
Towards a Broader Understanding of the Emergence of Iron Technology in Prehistoric Arctic Fennoscandia

Carina Bennerhag, Sara Hagström Yamamoto &
Kristina Söderholm 

The article critically examines interpretations of Old World ferrous metallurgical developments with reference to their consequences for Arctic Fennoscandian iron research. The traditional paradigm of technological innovations recurrently links the emergence of iron technology to increasing social complexity and a sedentary agricultural lifestyle, typically downplaying 'peripheral' areas such as Arctic Fennoscandia and its hunter-gatherer communities. Even in postcolonial research of recent years, the archaeometallurgical record of Arctic Fennoscandia is interpreted and organized within the traditional frameworks on the time, course, and cultural context of the introduction of iron technology in Europe, where Arctic Fennoscandia is not considered to have any noteworthy role. However, current archaeological research with new data in Arctic Fennoscandia disputes prevailing ideas in European iron research and shows substantial evidence that iron technology was an integrated part of hunter-gatherer subsistence already during the Early Iron Age (c. 200 BC). Archaeometallurgical analyses reveal advanced knowledge in all the operational sequences of iron technology, including bloomery steel production and the mastering of advanced smithing techniques. Therefore, we urge dispensing with traditional ideas and call for an increased interest in the underlying mechanisms for the transfer of iron.

Introduction

Current archaeological research with new data disputes prevailing ideas in European iron research and shows substantial evidence of elaborate craftsmanship, including bloomery steel production and the mastering of advanced smithing techniques, as an integrated part of the Arctic Fennoscandian hunter-gatherer subsistence already during the Early Iron Age (c. 200 BC) (Bennerhag *et al.* 2021). The emergence and dispersal of iron technology is a long-term theme in socio-evolutionary views and a hallmark of European industrialization and civilization, with emergence being closely connected to social complexity and significant economic change, i.e. typically farming societies and a sedentary lifestyle. These

views marginalize the use of iron in hunter-gatherer communities and make the advanced production of steel in such societies a highly unlikely phenomenon. The main purpose of this article is to shed light on the far-reaching and constraining influence of long-standing diffusionist and evolutionist views in European iron research on investigation of Arctic Fennoscandia and its prehistoric hunter-gatherer communities. This is manifested partly in a sharp (both temporal and spatial) under-estimation of the role of iron in hunter-gatherer societies of the region, even in recent iron research, and partly in the fact that a rather extensive range of prehistoric iron finds in the area (including iron-production sites) are largely unanalysed. Overall, although there is literature dealing with aspects of the introduction of iron to the

region, there is little that can contribute to a greater understanding of the findings of elaborate craftsmanship during the Early Iron Age.

It is a global phenomenon that archaeological finds in more peripheral areas of nations/regions/continents are under-researched (Killick & Fenn 2012; White & Hamilton 2018). At the same time, these same areas often strive for restoration in the literature on prehistoric societies defined as less stratified or highly mobile, which makes it urgent to reframe old narratives and explanatory models in new ways. We live and work geographically as researchers in such an area. Here the indigenous Sámi, and also other minorities, live alongside a Swedish majority and strive to formulate a long-neglected past, where our archaeological finds automatically have acquired a highly topical ethno-political value.

Influenced by a new direction in archaeological research (metals as well as other archaeological materials) drawing on innovative theories of transmission (Damm 2012; Jordan & Zvelebil 2009; Skandfer 2009) and an analytically integrated *chaîne opératoire* approach (Roux 2019; White & Hamilton 2018), we have come to a realization of the great possibilities offered by archeometric analyses for the understanding of the underlying mechanisms for the transfer of iron, to move beyond arrows on maps and simplistic explanations of diffusion and trade (Roberts 2009). Discussions of paradigms, methods and theories are needed for assessment of the significance and meaning of the finds in a contemporary framework. This is how we can make inferences about the rather weakly researched prehistoric Arctic Fennoscandian hunter-gatherer communities and their involvement in the introduction of iron.

