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ARTICLE

Traditional knowledge of iron metallurgy in North-East India, with reference to Manipur: A historical and technological perspective

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Abstract
Metallurgy has been taking an important role in the development of civilizations throughout the world since ancient times. North-East India has a rich yet relatively understudied history of traditional ironworking practices. Manipur, in particular, has a deep-rooted tradition of iron smelting and blacksmithing, which is integral to its socio-economic and cultural fabric. This paper explores the traditional metallurgical techniques employed in North-East India, with a special focus on Manipur. It also examines historical records, archaeological findings, ethnographic accounts and oral traditions to understand not only the technological methods but also the historical background of ironworking in the region.

Keywords Metallurgy · Manipur · Kakching · Iron · Smelting · Nongda lairen pakhangba · Ebudhou khamlangba · Myanmar

1 Introduction

North-East India, comprising the eight states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura, is a region of immense cultural, ecological, and historical diversity. Despite its significance as a transitional zone between South and Southeast Asia, the region has long remained peripheral to the mainstream historical and archaeological narratives of the Indian subcontinent. However, there has been a gradual yet notable improvement in recent decades. Scholars such as T.C. Sharma, O.K. Singh, Marco Mitri, Paromita Das, Tage Tada, Manjil Hazarika, and many others have worked relentlessly, focusing on the material culture of the region. Their works have significantly contributed to the understanding and reconstruction of the History of North-East India since the prehistoric period. Although limited in number, several archaeological sites across the North East have also been excavated and studied since the first systematic excavation at Daojali Hading, Assam, in 1961, by two renowned archaeologists, M.C. Goswami and Tarun Chandra Sharma (Jamir & Hazarika, 2014, p. 1). Yet, the lack of the application of scientific tools and techniques in the archaeological and historical studies of the region still creates a problem in the chronological reconstruction and periodization of the history of north-east India (Thakur & Rigam, 2023, p. 60). Jamir and Hazarika have also rightly observed "Application of radiocarbon dating and other analytical techniques to Northeast India prehistoric and historic sites is still in its infancy" (Jamir & Hazarika, 2014, p. 5).

One of the most underexplored yet crucial parts of the history of North-East India is the iron metallurgy. Iron, with its abundance, strength, and durability, has played a significant role in shaping human civilizations by driving technological advancements, economic progress, and military power. While the history of iron use and its metallurgy in mainland India has been extensively studied, especially in the Ganges Valley and the Deccan regions, the metallurgical traditions of the North-East remain significantly underdocumented. However, studies of available archaeological findings, literary sources and oral traditions reveal the existence of rich localized ironworking traditions often deeply associated with culture of the region.

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2 Iron metallurgy in North-East India

2.1 Meghalaya

Among the most prominent ironworking communities in the North-East are the Khasis of Meghalaya. The Khasi term for iron, *nar*, reflects a deeply rooted metallurgical tradition. Iron ore was abundantly distributed throughout the Khasi-Jaintia hills, particularly in regions like Mylliem, Nongkrem, Laitlyngkot, Nogundee, and Sohra (Umdor, 2017, p. 247). Chakrabarti (1977, p. 171) identified the region's iron ore as impure limonite, whereas Umdor described its source as titaniferous iron crystals derived from the decomposed granite of the Khasi Hills. The miners extracted the ores from the open mines mainly during the monsoon season, taking advantage of the rains to loosen the iron nodules embedded in the upland granites. It is said that the women of the Khasi community performed the process of cleaning the ore (Umdor, 2017, p. 425).

To determine the age of this traditional iron smelting craft in the Khasi Hills, Polish researchers Pawel Prokop and Ireneusz conducted radiocarbon dating on the iron slag from the Nongkrem and Raitkteng sites. One of the samples was dated to around 2040 ± 80 years BP. They claim it as the earliest iron-smelting site in Meghalaya and possibly the entire Northeast. These sites were also found to be associated with megalithic structures, suggesting ritual or commemorative uses of iron in local cultural contexts (Pawel & Ireneusz, 2013, p. 762). Iron production among the Khasis was economically significant, supporting a robust barter-based trade network that connected the hills with the plains. Iron ore, along with cotton, wax, ivory, and betel leaf, was traded for salt, tobacco, rice, and goats at regional hubs like Jaintiapur (Umdor, 2017, p. 426). Their trading connection also extended to Sylhet, where they exchanged iron for rice, salt, and dried fish. And they even supplied crude iron to the Kamars, Iron smiths of Assam (Purkayastha, 2007, p. 159). However, the introduction of cheaper British iron into the region led to the sharp decline of traditional iron production by the late nineteenth century (Umdor, 2017, p. 428).

