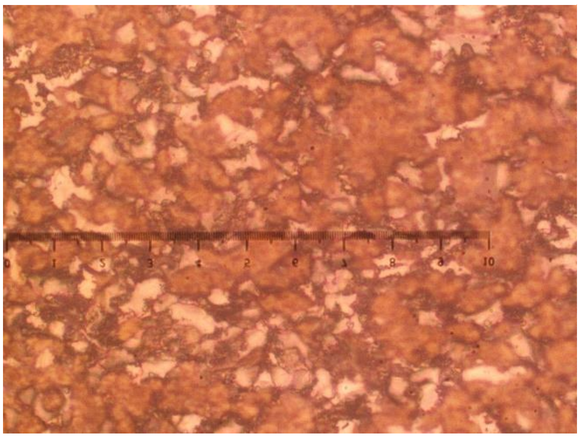
X10

X20

X40

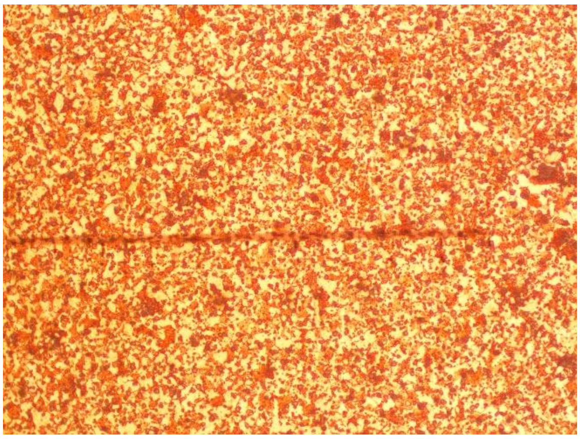


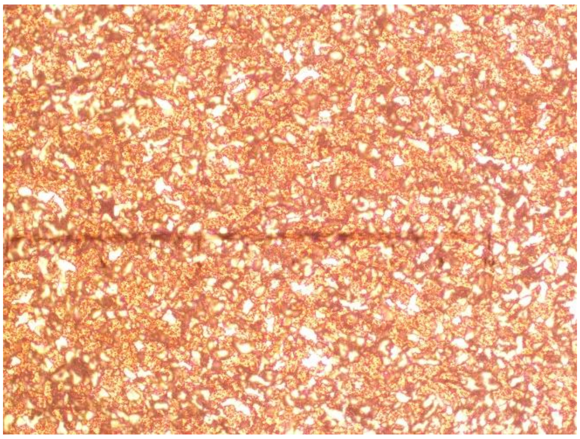
X1000



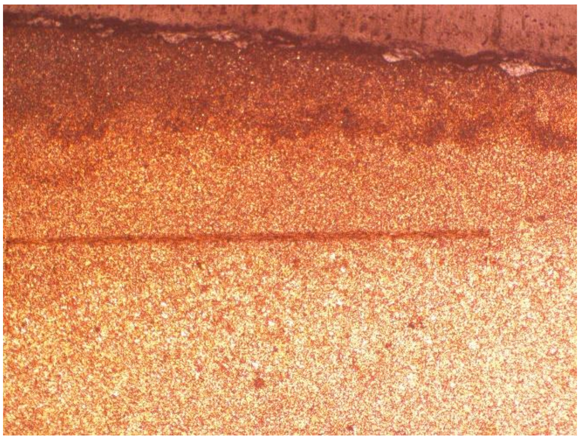
Object 8KS11

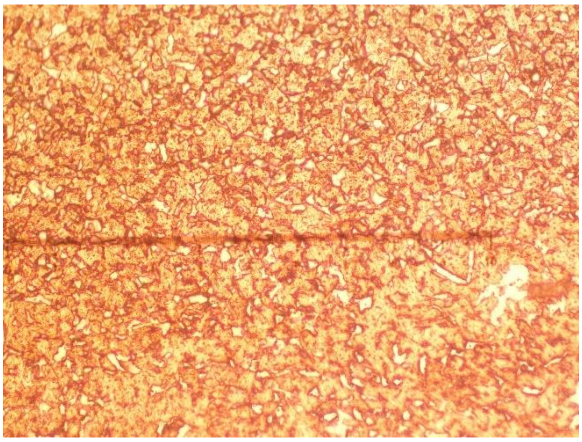
Sample 1 X10 X20



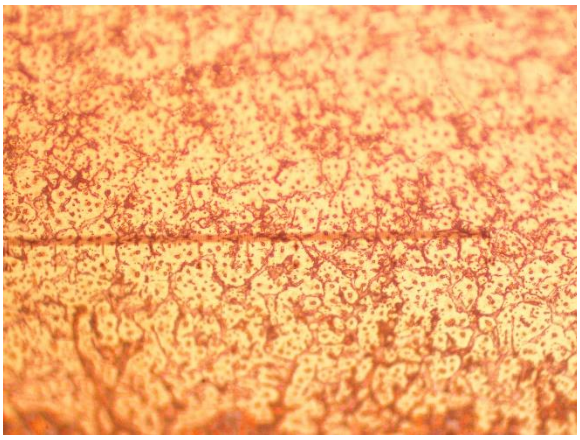


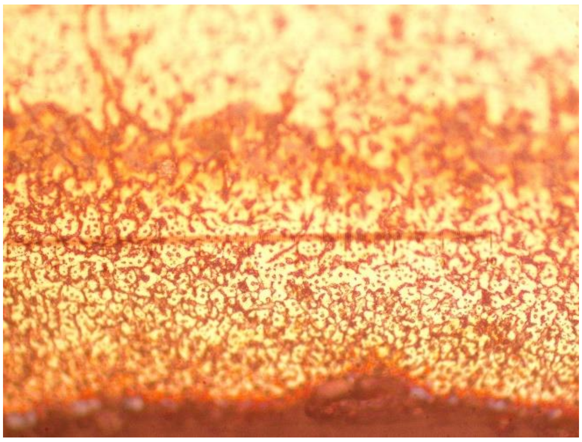
Sample 2 X10 X40



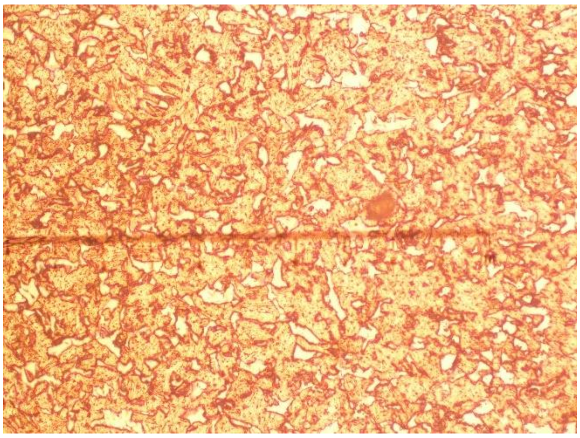


X30 X40





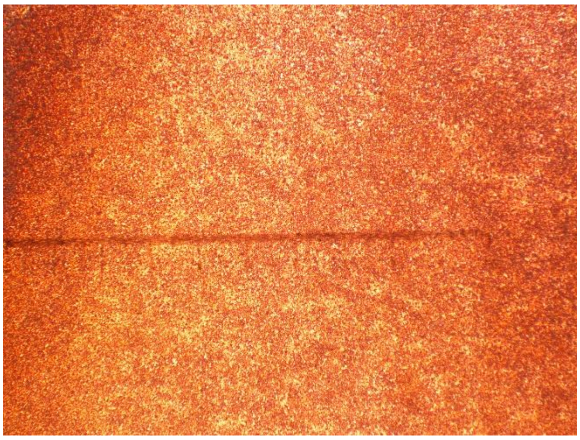
X45

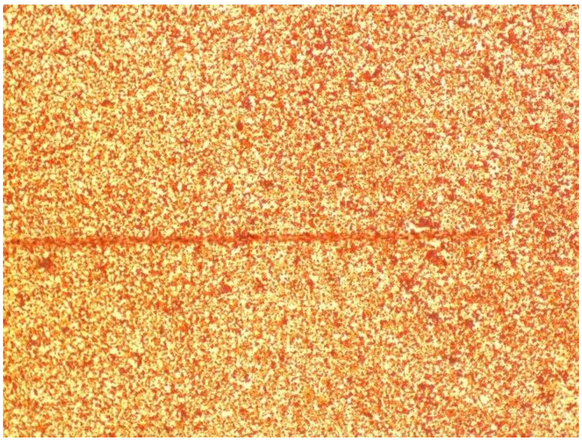


Sample 3

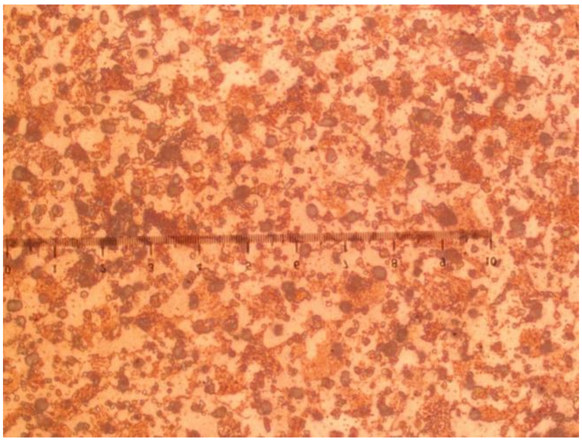
X10

X20

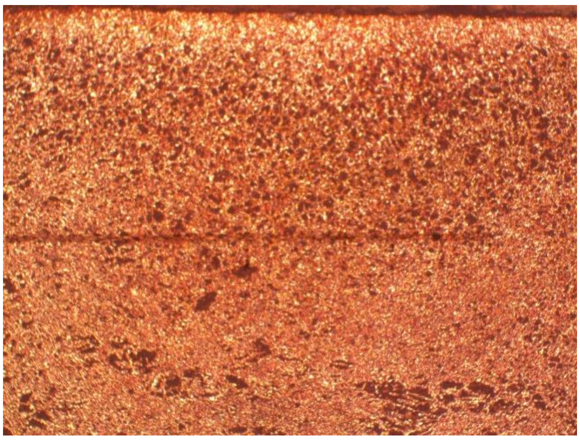


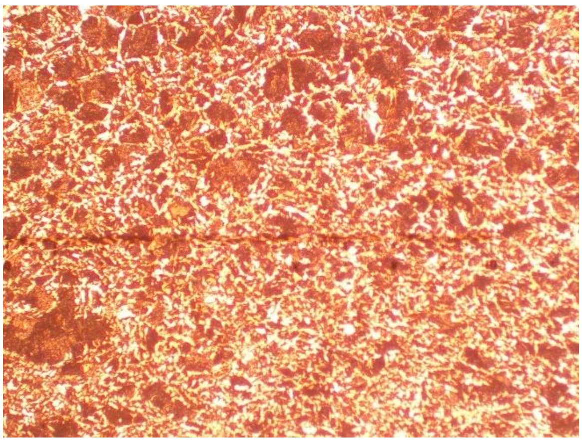


X 40