In what follows, we will present the new findings and the long-standing views in European iron research. Thereafter we go in depth into Arctic Fennoscandian iron research with focus on the far-reaching influences of long-standing diffusionist and evolutionist theories in European iron research on this literature, and how it fails to explain our new findings. Finally, in the Discussion and conclusions of the article, the most important restraining influences are summarized, and we will further exemplify how, through archeometric analyses of our finds, we can reach a more comprehensive understanding of the human dynamics involved in the emergence of iron in prehistoric Arctic Fennoscandia.

New findings

Between 2010 and 2019, archaeological excavations were carried out by the research group behind this

article in coastal (Sangis site) and inland (Vivungi site) areas of northernmost Sweden—about 200 kilometres apart, as the crow flies—resulting in finds of a breakthrough character including both prehistoric iron-smelting sites (containing features of shaft furnaces, reduction slag, technical ceramics and iron waste) and a smithing site (with residues from primary and secondary smithing, iron waste and iron objects). Radiocarbon analyses at both sites place the production of iron and manufacturing of objects around 200 BC–AD 100 (Bennerhag *et al.* 2021).

Notable are the characteristics of similar technological traits between the sites, where archaeometric analyses show a rather consistent picture of the technological system across the area. Numerous finds of iron waste from the smelting process consisting of iron with high levels of carbon indicate the preference for high-quality steel and even production of cast iron. This reflects the mastering of successful smelting processes, including high-temperature operations and extensive knowledge of the refractory properties of clays (as one of the most critical passages while allowing high temperatures is to maintain structural stability of the furnace shaft throughout the process). Also indicated through analysis is the usage and preference of manganese rich ores, facilitating the absorption of carbon into the iron. This suggests the deliberate grading of ores and specialized knowledge of their different properties. The smelters' acquaintance with a variety of raw materials, including their possibilities and limitations, is further evident through observed differences in curation strategies between the furnaces at the two sites, demonstrating the handling of a rather difficult raw material situation of suitable clays.

The deliberate production of different steel qualities is confirmed from numerous steel objects (knives and an axe) found at the Sangis smithing site, showing several different steel alloys and combinations thereof, suitable for hard and tough edges to be produced. Phosphoric iron with a higher ductility than carbon steel was also used, as well as soft ferritic iron. The forged artefacts show advanced craftsmanship, including skills in forge welding of composite constructions and techniques of altering the properties of the iron (i.e. heat treatments in several steps), traditionally associated with the Roman Empire in the first century BC (Pleiner 2000; 2006). Overall, the findings show the hunter-gatherer smiths already at this early stage had thorough knowledge about the properties of each alloy, and which materials were suitable for different products.

Regarding the organization of iron production and the manufacture of iron products, variations in

the chemical analyses of slag inclusions in iron waste and objects suggest the Sangis smithing site was supplied with various types of iron originating from different iron-smelting systems, based, however, on ores from the same geological area. This in turn suggests a workshop-based system featured by several shaft furnaces operating simultaneously in the nearby area, supplying the smithing site (the centre of the distribution chain) with various types of iron. Several aligned shaft furnaces can be discerned also at the Vivungi site, where at least two furnaces were operating simultaneously (including several indications of additional but not yet further investigated furnaces).

Considering economy and scale of production, analyses show each furnace was run several times. Productivity in iron production has not previously been calculated in terms of hunter-gatherer economies; however, based on the estimated consumption of a Late Iron Age farm (2–5 kg/year) (Hjärthner-Holdar *et al.* 2018), the scale of production at each furnace (ranging from 9 to 80 kg iron) would have exceeded the consumption of a single household, even if spread over several years. Overall, this shows iron technology most likely was a community undertaking, and further, as important to hunter-gatherer societies as to more sedentary and agriculturally based societies (Bennerhag *et al.* 2021).