2.2 Assam

Although Assam is not naturally endowed with high-quality iron ore deposits, local communities have used clay ironstone, a locally available ferruginous material, as the primary source of iron ore in Assam (Chakrabarti, 1977, p. 171). The smelters collected iron ores from locations such as, Hatigarh, Doyang, Teerugaon Hills, Tiru Hills, and the Dihing riverbed (Purkayastha, 2007, p. 153; Saikia & Goswami, 2021, p. 3). Despite the inferior quality of iron ore in the region, indigenous metallurgical knowledge enabled the local population to develop iron smelting and gold washing techniques. These metallurgical skills matured during the Ahom period (13th to early nineteenth century CE), with metal casting techniques reaching considerable proficiency. Artisans produced a wide range of items from gold, silver, bell-metal, copper, and iron, including tools, weapons, ritual objects, and domestic utensils (Kalita, 2019, p. 2604). Among the local metallurgists, the *Loh Shalias*, a distinct artisan class, specialized in iron smelting. These artisans belonged primarily to the Teerualia, Kacharis and Ahoms, who were of Tibeto-Burman and Shan origin. It is suggested that they may have maintained cultural and technological exchange with their kin groups in Upper Burma, particularly the Kunung tribe of the Bar Khampti area, renowned for their ironworking skills. Their expertise was complemented by the *Kamars* (the blacksmiths), who forged iron tools and weapons from the crude iron supplied by the *loh-shalias*. This reflects a formal division of labour between smelting and smithing. These artisan groups were further organized into separate khels, a system that structured labour in the Ahom society. From the western part, the Kalitas were another blacksmithing community in Assam (Purkayastha, 2007, p. 154).

Based on the nature of their work, Sudeshna Purkayastha observed that the technology used by the *Kamars* of Eastern Assam was quite similar to that of Bengal, while the technology of Western Assam was identical to that of Upper Burma. Regarding the significance of iron in the transitional phase of Assam, from tribal to feudal economy, he further expressed, "The existence of iron deposits in upper Assam, the continuous supply of pig iron from the neighbouring Khasi Hills along with the manufacture of weapons of war in the royal workshops made the Ahom state a strong base for feudal state formation" (Purkayastha, 2007, p. 161).

The latter part of the eighteenth century marked a significant turning point in Assam's history, primarily due to the outbreak of the Moamoria Rebellion, which later paved the way for the establishment of British colonial rule in Assam in 1826. This upheaval, followed by the Burmese invasion in the early part of the Nineteenth Century, forced many artisans, including the blacksmiths, to flee from the Ahom kingdom. The condition was worsened by the *Loh-Shalias'* inability to adapt to the more advanced and profitable smelting techniques used by the Khasi people. This led to the stagnation of their craft. The introduction of new socio-political transformations under colonial rule further impacted the traditional iron industry. It disrupted the traditional flow of the workforce. David Scott, the first Commissioner of Assam, who had freed a large number of slaves in Assam, is to be noted. As a result, many royal workshops for iron, previously run by forced labour, became useless as no smelting and smithy work was performed

(Purkayastha, 2007, p. 162). Furthermore, women who contributed to production were also systematically excluded from the organization of labour. These factors resulted in the scarcity of human resources, which severely hampered the iron industry. Thus, a combination of socio-political upheaval, technological stagnation, colonial intervention, and labour shortages led to the irreversible decline of Assam's traditional ironworking industry in the late nineteenth and early twentieth centuries.

2.3 Nagaland

Traditional blacksmithing was a significant occupation among the Naga tribes, including the Angami, Ao, Rengma, Lotha, and Sema/Sumi. The Angami blacksmiths used traditional tools like the *Rekrichi* (anvil), *Rekrichivii* (hammer) made from stone, and *Kuru* (bellows) made from bamboo and animal skins (Thakur, 2023, p. 61). Iron products, such as daos, hoes, knives, and spearheads, were often made from imported iron (Allen, 2002, p. 50). Although archaeological works in Nagaland have been limited, recent excavations at Wui have uncovered cord-marked pottery, iron slag, animal bones, glass beads, charcoal, and perforated slate tiles. Radiocarbon dating of charcoal samples places the metallurgical activity between 800–753 BCE and 980–1053 CE AD. Further metallurgical analysis, including microstructure examination, optical microscopy, FESEM, XRD, and hardness testing, has indicated that the village of Wui (a Khiamnungan Naga village near the Myanmar border) was a probable source of bog iron ore (Tzudir, Jamir & Sharma, 2019, p. 318). Iron weapons produced in this village were highly valued and sought after in Myanmar (Rayies, 2019).

3 Traditional iron metallurgy in Manipur

Manipur, one of the eight states in North-East India, is situated along the eastern frontier of the Country, sharing its border with Myanmar. Historically, it was an ancient kingdom with a well-documented past. Its rulers engaged in numerous battles against the Awas (present-day Myanmar) and the Takhels (modern Tripura). The people of Manipur also fought against the British forces in the renowned Khongjom Battle of 1891. Furthermore, Manipur was one of the very few regions in India that served as a battleground during the Second World War. It is a fact that Iron-based tools and weapons have played a vital role not only in warfare but also in shaping the kingdom's socio-political and economic landscape over time. It is also evident from both literary and archaeological sources that the people of Manipur have been using iron since ancient times. Additionally, the presence of multiple ancient iron smelting sites in and around the Kakching area suggests that iron, locally known as Yot, was smelted in Manipur since ancient times.