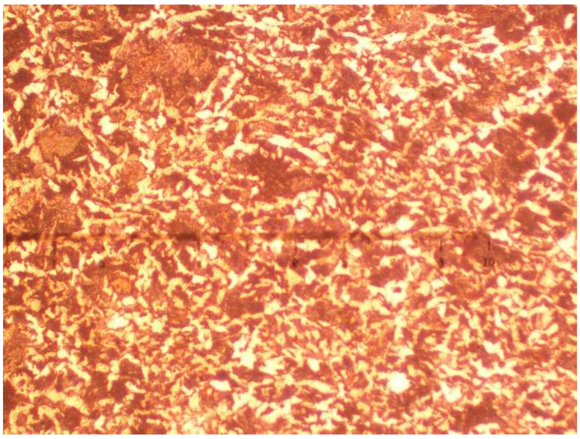


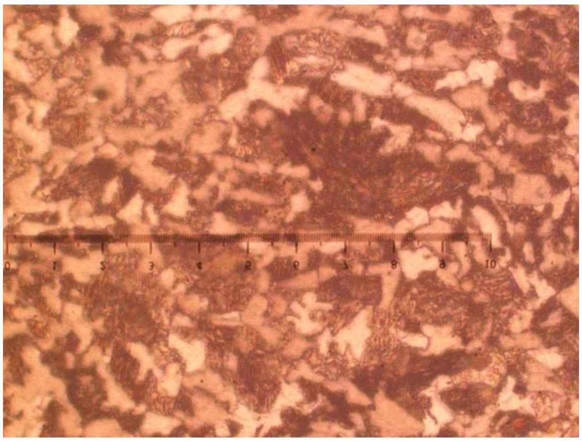
Sample 4 X10 X20





X40 X100



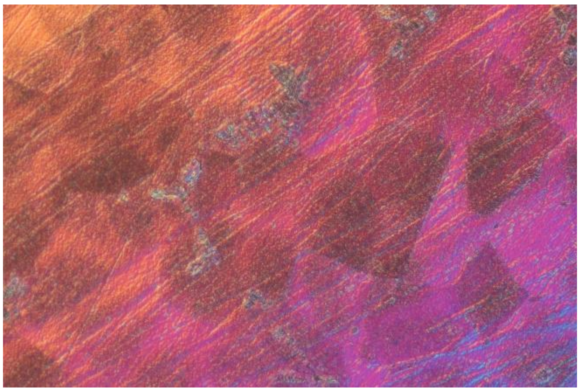


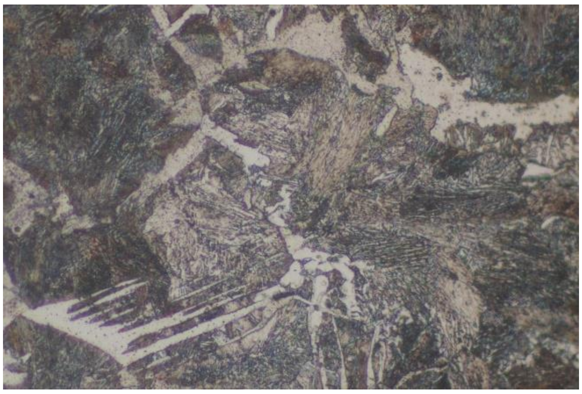
Object SL2

Sample 4

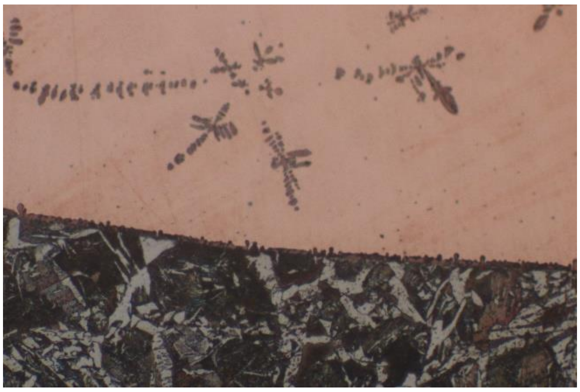
X20

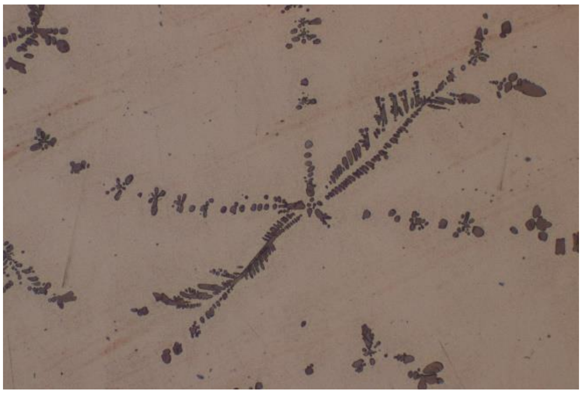
X40





X20 x20

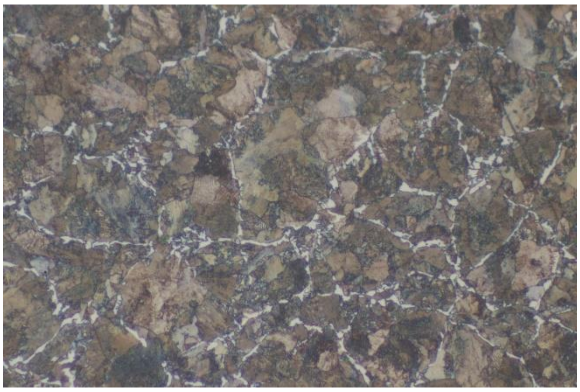


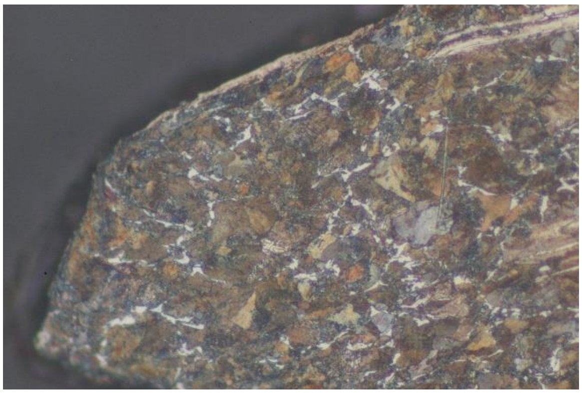


Object SL3

Sample 1

X20 x40

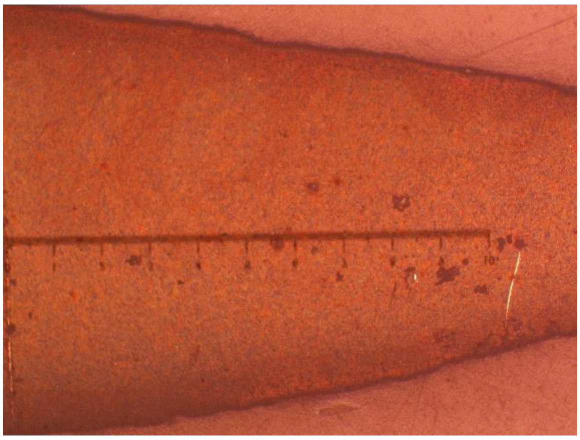




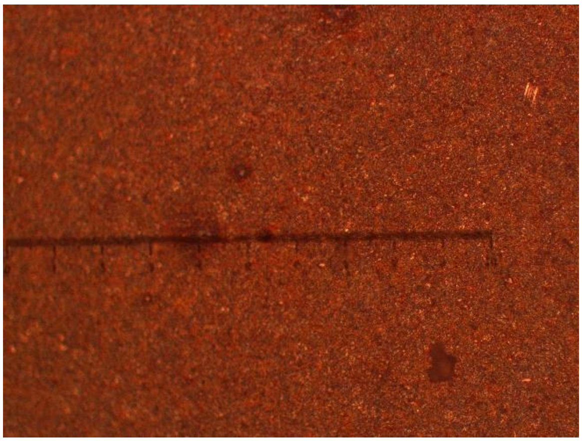
Juleff's Sri Lanka Objects

Sample G3- 39

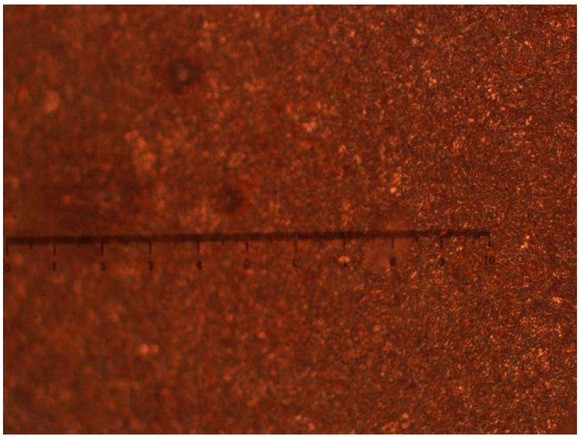
X10



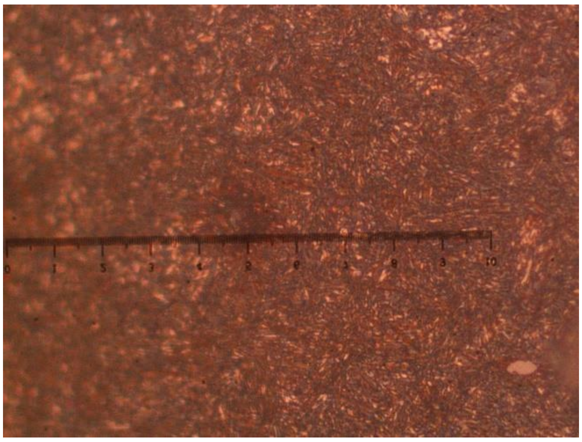