Long-standing views in European iron research

Understanding the origin of iron technology and its subsequent dispersal through time and space is a key theme in European iron research. Over time, two basic models have formed the core of discussions, i.e. the idea of a single centre of invention (from which iron diffused to the rest of the world) and of multiple centres of independent invention (for a review, see Killick & Fenn 2012). In the single invention model, the origin of iron technology is placed in the Near East in the second millennium BC (according to the earliest dated iron objects and written evidence), from where it is assumed to have spread by different routes to central and eastern Europe (Bebermeier *et al.* 2016; Pleiner 2000; Zavyalov & Terekhova 2018), Africa (Killick 2009) and eventually northern Europe and the New World (Buchwald 2005; Charlton *et al.* 2010). The long-lived notions of V. Gordon Childe (1944) have had a profound impact in viewing the Near East as the primary centre of important inventions.

The diffusion of iron constitutes an essential element in central narratives of the civilization and industrialization processes of the west (Engels 1972;

Pleiner 2000; 2006; Wertime & Muhly 1980), with succeeding civilizations in time and space (Rudebeck 2000). In European iron research, and with persistent and massive referencing typically to Childe (1944), the Near East, Greece, and the Roman Empire are considered drivers of technological change, providing 'less advanced' peripheral cultural groups with social and technological advances in a one-directional way.

Pleiner (2000; 2006) has been extremely influential in the history of European iron technology, typically narrated from a viewpoint of a Roman centre with the *limes* as the 'iron curtain' working as a cultural filter dividing the inner and outer Roman world. From this viewpoint, some skills, such as producing high-quality steel and advanced forging, are considered extremely rare outside the *limes*. Roman large-scale production is further the non-questioned point of departure for all other production. Although it has been pointed out that the strongly Romano-centric perspective contributes a general methodological and analytical neglect of iron remains found outside the Roman centre due to preconceived notions about low production levels (Rijk & Joosten 2014) and low quality (Godfrey & van Nie 2004), early finds of steel and high-quality objects are continuously interpreted as imported objects, accidental products or questioned as too old due to radiocarbon dating contamination effects (e.g. Bebermeier *et al.* 2016; Gassmann & Schäfer 2018; Pleiner 2006). These views are further accentuated in relation to metallurgical remains in societies considered as of low complexity and peripheral (such as nomads, pastoralists and hunter-gatherers), where early prehistoric metals typically are regarded as anomalies (considered as imports) and continuously dismissed in iron research (Alpern 2005; Dyakonov *et al.* 2019; Janz & Conolly 2019; Jørgensen 2011).

In this sense, the discourse structure of European iron research has been tightly packaged with nineteenth-century social-evolutionary frameworks with general schemes of technological progress as markers of social and economic change (Morgan 1877). Routinely, connections are made between knowledge of metallurgy and modes of subsistence, with iron technology predominantly linked to farming societies with a sedentary lifestyle, and hunter-gatherer/pastoralist societies considered incapable of mastering the production of metals from raw materials, although few studies overall have been conducted in this regard.

The socio-evolutionary ideas are not least firmly established within the conventional Three-Age

system (Thomsen 1848), with the notion of one material technology unilaterally replacing the other in connection to human evolution from savage to barbarian and civilized (Morgan 1877). Even though this has met criticism (e.g. Kanjanajuntorn 2020), it is still influential in metallurgical research (see, for example, recent research on the abandonment of metal tools by North American hunter-gatherers) (Bebber *et al.* 2021). Hence, there is a non-questionable departure in much of the literature that iron technology is guided by a pre-existing understanding and knowledge of bronze and copper (see recently Eliyahu-Behar *et al.* 2013). It is further common in historical overviews on metallurgical developments to emphasize the progressive and linear view in terms of an ‘increased importance’ of iron, ‘higher proficiency’ and ‘larger production levels’, over time leading to the ‘True’ or ‘Fully-fledged’ Iron Age, and ultimately to industrialized society. Progression is considered a later phenomenon in the periphery and is in its initial phase often referred to as small-scale and experimental, and typically contrasted to the ‘True’ Iron Age (Karlsson & Magnusson 2020; Pleiner 2000; Wertime 1973).