3.1 Analysis of literary sources

According to *Poireiton Khunthok,* an ancient Manipuri text, Poireiton, who is often associated with migration and the settlement of people in the Manipur valley, arrived in the region with a group of followers and wandered in search of a suitable place for settlement. The text mentions that he carried an iron staff during his journey (Chandra, 1979, p. 43). It also recounts an incident in which Poireiton encountered a stranger who was holding an axe. Kulachandra claims that it was an iron axe (Sharma, 2007, p.36). These references collectively suggest that Poireiton came from a place where iron use was already developed, while also implying that iron may have been in use in Manipur during that period. It is generally accepted that Poireiton arrived in Manipur during the reign of Nongda Lairen Pakhangba, who ruled the kingdom in the First Century CE. (Sharma, 2007, p. 38; Sharma & Singh, 2010, p. 159).

Meitei Ningthourol, another ancient Manipuri text, reports that Khuyoi Tompok, whose reign spanned from 154 to 263 CE, discovered lumps of iron ore while excavating the ground at Kakching (Bormani, 2018, p. 9). This is considered the earliest indication of the availability of iron ore in Manipur. According to Ranjit, Khuyoi Tompok's reign is also regarded as the period of technological advancement in Manipur (Singh, 2013, p. 9).

Khamlangba Khunkumlon is a Manipuri text that primarily narrates the life and achievements of Khamlangba,[1] as well as his settlements with his followers in different parts of the valley. This text clearly mentions that he once settled in Uripok, Imphal, and from there, he traveled to Takhel (present-day Tripura) with his followers in search of iron ore for smelting. These references to Khamlangba's association with iron suggest that the knowledge of locating iron ores and smelting had already been present in Manipur during that time. To determine the time period of Khamlangba and his ventures, another Manipuri text, called Sagol Kangjei, needs to be referred to**.** It describes a Sagol Kangjei match

[1] Khamlangba is a significant figure in the mythology and folklore of the Meitei people of Manipur, whose legend has been passed down through the generations among the people of Manipur. He is celebrated as a warrior, hero, and cultural icon whose stories reflect the martial traditions and societal values of ancient Manipuri society. The people of Kakching, in the southern part of the Manipur valley, have been paying homage to him as their local deity and protector since ancient times. According to the legends and Puyas (ancient Meitei texts), he is associated with the discovery of iron and the settlement of iron smelting community in the Kakching area. He is also referred to as the god of iron smelting.

(recognized as polo) hosted by Nongda Lairen Pakhangba, in which Khamlangba was one of the key players praised for his performance (Saratchandra, 2016, p. 14). Other sources have also revealed that Khamlangba was a contemporary of Nongda Lairen Pakhangba, ruler of Manipur during the first century CE (Pramodini, 2017, p. 25).

Manipurda Yotsung Yotsa, written by Mayanglambam Gourachandra in the Manipuri language, is an important text that highlights the significant cultural association between the craft of iron smelting and the people of Manipur. Gourachandra asserts that the local deity of Kakching, Ebudhou Khamlangba, was a historical figure who lived during or before the reign of Pakhangba (first century CE). He further claims that Khamlangba's exploits in the development of iron technology was of great significance in the agrarian development of Kakching. In this text, Gourachandra also writes about the traditional process of iron working practised at Kakching.

Meitrabakki Yot Thanggi Chak, written in the Manipuri language by B. Kulachandra Sharma, is an elaborate work on the history of iron use in Manipur. After analyzing various literary sources, Kulachandra asserts that the Iron Age in Manipur began around the first century CE. He also claims that the chronological sequence of the metal ages in Manipur was entirely different from the conventional sequence observed in other parts of the world, where the Copper Age and Bronze Age precede the Iron Age. Metal age sequence of Manipur, as claimed by Kulachandra: (i) Iron Age-1970–1200 years ago, (ii) Copper age-1200–900 years ago, and (iii) Bronze age-900-200 years ago (Sharma, 2007, p. 30).

In his '*Report on the Eastern Frontier of British India*' (1835), Capt. R. Pemberton notes that iron was the only metal known to occur in Manipur at the time. It occurred in the form of Titaniferous Oxydulated Ore, mainly found in the stream bed south of Thoubal and the hills near Langathel. The local method of locating iron involved thrusting an iron-headed spear into the ground. He asserts that when the spear was pulled from the ground, the iron particles adhering to it provided a clear sign of iron ore deposits beneath the surface. Iron was used to make basic tools, such as axes, hoes, and ploughshares, for agriculture, as well as spears and arrowheads for protection or warfare. It is further stated that ironworking was concentrated in villages such as Kokshinglungsaee, Kokshingkhoolel (presently Kakching), Kokshingkhoonao (presently Kakching Khunou), and Langathel, under the leadership of a chieftain named Bodhee Rajah, whose ancestors were credited with the discovery and initial use of iron in the region (Pemberton, 1835, p. 27). However, Kshetri Bira argues that Langathel was not an ironworking centre, but rather a charcoal production centre (Kshetri Bira, 74, personal interview, 2022).