X20



X40



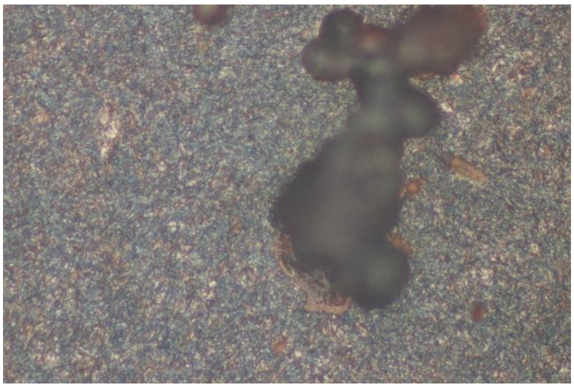
X100

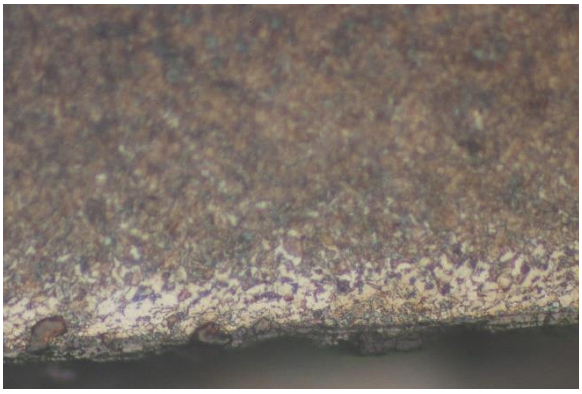


Sample GJ- 38

X 100

X 100

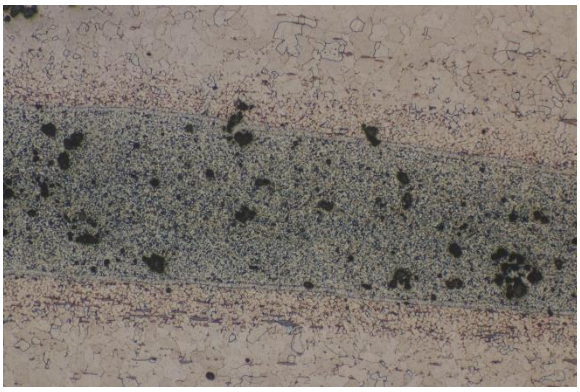


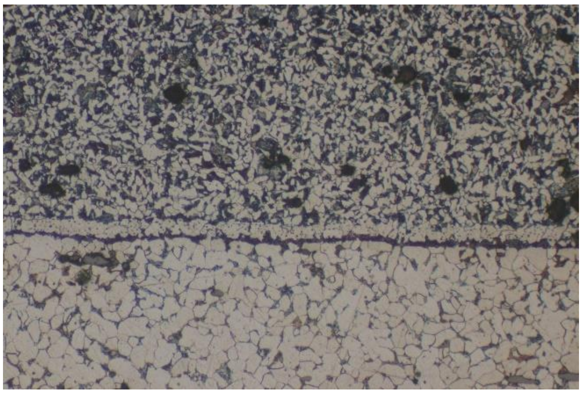


Sample GJR- 312

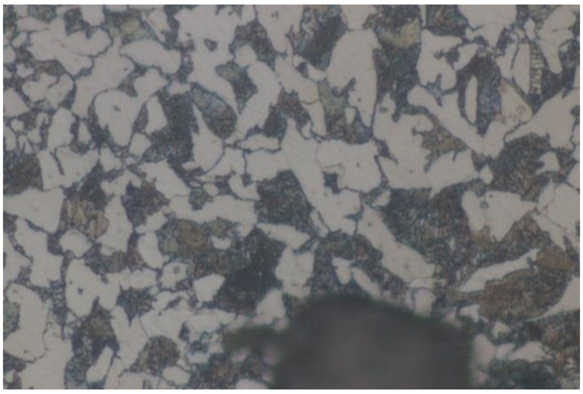
X 10

X 20





X 100



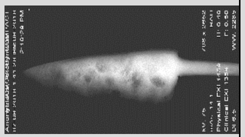
C.8 Researcher Two Sample Set 2 Findings

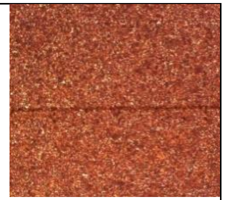
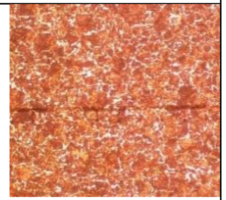
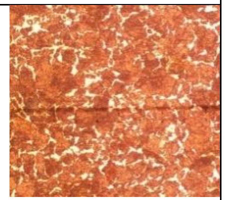
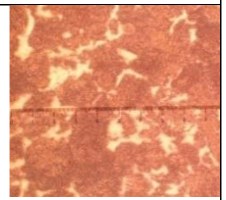
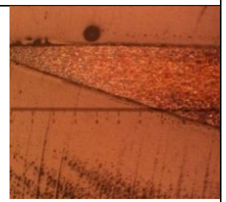
Katie Bonnet: Iron samples from India for comparitive metallographic analysis