Even though some researchers claim these views are long abandoned (Erb-Satullo 2019; Killick & Fenn 2012), we maintain that described civilization narratives, evolutionist and diffusionist theories and dichotomic discourse structures (Diaz-Andreau & Champion 1996) have become naturalized knowledge and are regenerated even within new perspectives. This is exemplified, not least, in the fact that although evidence has emerged that the actual smelting of iron in the Near East is dated to the first millennium BC (Veldhuijzen & Rehren 2007), which is contemporary with the oldest known evidence of iron smelting in Scandinavia (central Sweden) (Hjärthner-Holdar 1993), several researchers within European iron research consider the Scandinavian datings highly problematic, and do not acknowledge the finds, since they do not fit the traditional diffusion framework (see e.g. Bebermeier *et al.* 2016 and references therein; Gassman & Schäfer 2018).

Similar dismissive attitudes (Alpern 2005) have been applied also towards alternative perspectives that grew out of post-colonial theories and new scientific techniques since the 1960s of multiple (*versus* single) centres of invention (for a review, see Killick & Fenn 2012). Hence, through radiocarbon dating and general archeometallurgical development enabling more detailed, systematic, or contextual archaeological research, interest has been directed towards an understanding of local societies and regions,

identities, agencies and individuals in prehistory (Layton 1994; Smith & Wobst 2005), such as towards local (Mirau 1997; Renzi *et al.* 2013; Veldhuijzen & Rehren 2007), independent (Renfrew 1969; Wertime & Muhly 1980) and indigenous (Higham 2004; Kuusela *et al.* 2018; Ramqvist 2007; Renzi *et al.* 2013; Wertime & Muhly 1980; Yahalom-Mack & Eliyahu-Behar 2015; Zangato & Holl 2010) invention. These (more or less) new perspectives consider iron innovation from the perspective of individual subregions and often—as post-colonial counter-reactions to the top-down discourse structures on evidence of iron technology in societies defined as less stratified or highly mobile—extend the analysis to ‘non-complex’ societies. Although this has been a global trend in archeological research over the last decades (covering Africa and Eurasia and, as we will see below, Arctic Fennoscandia), it has not had any profound impact within central or north European iron research. Overall, the alternative perspectives have had greater impact in Bronze Age (rather than Iron Age) metallurgical research (White & Hamilton 2018).

Unfortunately, and as we will develop further below considering counter-reactive literature to the tenacious downgrading of iron technology in Arctic Fennoscandia, the overall orientation towards identities and ethnic groups in prehistory really only means a change of focus in the objects of discourse, from ‘civilizations’ to other delimited objects. Archaeologists continuously typically classify archaeological remains of iron technology according to the ‘cultural context’ in which they are found, and hence with a tendency to marginalize important aspects of actors, knowledge and activities in the complex processes of iron technology. In what follows, we will go in depth into how the older framework still features the scientific literature of northern Fennoscandian iron history. Hence, only through insight into how traditional ideas on the origin and adoption of technological innovations still recur in much of the literature on iron history can we develop explanatory models in more balanced ways.

Iron research in Arctic Fennoscandia

Ancient Arctic Fennoscandia and its hunter-gatherer communities is considered peripheral in much European archaeological research, and the region’s active phase in iron technology is considered established much later than elsewhere in Europe. Arctic Fennoscandia is geographically vast, and although it is highly unexplored archaeologically, it is a fact that since the middle of the twentieth century,

archaeologists have come across quite a lot of iron finds, and since the 1980s, also several (largely neglected) iron-production sites (Forsberg 2012; Jørgensen 2010; Kotivuori 2013).

Relatively extensive archaeological surveys and excavations were carried out in Arctic Fennoscandia in the 1940s to 1980s due to hydropower expansion and connected lake regulations, which in turn yielded large amounts of metallurgical remains in prehistoric hunter-gatherer contexts from various steps in the production and processing of iron, including slag, technical ceramics and metal objects (Forsberg 2012). Still, due to a general perception of a 'delayed stone age' (Loeffler 2005) alongside a general neglect of available analytical tools (such as radiocarbon dating), the metallurgical remains were heavily overlooked. Slag residues from iron working especially have been consistently neglected in Arctic Fennoscandian archaeological research as they have been considered waste material with limited chronological information.