Gazetteer of Manipur (1992) by Capt. E.W. Dun observes that Iron ore was found in multiple locations of the Manipur valley. And its occurrence was limited to swampy alluvial areas, where it was found in the form of small pisolitic nodules of hydrated iron oxide, commonly known as bog iron ore, mixed with clay. Dun also notes that the bed in which the ore was found was never exposed at the surface but lay beneath 2 to 5 feet of alluvial soil (Dun, 1992, p.7).

According to the *Gazetteer of Naga Hills and Manipur* (1905) by B.C. Allen, Iron ore in Manipur was primarily found at Kameng, Kakchingkulen (presently Kakching), and Kakchingkunao (presently Kakching Khunou), in the shape of small pisolitic nodules of hydrated oxide of iron intermixed with clayey material. Allen further expressed that the smelters of Manipur used methods such as separating impurities from the ore by heating it with straw, reducing the ore into powder, and smelting the iron in a charcoal fire.

In *Memoirs of the Geological Survey of India,* R.D. Oldham argues the existence of the method of locating iron ore by thrusting an iron- headed spear into the ground, as previously claimed by Pemberton. Oldham writes,

> I cannot, however, but think that he was misinformed as to this, or misunderstood the process. He explains it by supposing the spear, which is always kept stuck upright into the ground, had acquired magnetic properties; this, however, could only be the case to a very slight degree, nor does it seem possible to me." And regarding the type of furnace used in Manipur, he said, "The furnace used in Manipur for the reduction of the ore differs not much in appearance, but greatly in principle, from those used in other parts of India (Oldham, 1883, p. 24).

From the analysis of the above sources, it is revealed that the people of Manipur have been engaged in the craft of iron working for centuries, and it has also become an integral part of their culture. It is also suggested that by the 1st Century CE, the people not only knew about the occurrence of iron ore in the region but also knew how to smelt it. Moreover, colonial sources confirm the availability of bog iron ore in swampy alluvial areas, such as Kakching and Thoubal, as well as Langathel. Important ironworking centers were Kakching Khunou and Kakching.

3.2 Iron smelting at Kakching

Kakching is a small town located in the southern part of the Manipur Valley, situated along the Indo-Myanmar border road (NH 102). It is approximately 45 km south of the state capital, Imphal, and about 70 km from the Indo-Myanmar border. Presently, it is inhabited by a community belonging