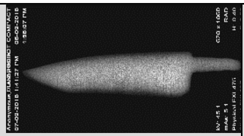
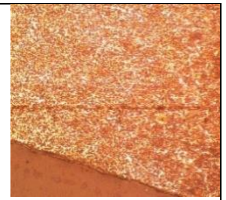
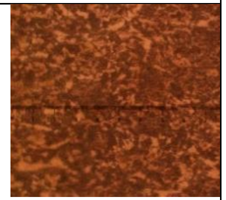
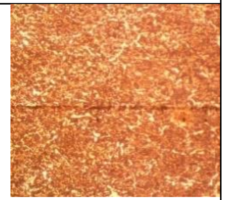
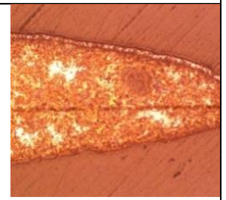
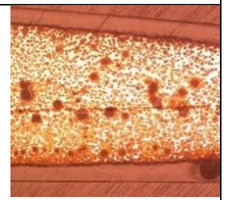
BG no	KB no	Type of section	Metallographic observations	Estimted carbon content (%)	Comments
1	1VS 3-1	Blade edge part	(a) Tip martensitic ut progressively gives way to very fine grain, homogeneous (equiaxed) mainly (unresolved) pearlitic microstructure; (?Phosphorus) banded macrostruc	~0.6-0.7%	Homogeneous modern (rolled) high carbon steel
2	1VS 3-2	Back part	Homogeous fine-grain medium to high carbon steel: unresolvable fine grain pearlite and ferrite - poss fast air cooled	~0.6%	Homogeneous modern medium carbon steel
3	2VS 3-1	Blade edge part	At tip - heat-treated structed: ultra fine grain medium carbon steel with partly spheroidised pearlite; away from tip showing as a high carbon steel - small-med grain ferrite/p	~0.6-0.7%	Homogeneous modern medium to high carbon steel
4	2VS 3-2	Blade, edge part	Homogeneous, partially spheroidised very fine grain hypoeutectoid steel quenched, martensitic structure at tip	0.6-0.7%	Homogeneous modern high carbon steel
5	3VS 13-1	Blade, edge part	Ultra fine grain, nearly eutectoid steel, unquenched, irresolvable pearlite	~0.8%	Homogeneous modern high carbon steel
6	3VS 13-2	Blade edge part	(a) Tip - fine grain (quenched and lightly) tempered martensitic structure, (b) centre - partly martensitic/partly bainite or radial pearlite:	~0.7%	Homogeneous modern high carbon steel
			partly quenched structure; (c) furthest from tip - unresolved fine grain pearlite plus ferrite - unaffected by quenching. Edge only quenched.		
			Rest of high carbon steel blade probably protected by a clay paste during heating/quenching process.		
7	3VS 13-3	Blade edge part	(a) Edge: Intermediate martensite/'troostite' (radial pearlite) at tip, ?very lightly quenched; (b) body shows homogeneous, fine grain ~eutectoid, unresolvable pearlite + MnS	~0.8%	Homogeneous modern high carbon steel
8	3VS 13-4	Back part	V fine grain, high carbon steel, just hypo-eutectoid	~0.8%	Homogeneous modern high carbon steel
9	4KS 9-1	Blade edge part	Uniform very fine quenched martensitic structure probably indicative of high carbon steel	~ 0.7-0.8%	Homogeneous modern high carbon steel
10	4KS 9-2	Blade edge part	Uniform, coarse slow etching martensitic microstructure; as-quenched, ?mediumto high carbon steel structure with some small probable MnS inclusions	~0.7-0.8%	Homogeneous modern high carbon steel
11	4KS 9-3	Blade edge part	All of blade (in) section slow etching, coarse , as (fully) quenched microstructure: Slow etched but fast quenching indicative of a high carbon steel.	?~0.8%	Homogeneous modern high carbon steel
12	4KS 9-4	Back part	Uniform fine martensitic structure - dark (faster) etching - probably quenched and lightly tempered	? ~0.6-0.8%	Homogeneous modern high carbon steel
13	4KS 14-4	Back part	Homogeneous, very fine grain low carbon iron, occasional tear-drop shaped MnS inclusions: Classic modern 'mild steel'	~0.2%	Low carbon (modern 'mild' steel)
14	5TS 5-1	Blade edge part	(a) Tip:- Banded macro-structure and very fast/dark etching partly tempered martensitic micro-structure. (b) Body:- Uniform partly spheroidised microstructure	~0.6-0.7%	Homogeneous modern medium to high carbon steel
15	5TS 5-2	Back part	Generally homogeneous, fine grain medium carbon steel (with flaw) consisting of fine grain ferrite plus pearlite	~0.6%	Homogeneous modern medium carbon steel
16	5TS 5-3	Back part	Ultra fine grain, high carbon steel, unquenched, ferrite plus pearlite	~0.6-0.7%	Homogeneous modern medium to high carbon steel
17	6 KS 17-2	Blade edge part	All quenched structure across section: (a) tip with coarse, slow etched (fast quenched) martensite; (b) body faster/darker etched (slower quenched), podd partly auto-temp	? ~0.7-0.8%	Homogeneous modern high carbon steel
18	6KS 17-4	?Back part	Mostly homogeneous, ultra fine grain low carbon iron, some tendency towards widmanstatten distribution, some very small, prob MnS inclusions (therefore = 'mild steel')	~0.1-0.2%	Low carbon (modern 'mild' steel)
19	6KS 17-1	Blade edge part	Mostly homogeneous, fine grain low carbon iron, mainly ferrite with some pearlite plus a scattering of v small MnS inclusions = 'mild steel'	~0.2%	Low carbon (modern 'mild' steel)
20	6KS 17-3	Back part	Uniform, very fine grain low to medium carbon steel showing as ferrite plus martensite, with some prob MnS inclusions	~0.3%	Low carbon steel
21	7KS 9-1	Blade edge part	(a) Tip, partially transformed/incompletely quenched martensitic structure; (b) Body - homogeneous, fine grain low carbon steel with (?phosphorus) banded macrostructu	~0.3%	Homogeneous modern (rolled) low carbon steel
22	7KS 9-2	Back part	Fine horizontal - P - banded macrostructure; at higher mag'n fine grain low carbon iron plus occasional MnS inclusions: modern 'mild steel'	~0.2%	Low carbon (modern 'mild' steel)
			Banded microstructure suggests this is a 'piled' (folded and forge-welded back together several times, resulting in phosphorus enrichment		
			(indistinct pale bands at the welds.		
23	7KS 9-3	Back part	Banded diffuse macro-structure: ?remnant effect of modern 'rolling' process; micro-structure: mostly fine grain low carbon iron, some widmatstatten dispersion, plus MnS	~0.2%	Low carbon (modern 'mild' steel)
24	8KS 11-1	Back part	Uniform ultra fine grain low carbon iron	~0.1-0.2%	Low carbon (modern 'mild' steel)
25	8KS 11-2	Blade, edge part	(a) Tip: slow etching fine martensitic structure - quenched but not tempered; (b) body fine to med grain (unresolved) pearlite plus ferrite	~0.4-0.5%	Homogeneous modern medium carbon steel
26	8KS 11-3	Back part	Uniform, ultra fine grain medium carbon steel, not quenched	0.3-0.4%	Homogeneous modern medium carbon steel
27	8KS 11-4	Back part	Fine to medium grain steel stucture, partially widmanstatten	~0.6%	Homogeneous modern medium carbon steel
28	GJ39	Blade edge part	Fine martensitic microstructure: not intentionally tempered but possibly slightly auto-tempered - ?cooled slowly	(?) ~0.6-0.8%	Homogeneous modern high carbon steel

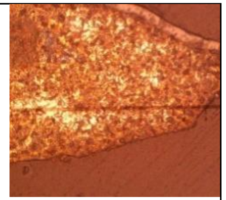
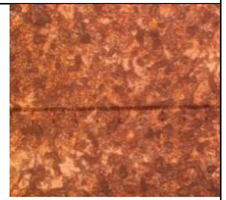
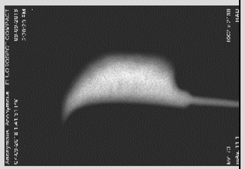
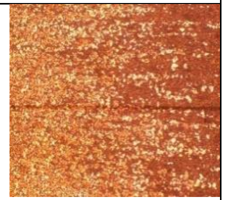
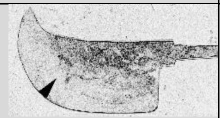
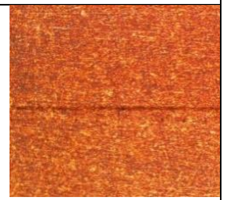
C.9 Researcher One Findings Overview Table

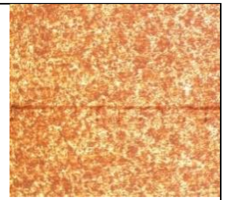
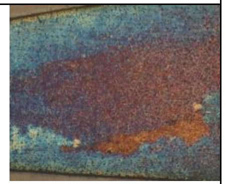
*Details that were not shared with the metals specialists are shaded in grey

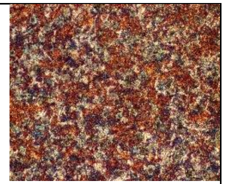
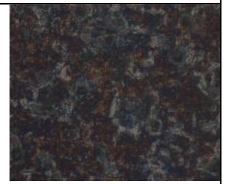
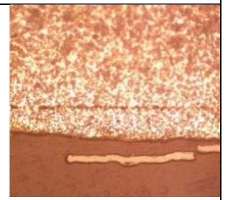
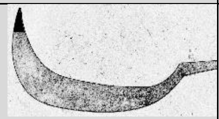
Object	Object Origin	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description	Image and Magnification	Micrograph
1VS3	Kerala	Medium Knife			1VS3-1KB		The cutting tip looks like it is not quenched but just rather fine pearlite. The structure further back from this is a very uniform pearlite and ferrite microstructure with more about 0.5% carbon content. It is a good modern steel. Seems to have some directionality to the structure along the length of the section.	1VS3-1KB X 10	
								1VS3-1KB X 20	
								1VS3-1KB X 40	
								1VS3-1KB X 100	

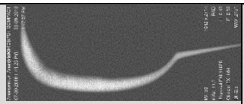
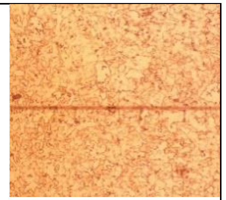
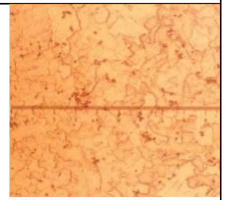
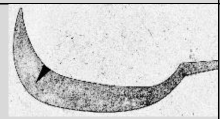
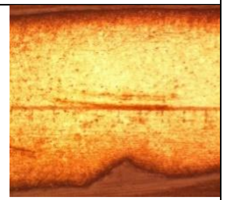
					1VS3-2KB		Fine pearlitic microstructure. Small grain size. Typical modern steel. Carbon content about 0-6-0.7%. The exterior can be seen to be a little decarburized from working or forging while the interior etches to a fine pearlitic structure with about 0.7% carbon content.	1VS3-2KB X 10	
								1VS3-2KB X 20	
								1VS3-2KB X 40	
								1VS3-2KB X 100	
					2VS3-1KB		The cutting tip looks very similar to 1VS3-1KB and has a similar carbon content and	2VS3-1KB X 10	

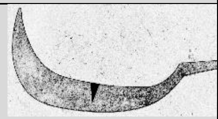
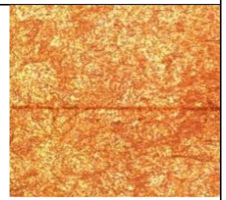
2VS3		Small Knife					microstructure. It appears to be mostly fine pearlite, back from the cutting tip the microstructure is of ferrite and pearlite with about 0.5% carbon content. Appears very uniform in microstructure.	2VS3-1KB X 20	
								2VS3-1KB X 100	
								2VS3-1KB X 400	
					2VS3-2		A strange rather porous-looking structure with patches of white, which may be ferrite and a fine-grained phase which is possibly pearlite, but the structure is rather odd and looks as if	2VS3-2 X 10	
								2VS3-2 X 20	

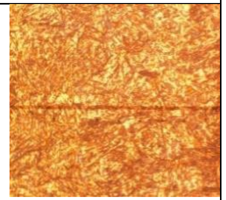
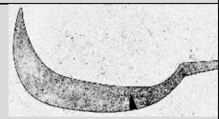
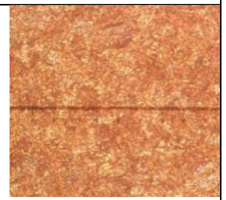
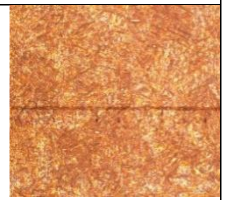
							the pores are filled or partially filled with a mineral phase.	2VS3-2 X 40	
								2VS3-2 X 100	
3VS13		Elephant Knife			3VS13-1KB		Very fine structured eutectoid steel blade. Practically 0.8% carbon.	3VS13-1KB X 20	
								3VS13-1KB X 40	
					3VS13-2		Differential structure with the cutting tip being apparently unquenched here ?)...while the rest of	3VS13-2 X 20	