The perception of a 'delayed stone age' is strongly related to the tenacious evolutionary ideas inherent in both the dichotomy of hunter-gatherers *versus* farmers and the succession of stone-bronze-iron. Hence, as a general lack of stratigraphies on the multi-strata sites in Arctic Fennoscandia makes chronological systematization of the metallurgical record problematic—especially with a parallel general neglect of radiocarbon dating—the presence of iron in the same contexts as typical Stone Age finds (knapped lithics, scrapers, points of stone and pottery) has simply been interpreted as evidence of unfulfilled stages of development. Overall, despite abundant archaeological evidence indicating a widespread knowledge and practice of iron, tenacious social-evolutionary views have long resulted (and still do) in a general dismissal/tendentious and limited selection of metallurgical finds in early hunter-gatherer contexts. Archaeologists have instead typically focused solely on chronologically significant artefacts from later periods (e.g. Hakamäki & Kuusela 2013; Henriksen 2019; Semning 1960; Zachrisson 1976).

Northern metals, industrialization and the creation of nation states

The exclusion of the Arctic area and the hunter-gatherer communities in the narrative of ferrous metallurgical developments should partly be understood in the light of the general importance given to metals and metal technology in the civilization process and creation of the nation states in Sweden, Finland, and Norway (not least in Sweden; see

Hagström Yamamoto 2010). Metal handling and the extraction of metals (which generally takes place right in the Arctic parts of these countries) were already at an early stage of central importance for the nations' economies and politics and overall nation-building. In line with this, the Swedish state recurrently, at least until the middle of the twentieth century, identified Arctic Sweden as an area in need of modernization, civilization or 'Swedishization', for defence-policy, nationalist and/or economic reasons. Iron and iron technology formed the basis for industrialization, where industrial society finally, after a long time and through southern immigration (first of farmers and later of miners), made the Arctic part of the country 'civilized'. In relation to the grand industrial narrative of the region, the indigenous Sámi population of the area was often treated as a timeless 'Other' (Hagström Yamamoto 2010; Ojala 2009; Ojala & Ojala 2020). In recent publications (Karlsson & Magnusson 2020), iron production in terms of the establishment of the mining industry in the seventeenth–eighteenth centuries is still highlighted as *the* process creating preconditions for the building of societies in Scandinavia. Early iron technology by hunter-gatherers is totally at odds with this narrative.

Explanatory frameworks of the emergence of iron technology in Arctic Fennoscandia

Three explanatory frameworks emerge in the literature on prehistoric iron technology in Arctic Fennoscandia: (1) a *migrationist view* which is partly connected to the economic and political expansion of the Nordic society during Late Iron Age/Early Middle Ages (Magnusson 1987; Stenvik 2003), partly to the establishment of a considered full-scale knowledge in iron production (equated with large-scale production and considered as the true Iron Age/industrial stage in the developmental scheme of Pleiner 2000) in the seventeenth–eighteenth centuries (Norberg 1958); (2) A *diffusionist view* based on trade-network mechanisms and center-periphery relations with eastern and southern agricultural societies during the Late Bronze Age/Early Iron Age (see a review in Forsberg 2012). The initial iron phase (Late Bronze Age/Early Iron Age) is overall considered to have had little impact on Arctic Fennoscandian society compared to the fully fledged industrial phase; (3) a *localizationist view* (Amzallag 2009), where the emergence of iron technology in Arctic Fennoscandia since the 1980s is explained also from partly new perspectives in postcolonial, ethno-political and revitalizing archaeological

research focusing on local power strategies/individual agency and ethnicity. Below is first a presentation of the migrationist, diffusionist and localizationist views, followed by an analysis of the implications of long-standing European views on Arctic Fennoscandian iron history, in particular related to our new findings.