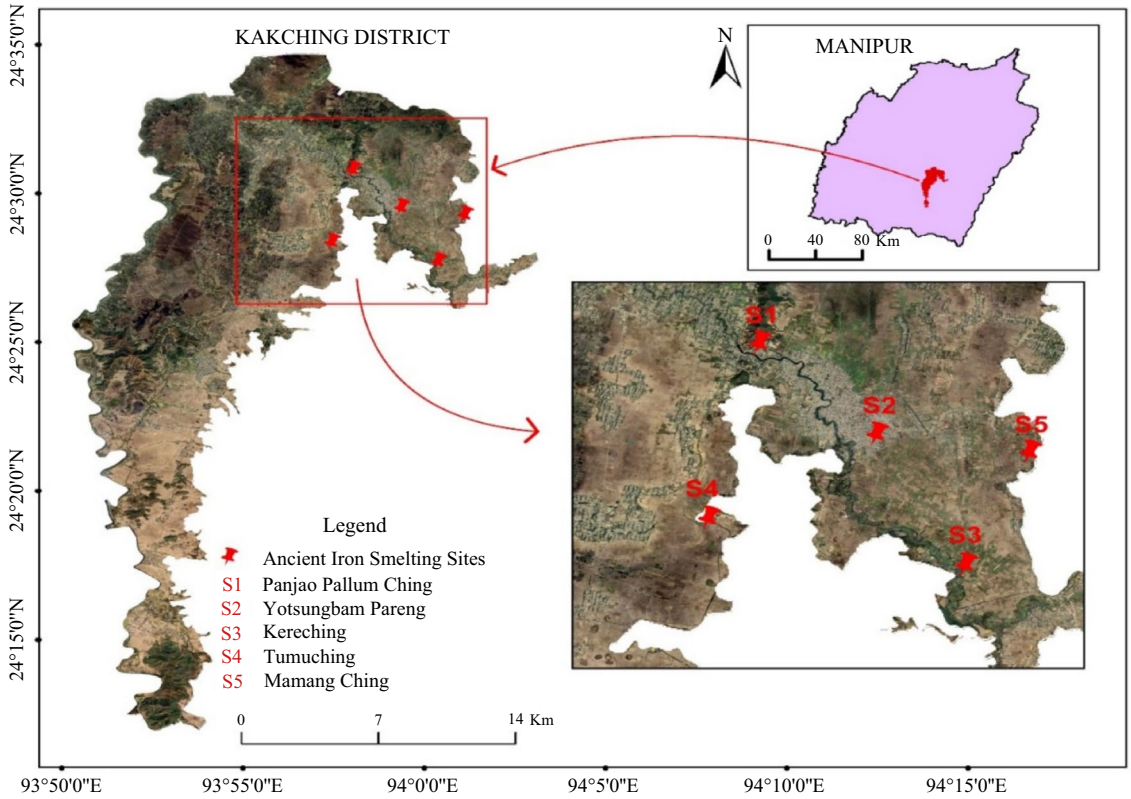


Fig. 1 Ancient Iron Smelting sites, in and around the Kakching Area

to the Lois of Manipur.[2] It is said that the term 'Kakching' was originally the name of a group of people who went from place to place in search of Iron ore during ancient times and ultimately settled at the present location known as Kakching (Sharma, 2007, p. 91) (Pramodini, 61, personal communication, 22nd Sept. 2023). Historically, this group of people is known for their expertise in iron smelting, which has become a part of their cultural heritage and identity. It is further suggested that they were the only suppliers of iron to the ancient kings of Manipur. As a form of tax, every smelter from Kakching had to give two pieces of iron to the king, each measuring 6 inches in length and 2 inches in thickness (Shakespear, 1910, p. 351). This tax was called *Yotkhai* (Kshetri Bira, 74, personal interview, 2022). According to various scholars from Kakching, iron was smelted at a number of sites in and around the Kakching area. (Gourachandra, M. 76, personal communication, 13th May-2021) (Naorem Pramodini Devi, 61, personal communication, 22nd Sept. 2023) (Kshetri Bira, 74, personal communication, 13th April 2022).

They were: (a) Panjaopallum-ching, (24° 30′ 47"N 93° 58′ 01"E) (b) Kere-ching (24° 27′ 42"N 94° 00′ 22"E) (c) Yotshungbam-Pareng (24° 29′ 31"N 93° 59′ 21"E)[3] (d) Tumu-ching (24° 28′ 38"N- 93° 57′ 28"E) (e) Mamang Ching (24° 29′ 15"N 94° 1′ 6"E).[4] The geographical locations of these sites are shown in Fig. 1.

4 The traditional process

Just after *Poinu*, the paddy harvesting season (roughly corresponds to the period between late November and early January in the Meitei Calendar), the people of Kakching got ready for the iron smelting. In fact, it was a lengthy process that required a lot of labour and skills. It was performed in groups, each comprised of three to four persons, led by an elder who was an expert in the craft. This group worked as a team throughout the entire process, from making charcoal

[2] Loi' is a Manipuri term synonymous to the 'Scheduled Caste'. For more information about the Lois, See file:///C:/Users/Naresh/Desktop/journal%20paper/socio%20economic%20of%20lois.pdf.

[3] *Yotsungbam pareng* the name itself means '*locality of iron smelting'*.

[4] During my recently survey at the Mamang-Ching iron smelting site, the authors found an unexcavated mound of Iron slag (Shown in Fig. 2). The locals call it 'Yothipung', meaning 'iron-slag mound'.

Fig. 2 Unexcavated mound of Iron Slag (yot-thi-pung) found at Mamang-Ching, Kakching

to producing iron. Prior to the iron smelting process, a ritual was performed. The smelters prayed to their ancestral god *Khamlangba* with offerings, seeking his blessings for a successful and productive process. Shakespear also expressed,

> All these deposits are under the protection of an Umang Lai, i.e., a forest god named Khumlangba, who must be propitiated before the iron can be worked. When fresh ground has to be broken, a buffalo is sent by the Raja, and this animal is taken to the site of the proposed excavation; and in olden times was slain there, but since the introduction of Hinduism the animal is released and dedicated to Khumlangba, after a few hairs from each fetlock and the end of his tail, and a drop or two of blood from his ear have been offered to the Lai. Khumlangba is credited with the power of causing the iron ore to move about (Shakespear,1910, p. 349).

The whole process of iron smelting can be divided into the following steps.