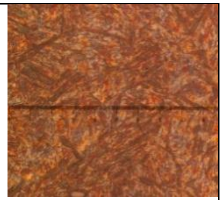
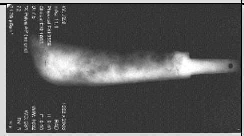
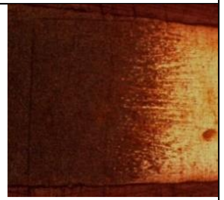
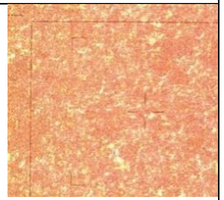
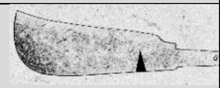
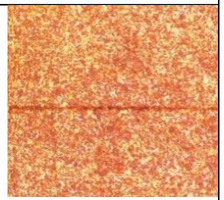
							the structure is fine ferrite and pearlite. the structure in part may be quenched to produce very fine pearlite microstructure. direct ionality is evident in the way the ribbons of the unquenched part of the structure meets up the very fine-grained structure.	3VS13-2 X 40	
								3VS13-2 X 100	
					3VS13-3KB		The low magnification view shows a partially heat-treated edge with blue-etching possible martensite or very fine pearlite. Higher magnification shows patches of pearlite surrounded	3VS13-3KB X 10	
								3VS13-3KB X 20	

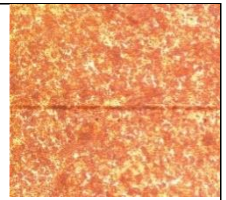
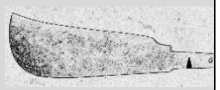
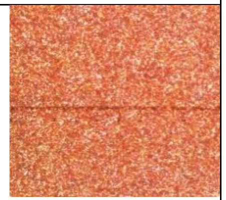
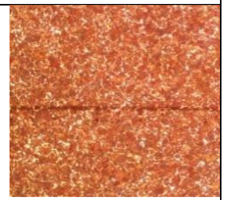
							by lower carbon areas. At the areas between the different constituents, the areas look as if they have variable carbon content, but not especially high.	3VS13-3KB X 40 3VS13-3KB X 100	 
					3VS13-4KB		A decarburized surface zone is quite thick here. The interior is practically a eutectoid steel. The carbon content drops off a lot to the outer surface here, becoming principally ferrite.	3VS13-4KB X 20 3VS13-4KB X 40	 
4KS9		Large Sickle			4KS9-1KB		Very fine-textured eutectoid steel.	4KS9-1KB X 10	

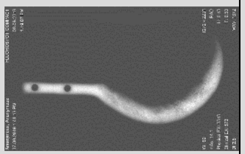
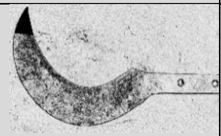
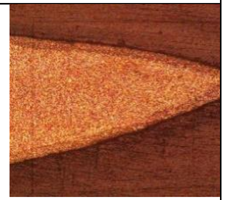
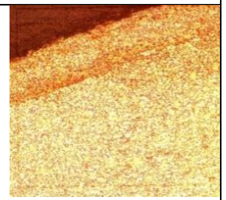
								4KS9-1KB X 20	
								4KS9-1KB X 40	
								4KS9-1KB X 100	
					4KS9-2KB		On etching this sample, the edges have etched quicker than the interior, and looks as if it has a higher carbon content than the interior. The microstructure at high magnification looks acicular as if the	4KS9-2KB X 10	
								4KS9-2KB X 20	

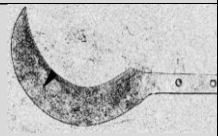
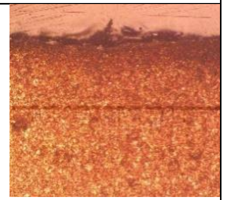
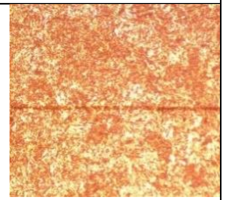
							material has been heat-treated to some extent. But there is no martensite. Fine acicular pearlitic microstructure.	4KS9-2KB X 40	
								4KS9-2KB X 100	
								4KS9-2KB X 400	
					4KS9-3KB		This sample is of a fine pearlitic steel with about 0.6-0.7% carbon in fine microstructure which looks very uniform throughout as a fine mixture of ferrite and pearlite.	4KS9-3KB X 10	
								4KS9-3KB X 200	

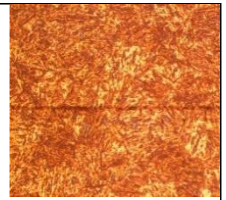
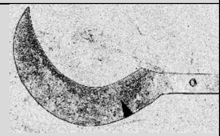
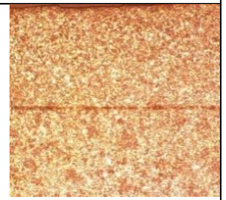
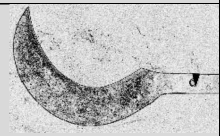
								4KS9-3KB X 1000	
								4KS9-3KB X 2040	
					4KS9-4KB		Almost a eutectoid steel. At x100 the steel has an acicular texture. At x20 the steel has a fine eutectoid microstructure, very even grains, very fine modern steel structure.	4KS9-4KB X 10	
								4KS9-4KB X 20	
								4KS9-4KB X 40	

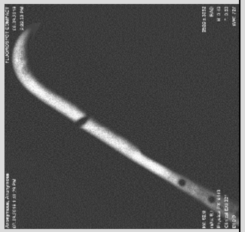
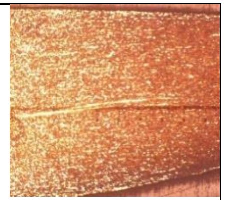
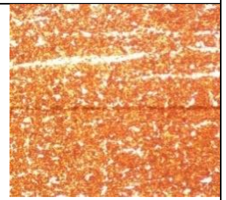
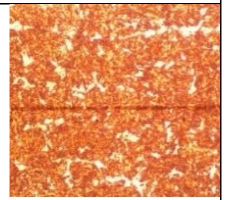
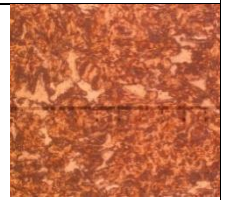
								4KS9-4KB X 100	
5TS5		Medium Flat Knife			5TS5-1KB		This sample looks as if heat-treated with exceptionally fine dark etching pearlitic structure and meeting up with a transitional zone of possibly high carbon steel. Certainly, these components have been heat-treated to create this microstructure.	5TS5-1KB X 10	
								5TS5-1KB X 20	
								5TS5-1KB X 40	
					5TS5-2KB		Fine, slightly coarser microstructure that 4KS9-3KB, has a slight directionality and a fine pearlitic	5TS5-2KB X 20	

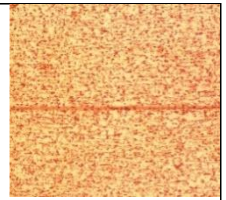
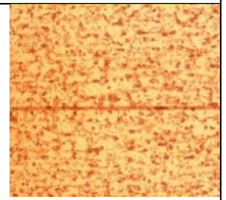
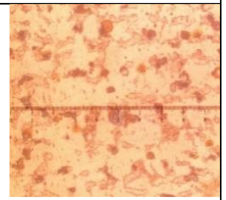
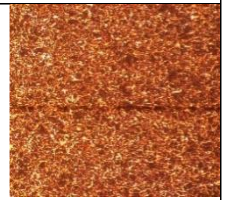
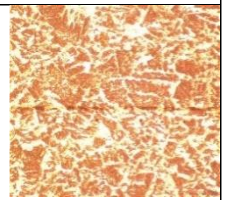
							microstructure with larger areas of pearlite which, like many of the samples here cannot be resolved using the eyepiece camera.	5TS5-2KB X 40	
								5TS5-2KB X 100	
					5TS5-3KB		Some decarburization along the edge of the sample. The interior is a fine pearlitic steel with about 0,6% carbon content.	5TS5-3KB X 10	
								5TS5-3KB X 20	
								5TS5-3KB X 40	

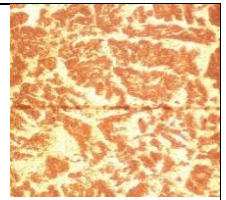
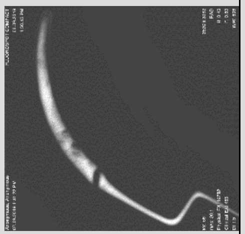
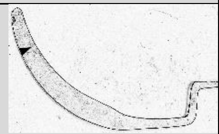
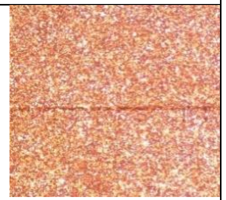
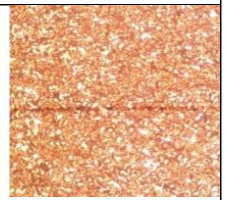
								5TS5-3KB X 100	
6KS17		Medium Sickle			6KS17-1KB		Good cutting edge produced with the welding on of an external strip around the core of the lower carbon steel. At higher magnification the join between these two areas can be clearly seen. Like all of these samples so far the microstructure is unlike ancient examples, totally clean and no slag content. The external layer of the blade does not look too different from the underlying steel, but has a slightly higher carbon	6KS17-1KB X 10 6KS17-1KB X 20	 

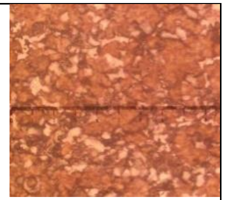
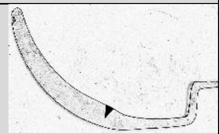
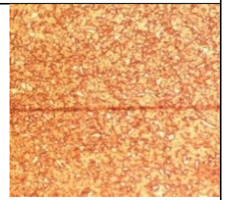
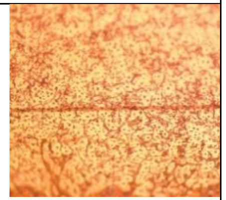
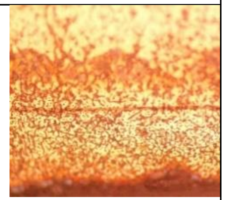
							content. Towards the butt end, the slightly higher carbon content component moves around the back to some extent suggesting that this piece has been made by the welding together of two slightly different carbon steels, the outer edge one being perhaps 0.65% and the internal 0.5% carbon.		
					6KS17-2KB		Fine eutectoid steel with very even grain structure.	6KS17-2KB X 10	
								6KS17-2KB X 20	

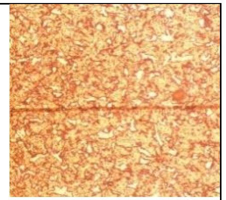
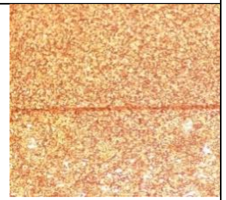
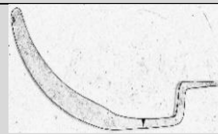
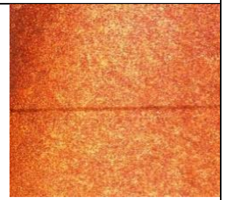
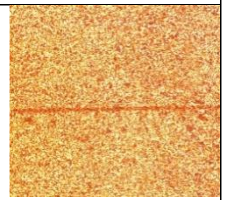
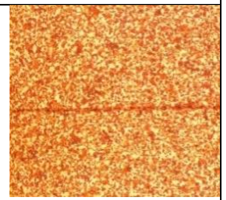
								6KS17-2KB X 40	
					6KS17-3KB		Lower carbon steel with about 0.3% carbon content, otherwise similar to other examples here.	6KS17-3KB X 20	
					6KS17-4		Different from most other samples, this one is principally ferrite. at high magnification, a little slag can be seen together with a trace of carbide. very close to being a pure wrought iron of ferrite.	No Data	No Data

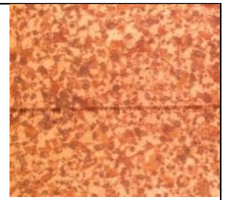
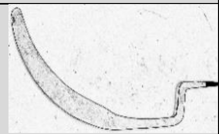
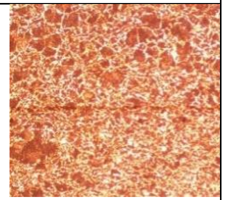
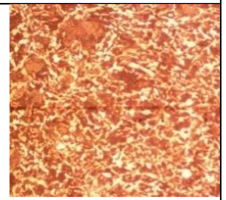
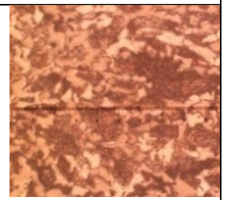
7KS9		Plantation Knife			7KS9-1KB		Looks worked to shape, with variable threads of ferrite running through the structure, which is of a carbon steel with about 0.6% carbon content.	7KS9-1KB X 10	
								7KS9-1KB X 20	
								7KS9-1KB X 40	
								7KS9-1KB X 100	
					7KS9-2KB		Fine microstructure close to the eutectoid at low magnification, while at higher magnifications, the	7KS9-2KB X 10	

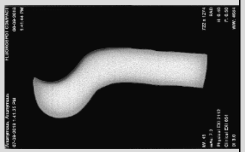
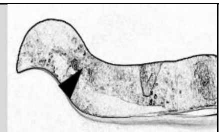
							structure can be seen to be a little lower than the 0,8% level, probably in the region of 0.7% carbon steel. Structure has a directionality to it from the forging process.	7KS9-2KB X 20	
								7KS9-2KB X 40	
								7KS9-2KB X 100	
					7KS9-3KB		Very similar to many other examples here with fine pearlitic microstructure. Small grain size. Typical modern steel.	7KS9-3KB X 10	
								7KS9-3KB X 20	

								7KS9-3KB X 40	
								7KS9-3KB X 1000	
					8KS1 1 - 1		This is a fine textured sample, almost of eutectic composition. very fine grained, no slag content. a good modern carbon steel	8KS11 – 1x10	
								8KS11 – 1x20	
								8KS11 – 1x40	

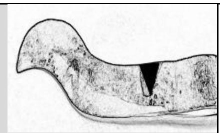
								8KS11 – 1x100	
8KS1 1		Large Knife to hold over shoulder			8KS1 1 – 2KB		A gradient in carbon content may exist between the outer surface and the interior. At least this is the result on the first etching. The interior has a carbon content of about 0.5%- 0.6% while the surface microstructure shows a higher carbon content in the region of 0.7%	8KS11 – 2KBx10	
								8KS11 – 2KBx20	
								8KS11 – 2KBx30	
								8KS11 – 2KBx40	

								8KS11 – 2KBx45	
								8KS11 – 2KBx240	
					8KS11 – 3KB		This sample appears to be of slightly lower carbon content than some of the others in this group. The structure is very fine, even, pearlitic, with about 0.6% carbon.	8KS11 – 3KBx10	
								8KS11 – 3KBx20	
								8KS11 – 3KBx40	

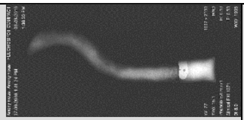
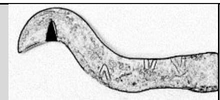
								8KS11 – 3KBx100	
					8KS11 – 4KB		This sample appears to be slightly decarburized towards the edge of the sample and has a slightly coarser microstructure than some of the other samples examined here. It is a pearlitic steel with about 0.6% carbon content.	8KS11 – 4KBx10	
								8KS11 – 4KBx20	
								8KS11 – 4KBx40	
								8KS11 – 4KBx100	

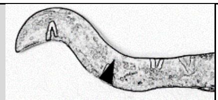
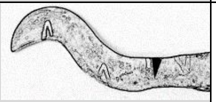
SL1	Sri Lanka Bonnet's Research	Small "billhook"			SL1-1		The cutting edge is essentially the same in composition as the steel used to make the blade or point. There is some surface distortion in the pearlite as a result of the hammering to shape the cutting edge, but has not been quenched. The carbon content is in the region of 0.5-0.6% carbon and the structure shows ribbons of pearlite with an infill of dark etching fine eutectoid of ferrite and cementite. There is little or no slag present. There is a small slag inclusion awkwardly positioned in the microstructure which is a region of weakness for this	No Data	No Data

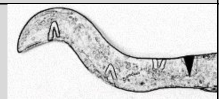
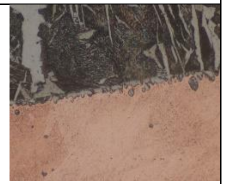
							blade or point. The carbon content appears to decrease towards the area of the cutting edge though as compared with the bulk and has dropped probably as a result of the forging process.		

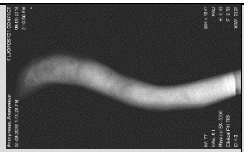
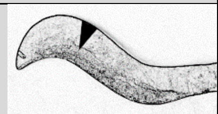
					SL1-2		This blade or point has a pronounced directionality to the structure in an unusual criss-cross pattern at low magnification which seems to have little to do with the shape of the finished product. There is a banding to the white phase, which here looks more like cementite than pearlite. Between the white banded structure there is fine pearlite, but the etching in methanolic picral failed to stain any of the white phase, showing that it is comprised of blocky ferrite rather than cementite. At high magnification small slag inclusions can be seen, elongated	No Data	No Data

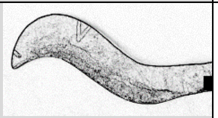
							along the length of the sectional view of the blade as a result of working and forging into shape.		

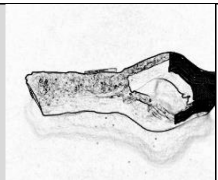
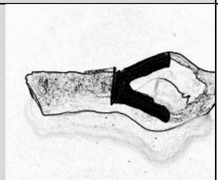
SL2		Medium "billhook" with Brazed Copper Socket			SL2-1		At low magnification, some decarburization has occurred on one edge, there is a lamination or banded structure of ferrite and pearlite which looks to be unrelated to the direction of working of a point or blade edge. At higher magnification, the ribbons of ferrite can be seen to have some directionality, with fine eutectoid infill. Carbon content about 0.4%. No slag content and no quenching.	No Data	No Data

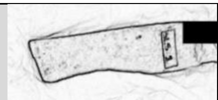
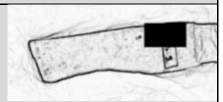
					SL2-2		At low magnification a straited appearance can be seen running diagonally across the blade. No quenching and no slag present. At higher magnification, the structure can be seen to include a great deal of blocky ferrite with pearlite infill, carbon content about O.3 – 0.4%.	No Data	No Data
					SL2-3		Good brazed copper surface with no excessive diffusion of iron into the copper. The steel is a lower carbon steel with about 0.5-0.6% carbon and dark etching very fine pearlite. The grain size is noticeably larger than SL3-2 OR	No Data	No Data