4.1 Preparation of raw materials

The process of iron smelting began with the preparation of essential raw materials. Iron ore was collected from the nearby fields in the form of clayey earth containing the ore particles. Charcoal, the primary fuel for the smelting process, was also produced locally by the smelters. Water was also crucial for the process, particularly in cleaning the ore. It was collected from any nearby source of water. The preparation of raw materials involved the following processes:

4.1.1 Making charcoal

In fact, making charcoal was a whole different process that required a different set of skills and Knowledge. Usually, it was done before the iron smelting process, so as to keep the charcoal ready for the smelting process. The group just created for iron smelting set out with tools like a Yotpak (spade), Thangchou (a large knife), and Singchang (an axe) for making charcoal. They cut down small trees locally known as *Shayi* and *Uyung* from the nearby forest. After that, a pit was dug on the nearby ground, where they threw the wood and set them on fire. Just before the woods turned to ashes, they covered the whole pit with earth and green leaves. This method allowed them to limit the oxygen supply for the combustion and prevented the wood from completely turning into ashes, leaving behind charcoal. Once the fire was extinguished and the pit was cooled, they dug out the pit and collected the charcoal. The charcoal was then brought to the place where the smelting process was to be done (Fig. 2).

4.1.2 Collection of ores (Nungchak Pekpa)

The iron ore, locally known as '*Nungchak'* was generally collected from the nearby fields. They used items such as a pot, bamboo baskets, a spade, and a long bamboo skewer for this task. At the location where they expected the iron ore, they dug a small pit, approximately 1 ½ feet deep. Inside the

pit, a specially made bamboo skewer called *'Nungthinchei'* was thrusted deeply into the ground and poured a small amount of water into the hole just created by the skewer (Gourachandra, 2002, p. 41). After that, the skewer was moved up and down repeatedly. Then by skillfully hearing the sound and feeling the vibration through the skewer, they could detect the presence of iron ore beneath the ground. Once the presence of the ore deposit was confirmed, they excavated the earth from the area and left it under the sunlight to dry. It is said that the ores generally occured in two layers, i.e., *Leithak*, the upper layer, where the ore was found mixed with blackish Clay (Sample from this layer is shown in Fig. 3) and *Leikha*, the lower layer, where the ore was found mixed with reddish clay (Sample from this layer is shown in Fig. 3). It is also said that better-quality deposits were found in the lower layer (Gourachandra, 1997, p. 3).

4.1.3 Cleaning of the ore (Nunchak kaoba)

This process was done to wash out the unwanted impurities from the clayey ore. A pit measuring roughly 4 feet in diameter and 2 ½ feet in depth, with the base gradually sloped towards the centre, was made near the excavation site and filled with water. The collected earth was then thrown into the water and left to soak overnight. The next day, the soaked earth was repeatedly trodden underfoot to further break it down. Then by pouring more and more water into the pit, the muddy water from the top was flowed out until the ore was cleaned, leaving the heavier ore particles at the bottom. It is said that the earth collected from *Leithak* (upper layer) and the *Leikha* (lower layer) were washed separately (Gourachandra, 1997, p. 18). The cleaned ore was then collected and transported to the place where the smelting was to be carried out. Another interesting fact is that the reddish water left from washing the *Leikha* was used for dyeing white cloths. The cloth dyed with this water was called *Leingang Sangba Phee* (Gourachandra, 1997, p. 18).

4.1.4 Burning of the ore

This process was required to completely extract moisture from the ore. For this process, a piece of ground was smoothed and plastered with cow dung and mud. The iron ore was then placed on the ground in layers, alternating with a layer of straws between each layers. Once the layering was complete, the entire heap was burnt altogether and left untouched for a night. In the next morning, the burnt ore particles were separated from the ashes by method of hand-picking and winnowing (Fig. 4).

Fig. 4 Reddish Clay sample, collected from Lamdong, near the Yotshungbam-Pareng Iron Smelting site

Fig. 3 Blackish Clay sample, collected from a field near the Mamnang-Ching iron smelting site

Fig. 5 Two women pounding iron ore with wooden pounders. (Photo source: Gourachandra, 2002, p. 57)

4.1.5 Powdering of ore (Nungchak Suba)

The separated iron ore was then pounded by using a large wooden pounder to break it into very smaller particles, turning the ore into a fine powder. According to Kulchandra, this powdering of the iron ore enabled it to be melted at a significantly lower temperature than its actual melting point of 1,538 °C (Sharma, 2007, p. 149). Once adequately powdered, the ore was collected in wooden baskets and kept ready for the smelting process. Interestingly, these works of separating and powdering are said to be generally done by the women folk of the community (Fig. 5).

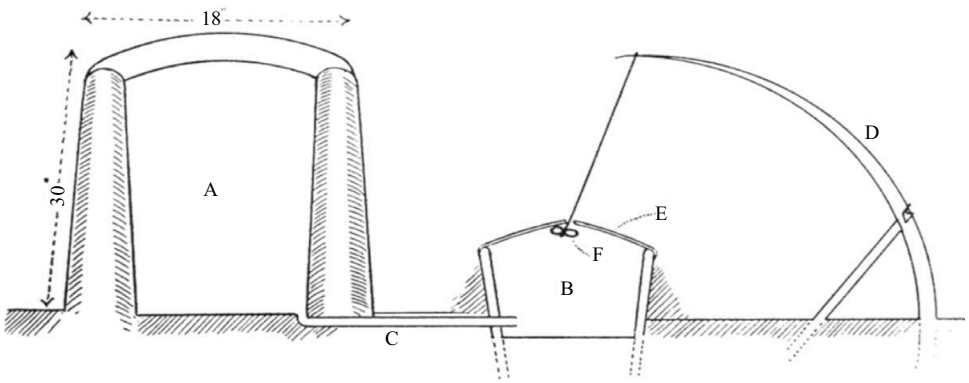
4.2 Construction of the furnace

The people of Kakching used earthen furnaces for the iron smelting process. However, their uniqueness lies in the mechanism used for the construction of bellows. The furnace was an earthen cylinder of approximately 3 ½ feet in height. It was built with clay and dried under the sun for about 4–5 days. At its base, there were two holes of different sizes and opposite to each other. The larger one served as the outlet, while the smaller one was connected to the bellows through a pair of bamboo tuyeres. The bellows consisted of two hollow wooden cylinders fixed on the ground beside of the smaller hole of the furnace. They were covered with buffalo hides and securely bound around the rims. In the center of each cover, a hole was made through which a piece of cord with a toggle was attached. The other end of each cord was tied to a stick that was partially buried in the ground and bent over. It acted as a spring system, keeping the cover always raised to its utmost. This mechanism transformed the two wooden cylinders into a pair of bellows, from which air was be blown into the furnace with pressure through the tuyeres. This airflow supplied more oxygen to the furnace and enabled the smelters to maintain the high temperature combustion required for smelting iron. Illustrations of the furnace are shown in Figs. 6 and 7.

4.3 Smelting

The process began by placing live charcoals at the centre of the furnace and covering them completely with fresh charcoal. The bellowsman operated the bellows by standing on the two cylinders, placing one foot over each cover. Using a crossbar for support, he alternately raised and lowered his feet in a rhythmic motion, continuously (Figs. 8, 9 & 10). As he raised each foot, the cover was also raised by the spring system, allowing air to enter the cylinder through the hole in the cover. When the foot descended, the trapped air inside the cylinder was forced into the furnace through the bamboo tubes (tuyeres). This forced airflow increased the supply of oxygen to the furnace, thereby significantly raising its internal temperature. Meanwhile, the feeders alternately fed the ore powder and the charcoal into the furnace. Through this process, the impurities in the ore were burnt away, while the molten iron was collected at the base of the

Fig. 7 A replica of the Iron-smelting Furnace at the Peoples' Museum, Kakching



A = Furnace.
There are two cylinders, B, each with a separate tube C, and spring D.
E = Leather cover. F = Toggle.

Fig. 6 An outline of the furnace and the bellows. *Source*: Shakeaspear, J. 1910, p. 350

Fig. 8 A bellowsmen operating the bellows during an iron smelting process at Kakching. (Photo source: Gourachandra, 2002, p. 55)

Fig. 9 Mayanglambam Gourachandra, illustrating the traditional process of Iron smelting. (Photo Source: Peoples' Museum, Kakching.)

furnace along with its slag. In this way, the iron smelters of Kakching successfully extracted iron from their ores using traditional tools and techniques.

5 Theories of origin

Regarding the origin of iron smelting knowledge possessed by the iron smelters of Kakching, the most popular theory is that the Kakching people, who were originally iron smelters, went from place to place in search of iron ore deposits,

Fig. 10 An illustration of the traditional process of Iron smelting. (Photo Source: Peoples' Museum, Kakching.)

eventually settled in their present location, and introduced iron smelting there. J. Shakespear in his note states,

> The people claim that their ancestors came from Cachar, from which their most important clan's name, Meyanglangbam, derives; Meyang denoting a foreigner from Cachar. The story runs that the ancestors of the Meyanglangbam and Khettrimayum clan were one day walking near Thobal, and noticed some earth thrown out of a bamboo rat's burrow, which resembled that in which iron was found in Cachar, so they gathered it and on their way home they met the Raja, who asked what they were carrying, and, being told, ordered them to experiment and report the result. Eventually, the community, numbering then only five or six households, was settled near the spot where the ore was found and subsequently moved to their present locations, where the ore deposits are more extensive (Shakespear, 1910, p. 351).

This assertion not only supports the theory but also points to the origin of this knowledge in Cachar (present-day Assam), located on the western side of the kingdom. Another historical connection with the western side of the kingdom is found in the legend of Khamlangba, according to which he once went to Takhel (present-day Tripura) in search of iron ore and even married a Takhel Lady (Gourachandra, 2002, p. 9). And to determine the time of the first settlement of this community at the present location, the text 'Meitrabakki Puwarida Kakching' suggests that the community came to the present location from their previous settlement in the Thoubal area (25 kms to the north) in 1740 CE during the reign of Gharibniwaz, also known as Pamheiba (Gourachandra, 2002, p. 5). However, recent archaeological findings challenge this theory and the timeline. In 2008, M.R. Sheikh and his team excavated an ancient iron smelting site called Tamu-Ching, a small hillock