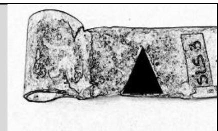
							SSLS-1. Not quenched.		
					SL2-4		Brazed copper central strip in join with iron. Dendrites of iron are visible in the copper. Steel is very dark etching with ferrite at former austenite grain boundaries. Some diffusion of iron into the copper along the join. Partially widmanstatten microstructure with about 0.6% carbon. Perhaps quickly cooled.	SL2-4 X 20	
								SL2-4 X 40	

SL3		Medium “billhook”			SL3-1		Homogeneous carbon steel. No slag. Very even grained. At high magnification can see ferrite at grain boundaries with fine pearlite infill. Carbon content about 0.7%. No quenching.	SL3-1 X 20	
								SL3-1 X 40	
					SL3-2		Good quality carbon steel with less than 0.8% carbon, the carbon content is about 0.7%. No slag content. At X100 the pearlite spacing can be seen in some areas. Clean hypoeutectoid steel. No quenching.	No Data	No Data
					SL3-3		Clean hypoeutectoid steel with no slag content. Carbon	No Data	No Data

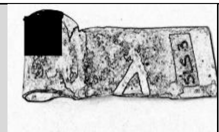
							content about 0.6 – 0.7% carbon.		
					SL3-4		Good hypoeutectoid steel.	No Data	No Data
SLS-1		Scraped attempt at Forging a “billhook”	No Data		SSLS 1-1		Homogeneous carbon steel, looks slightly coarser than SL3-1 but at high magnification there is no ferrite really, hence this is a eutectoid steel with 0.8% carbon as the structure is all pearlite.	No Data	No Data

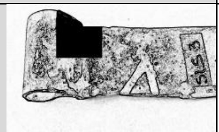
					SSLS 1-2		Good quality steel with no slag content. Small even grain size of fine pearlite. At 100X the pearlite structure is very finely spaced.	No Data	No Data
					SSLS 1-3		Banded carbon steel with thin bandes of ferrite between pearlite groundmass.	No Data	No Data

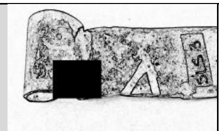
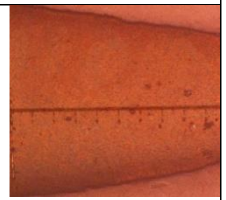
SLS-2		Scraped Section of Socket	No Data		SSLS 2-1		Striated banded structure at low magnification. At higher magnification one can see that the structure consists mostly of ferrite with some pearlite between the bands. Carbon content is low compared with most others here, about 0.4% carbon.	No Data	No Data
					SSLS 2-2			No Data	No Data

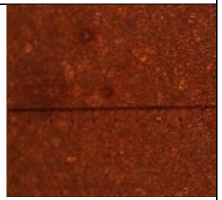
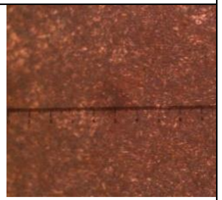
SLS-3		Scraped Brazed Copper Socket	No Data		SSLS 3-1		Lower carbon content than many in this group, has a distributed widmanstatten structure with carbon content around 0.2-0.3 %. Some decarburization towards surface and brazed join area seems to have less carbon but has very clean brazed interface with no iron migration into the copper. Very little slag content. Towards the surface has lower carbon content with brazed copper, here the copper has been expertly brazed with not iron content in the copper. Carbon content estimated to	No Data	No Data

							be about 0.1-O.2% Not quenched.		

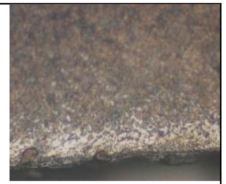
					SSLS 3-2		Interesting fine structure of large grains with some windmanstatten ferrite at grain boundaries with partially quenched interior of what might be bainite or very fine feathery pearlite. At low magnification high contrast between ferrite grain boundaries and dark etching grain interiors. Brazed copper surface with iron droplets at brazed surface.	No Data	No Data
					SSLS 3-3		Steel with about 0.7% carbon with windmanstatten aspect. Some of the detail looks like bainite with a feathery appearance as if it might have	No Data	No Data

							been partially quenched.		
					SSLS 3-4		Interesting brazed join with extensive iron dendritic structures within the copper due to some dissolution. Large pores present in some of the joins. Feathery structure between the ferrite boundaries is suggestive of bainite, showing that this object could have been quite quickly cooled.	No Data	No Data

					SSLS 3-5		Low carbon steel with good brazed copper join. The microstructure has a widmanstatten aspect with a low carbon content of about 0.25% no slag content. Very little iron content in the brazed join itself.	No Data	No Data
Juleff's Samples	Sri Lanka Juleff's	Knife forged out of bloomery iron from Juleff's	No Data		G3-39		This sword blade is made of a eutectoid steel, very fine microstructure which looks very much like an 0.8% steel. Very even throughout with not much variation apparent.	G3-39 X 10	

	Research	experiments						G3-39 X 20	
								G3-39 X 40	
								G3-39 X 100	

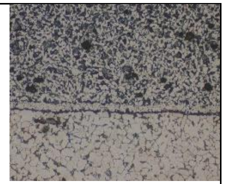
					GJ-36		Nicely textured windmanstatted hypoeutectic steel with about 0.4 – 0.3% carbon. As a result of forging there has been some decarburization of the steel along the edges. The structure is that of grain boundary ferrite and cross-hatched pearlite, showing quite an acicular structure which might have formed through cooling quickly in the final stage of fabrication, but not quenched to get martensite.	No Data	No Data

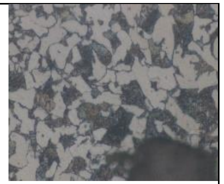
					GJ-38		At low magnification this looks like a eutectoid steel which has probably been heat-treated. The structure consists of a mass of interlocking needles, martensitic in effect. Probably 0.8% carbon steel quenched.	G3-38 X 100	

					GJR-312		A classic sword or blade with a high carbon steel central core. Towards the cutting edge this section goes down to a high carbon edge and one low-carbon side, while in the central region the high-carbon steel strip is sandwiched between the two low carbon sides. The outer, low carbon outer surfaces are typical wrought iron with slag stringers, has no carbon content and is very soft. There appears to have been some diffusion from the higher carbon central strip as a little pearlite can be seen in the area of the weld. There is a weld line passing along the join	GJR-312 X 10	

							which may be sue to some segregation during the heating and joining of the components. The inner steel core etches very fast towards the cutting edge showing that it has been heat treated in this area and has a martensitic aspect. Further back from this edge, ferrite begins to appear in this core and the carbon content is about 0.5 – 0.6%. So in the manufacture, a wrought iron with typical slag content has been welded to a medium carbon steel central strip, with very little slag content, showing that the fabrication technology of these		

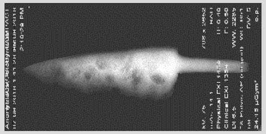
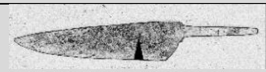
							two components is quite different.		

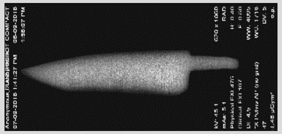
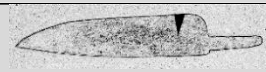
								GJR-312 X 20	

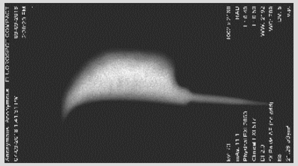
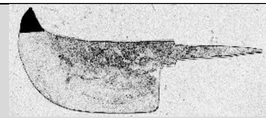
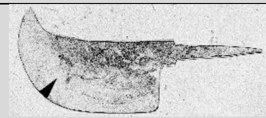
								GJR-312 X 100	

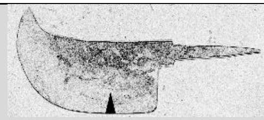
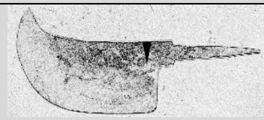
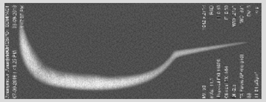
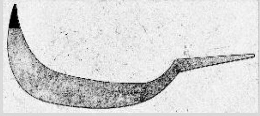
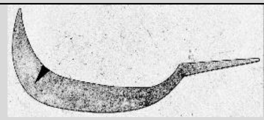
C.10 Researcher Two Findings Overview Table

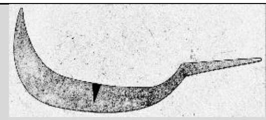
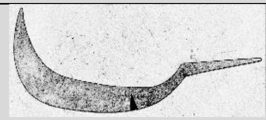
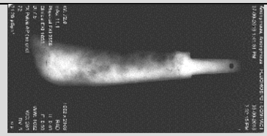
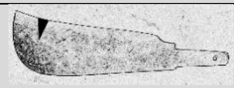
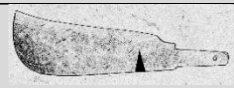
*Details that were not shared with the metals specialists are shaded in grey

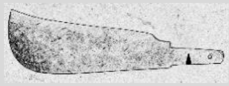
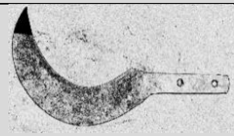
Object	Object Origin	Description	X-Ray	Photo	Sample Number	Location of Sample	Sample Description
1VS3	Kerala	Medium Knife			1VS3-1KB		(a) Tip martensitic ut progressively gives way to very fine grain, homogeneous (equiaxed) mainly (unresolved) pearlitic microstructure; (?Phosphorus) banded macrostructure.

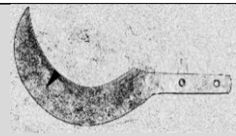
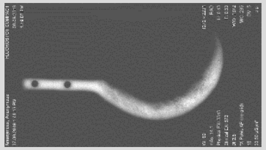
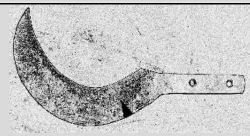
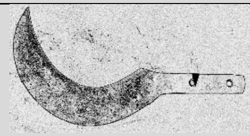
					1VS3-2KB		Homogeous fine-grain medium to high carbon steel: unresolvable fine grain pearlite and ferrite - possibly fast air cooled
2VS3		Small Knife			2VS3-1KB		At tip - heat-treated structed: ultra fine grain medium carbon steel with partly spheroidised pearlite; away from tip showing as a high carbon steel - small-med grain ferrite/pearlite
					2VS3-2		Homogeneous, partially spheroidised very fine grain hypoeutectoid steel quenched, martensitic structure at tip

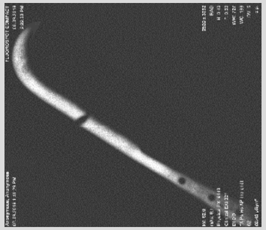
3VS13		Elephant Knife			3VS13-1KB		Ultra fine grain, nearly eutectoid steel, unquenched, irresolvable pearlite
					3VS13-2		(a) Tip - fine grain (quenched and lightly) tempered martensitic structure, (b) centre - partly martensitic/partly bainite or radial pearlite: partly quenched structure; (c) furthest from tip - unresolved fine grain pearlite plus ferrite - unaffected by quenching. Edge only quenched. Rest of high carbon steel blade probably protected by a clay paste during heating/quenching process.
					3VS13-3KB		(a) Edge: Intermediate martensite/'troostite' (radial pearlite) at tip,

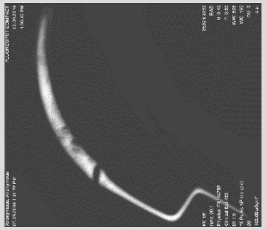
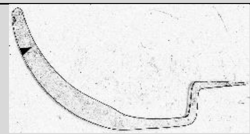
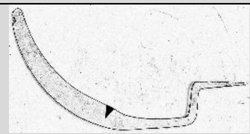
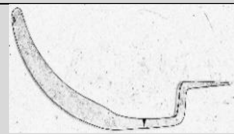
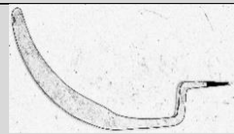
							?very lightly quenched; (b) body shows homogeneous, fine grain ~eutectoid, unresolvable pearlite + MnS inclusions
					3VS13-4KB		V fine grain, high carbon steel, just hypo-eutectoid
4KS9		Large Sickle			4KS9-1KB		Uniform very fine quenched martensitic structure probably indicative of high carbon steel
					4KS9-2KB		Uniform, coarse slow etching martensitic microstructure; as-quenched, ?mediumto high carbon steel structure with some small probable MnS inclusions
					4KS9-3KB		All of blade (in) section slow etching, coarse , as (fully) quenched

								microstructure: Slow etched but fast quenching indicative of a high carbon steel.
					4KS9-4KB			Uniform fine martensitic structure - dark (faster) etching - probably quenched and lightly tempered
5TS5		Medium Flat Knife			5TS5-1KB			(a) Tip:- Banded macro-structure and very fast/dark etching partly tempered martensitic micro-structure. (b) Body:- Uniform partly spheroidised microstructure
					5TS5-2KB			Generally homogeneous, fine grain medium carbon steel (with flaw) consisting of fine grain ferrite plus pearlite

					5TS5-3KB		Ultra fine grain, high carbon steel, unquenched, ferrite plus pearlite
					6KS17-1KB		Mostly homogeneous, fine grain low carbon iron, mainly ferrite with some pearlite plus a scattering of v small MnS inclusions = 'mild steel'
					6KS17-2KB		All quenched structure across section: (a) tip with coarse, slow etched (fast

							quenched) martensite; (b) body faster/darker etched (slower quenched), podd partly auto-tempered +MnS incl's
6KS17		Medium Sickle			6KS17-3KB		Uniform, very fine grain low to medium carbon steel showing as ferrite plus martensite, with some prob MnS inclusions
					6KS17-4		Mostly homogeneous, ultra fine grain low carbon iron, some tendency towards widmanstatten distribution, some very small, prob MnS inclusions (therefore = 'mild steel')
					7KS9-1KB		(a) Tip, partially transformed/incompletely quenched martensitic structure; (b) Body - homogeneous, fine grain low carbon steel with

7KS9		Plantation Knife					(?phosphorus) banded macrostructure
					7KS9-2KB		Fine horizontal - P - banded macrostructure; at higher mag'n fine grain low carbon iron plus occasional MnS inclusions: modern 'mild steel' Banded microstructure suggests this is a 'piled' (folded and forge-welded back together several times, resulting in phosphorus enrichment (indistinct pale bands at the welds.)
					7KS9-3KB		Banded diffuse macro-structure: ?remnant effect of modern 'rolling' process; micro-structure: mostly fine grain low carbon iron, some

							widmatstatten dispersion, plus MnS inclusions
8KS11		Large Knife to hold over shoulder			8KS11 - 1		Uniform ultra fine grain low carbon iron
					8KS11 – 2KB		(a) Tip: slow etching fine martensitic structure - quenched but not tempered; (b) body fine to med grain (unresolved) pearlite plus ferrite
					8KS11 – 3KB		Uniform, ultra fine grain medium carbon steel, not quenched
					8KS11 – 4KB		Fine to medium grain steel stucture, partially widmanstatten

Juleff's Samples	Sri Lanka Juleff's Research	Knife forged out of bloomery iron from Juleff's experiments	No Data	No Data	GJ-39		Fine martensitic microstructure: not intentionally tempered but possibly slightly auto-tempered - ?cooled slowly

C .11 Analysis Selection Summary Table

Selected Objects		Objects Not Selected	
Object Number	Reason for Selection	Object Number	Reason Not Selected
Kerala Objects		Kerala Objects	
1VS3	Manufacturing Detail in sample 1VS3-1 and images	2VS3	No manufacturing details
3VS13	Manufacturing Detail in sample 3VS13-2 and 3VS13-3 and images	7KS9	No manufacturing details
4KS9	Manufacturing Detail in sample 4KS9-2 and images	8KS11	No manufacturing details
5TS5	Manufacturing Detail in sample 5TS9-1 and images		No manufacturing details
6KS17	Manufacturing Detail in sample 6KS17-1 and images		No manufacturing details
Bonnet Sri Lanka Objects		Bonnet Sri Lanka Objects	
SL2	Manufacturing Detail in sample SL2-1, SL2-2, SL2-3 and SL2-4 and images	SL1	No images
SL3	Manufacturing Detail in sample SL3-1 and SL3-2 and images	SLS1	No images
		SLS2	No images
		SLS3	No images

Juleff's Sri Lanka Objects		Juleff's Sri Lanka Objects	
GJ-38	Manufacturing Detail in sample and images	G3-39	No manufacturing details
GJR-312	Manufacturing Detail in sample 1VS3-1 and images	GJ-36	No images

C. 12 Interview With David Scott

1) When you begin a new project how do you approach it. Do you do background research, how much? What is the main information you like to have before starting?

Yes I usually do a lot….having decided on a topic I usually try to do as much background reading as possible. Sometimes I already collect together some of the digital offprints or actual offprints.

2) What do you believe is the most significant project you have worked on so far?

The work on ancient pigments probably, especially on ancient Egyptian pigments on which I have published several papers. The other one I would call out is the work on the use of native platinum in ancient Colombia and Ecuador.

3) Which area of the world do you think is the most promising for focusing future research?

Ancient South America…..places like Argentina…very much understudied in terms of metallurgy.

4) What do you think are the newest metallurgical analysis techniques that show the most promise in enhancing our knowledge of metalworking?

I am too old to know really….I always like the EPMA….but I suppose that isotopes have done a great deal over the past decade…and trace elements.

5) How has the field of metals analysis research, or archaeometallurgy, changed since you began you career?

EErgh….detailed knowledge much more diffused…a greater range of work going on worldwide….in the old days it was mostly USA and UK and a little from the USSR and Poland and Czech…..now they have gone down I would guess and been replaced with Turkey, Spain, France, Germany, China, Japan.   There is still a shortage of jobs in archaeometallurgy.

6) Do you think there is a way to standardise analytical techniques to compare metalworking sites across the world?

Eeergh…not well qualified to answer that question…in terms of sites? Where to start? Better international teams I suppose. Both Brett Kaufman and Seppi Lehner, my old students are better qualified to answer that question.

7) What is the most memorable moment of your career?

Many such moments. I suppose when my book Copper and Bronze in Art won the prize in 2002 as the best scholarly/art book published in the USA that year, and a host of other prizes. This major prize was awarded in Washington. Despite all the money the Getty has, it was only the second book published by the Getty to ever win this prize, and they have published hundreds. The fact that it has sold over 2000 copies hardback and been translated into four languages. The Chinese translation took 4 years…..a testament to the mighty strength of the Chinese cultural system and its advancement.

8) What advice would you give to metallurgist just entering the field?

Get a good range of skills under your belt and a few good publications. Be able to teach a variety of first or second year courses…..general materials science, or metallurgy, or science in the arts….etc….Be prepared to move anywhere. Great tenacity needed. My two stars are my old students Brett Kaufman and Seppi Lerner…..Brett…he tried and tried…he got a post-doc at Brown…of course Brown…..never gives you a job…then he got an offer to go to….you guessed it…..China…so he got another post-doc in Beijing…all the while he was excavating in Tunisia…..then he tried some more…..then he got a position at the University of Illinois….not everyone's cup of tea weatherwise, but that is Brett….he was so determined to get a job! Seppi went all over too…including Australia…..his work in Turkey was excellent…..have a look at some of his publications…..again it was a few years before he got a permanent position. Looks like good degree, variety of experience, some site work, lab research, post-docs here and there, and then you get a position…..somewhere….could be Hong Kong or Illinois or Australia……..