located at the outskirts of Kakching. There, they discovered large lumps of iron slag, which are clear evidence of early metallurgical activity in the area. To determine the age of the slag, Thermoluminescence dating was conducted on the baked sediment which were found attached to the slag. And, it was dated to the 4th Century CE (Sheikh & et al., 2010), which is significantly earlier than the settlement of the Kakching community mentioned above. Another interesting fact is that the name of this iron-smelting site, 'Tumu Ching' or 'Tumu Hill', closely resembles the name of a town called 'Tamu' in the Sagaing Region of northwestern Myanmar, near the Indo-Myanmar border, which is locally known to the people of Manipur as "Tumu". Moreover, when Sheikh asked the watchman of the area about name of the hillock. The watchman replied,

> The place has remained covered with such slag, which they called 'Yothi', since time immemorial. The hillock was known as Tumuching simply because the people from Tumu, now in Myanmar, crossed the series of mountain ranges in search of iron ores and settled there to work on iron smelting (Sheikh & et al., 2012).

Similar information was provided by an elderly person from Laimanai, a nearby village (Heikrujam Ibobi, 86, Personal Communication, March 8, 2025). The slag found at the site was further characterized using advanced techniques, including X-ray diffraction (XRD), X-ray fluorescence (XRF), Optical microscopy, Fourier transform infrared (FTIR) spectroscopy, Differential Thermal Analysis (DTA), and Scanning Electron Microscopy (SEM). The phosphorus content in the iron slag of Tumu Ching (Kakching) was also found to be higher compared to the conventional iron produced in other parts of India (Sheik, 2013, p. 124). These discoveries and assertions not only contradict the prevailing assumptions about the historical timeline of iron metallurgical practices in the area but also suggest the possibility that people from the eastern side of the kingdom, i.e., Myanmar, may have traveled to the area to smelt iron. This new concept also aligns with Kulachandra's claim that the use of iron (Cast iron) was diffused to Manipur from China through Myanmar (Sharma, 2007, p. 49).

On the other hand, due to the existence of iron smelting sites in the area, besides Tumu-Ching, and the fact that Kakching is presently inhabited by people with different surnames/clans other than Mayanglambam and Kshetrimayum, the possibility of the indigenous origin of this expertise cannot be denied. In fact, the historical background of the Kakching community is still needs to be studied.

But, considering the significance of all these assertions and information, none of the different aspects can be overlooked while studying the origins of the knowledge of iron metallurgy possessed by the Kakching people. Therefore, the only possible conclusion that can be drawn from these findings is that, due to its richness in Iron ore, Kakching was an iron smelting hub in ancient times, where people from different directions and places came to the region and smelted iron at various points in time, as early as the fourth century CE. And that is how iron smelting, ultimately, became a cultural heritage of the Kakching people.

6 Conclusion

The study of traditional iron metallurgy in Northeast India, with a specific focus on Manipur, reveals a fascinating blend of technological ingenuity and cultural heritage. After a critical analysis of all the different types of information gathered from Oral traditions, Archaeological and literary sources, it becomes evident that the people of the ancient kingdom of Manipur, which is a part of the North-East India, possessed the knowledge of iron working by the 1st Century CE, during the reign of Nongda Lairen Pakhangba who is known as the founder of the Ningthouja Dynasty. Ebudhou Khamlangba, who is referred to as the god of iron smelting and its associated works, was also a contemporary of Nongda Lairen Pakhangba. Further analysis has revealed that Iron smelting, which requires a level of technological expertise, was practiced at different sites in and around Kakching during the 4th Century CE. Kakching is situated in the southern part of the Manipur Valley, approximately 45 km from the state capital, Imphal. The practice of iron smelting became an integral part of the cultural traditions of the Kakching people. They supplied iron to the kings of Manipur as a form of tax called '*Yotkhai*'. However, regarding the origins of this metallurgical knowledge, different pieces of information point in different directions – ranging from indigenous development to possible influences from neighboring regions, such as Myanmar, Assam, and Tripura. Therefore, the only conclusion that can be drawn is that, due to its richness in iron ore, people from different directions came to the Kakching area at various periods and smelted iron as early as the fourth century CE. Over time, the area evolved into an iron smelting hub, ultimately integrating iron smelting into the cultural heritage of the region's people.

For a more precise understanding of the emergence of iron use and its metallurgy, not only in Manipur but throughout North East India as a whole, further ethnographic studies combined with systematic archaeological investigations of the iron smelting sites in the region are necessary. A comparative analysis of the findings with evidence from other parts of India and Myanmar should complement these studies. Such an integrated study will not only provide deeper insights into the development and diffusion of

ironworking technologies in North-East India but will also contribute to the broader narrative of technological exchange and innovation in ancient South and Southeast Asia.

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Data availability All data utilized in this study are included within the article and all the sources are clearly cited in the references.

Declarations

Conflict of interest The authors declare that there is no conflict of interest.

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