The migrationist view

The emergence of iron production in Arctic Fennoscandia is typically regarded a late phenomenon, much later than elsewhere in central and northern Europe. During the Migration period (AD 400–500), a first industrial-like large-scale production connected to a Nordic economic and political expansion and colonization is considered to be represented in the southern part of Sweden's widely spread Norrlandic area (in mid-Sweden, Jämtland, and in mid-Norway, Trøndelag) (Magnusson 1987; Stenvik 2003). In the peripheral areas of northernmost Arctic Sweden, the knowledge to make iron and steel is not considered to have begun until the seventeenth and eighteenth centuries, with the establishment of the mining industry (Hansson 1987). Both explanations are based on migration/colonization; during the early phase of Nordic expansion of agrarian societies from the south, and during the later phase of migrating miners from the south (Hansson 1987; Magnusson 1987; Norberg 1958). Early archaeological research in Arctic Fennoscandia long maintained the migrationist (from the south) view alone—clearly in line with the highly influential developmental schemes of Childe (1944), explaining the spread of metals through migrating metallurgists.

The diffusionist view

During the second half of the twentieth century, the migrationist view was supplemented by the diffusionist view, where some stray finds of metal contributed to the perception that Arctic Fennoscandia nevertheless experienced an initial phase (Late Bronze Age/Early Iron Age) of iron technology through diffusion of iron objects (in the early phase) and technological knowledge (later) that spread from one culture to another via trade. The dispersal of iron as a gradual process in several stages based on the mere exposure of iron is indeed a typical description in iron research. The early phase of iron technology is generally considered manifested by a single find (considered imported) of curved iron daggers in Finnish Lapland with Scythian appearance, typologically dated to 700–600 BC (Erä-Esko 1969; Kotivuori 2013). Iron fragments and horn/bone implements with rusty marks (fishing

hooks, knife handles) found in northern Norway and dated (stratigraphically) to c. 780–420 BC, have in turn been taken as evidence for early use of iron, starting already during the Late Bronze Age (Sundquist 1999). Early finds of iron working, such as slags, are overall interpreted as evidence of a certain knowledge in forging reaching the area during the Early Iron Age. With finds of iron-production sites from the 1980s onwards, some small-scale iron production has been acknowledged, however with the assumption that the main need for iron was still met by imports from outside. Finds of slag and iron-production sites are still overall unexplored (Forsberg 2012). Neither has the question *how* knowledge of forging and production reached Arctic Fennoscandia been further investigated.

Based on the distribution of certain types of archaeological material (such as stylistically assigned metal artefacts and different ceramic types), there is a strong tradition of considering Arctic Fennoscandia as long-term exposed to cultural elements from eastern and western cultural spheres (see e.g. Kuusela 2020 and references therein)—and the spread of iron is no exception. Current explanations look either east to hierarchical societies in the Volga-Kama area near the Ural Mountains in present-day Russia, or south to agropastoralist Nordic societies in southern Scandinavia. The eastern outlook has been attested for societies in the inland areas and northernmost parts of Arctic Sweden, Norway and Finland, while the southern outlook has been a more prevalent explanation for coastal areas (especially the north Norwegian coast).

Researchers persistently emphasize eastern influence on the region, initially during the Stone Age (about 5000 BC), when the first metals reached Arctic Fennoscandia (Nordqvist & Herva 2013), and later through Seima Turbino (about 2000–1000 BC) and the Ananino culture (about 800–200 BC), where iron eventually was yet another (inevitable) feature in the long-term stream of eastern impulses (Forsberg 2012; Ojala & Ojala 2020). Several scholars point to the Ananino culture of the Volga-Kama region in Russia as an area from where impulses of iron to Arctic Fennoscandia originated, manifested by stylistic interpretations of finds of certain types of asbestos ceramics and copper-based finds of eastern origin found at hunter-gatherer sites in the same contexts as iron (Hansen & Olsen 2014; Hood & Olsen 1988; Ramqvist 2007).

The eastern connection is considered confirmed also by the so-called stone frame furnaces for iron production found in eastern and northern Finland (Kotivuori 2013; Lavento 1999; Peets 2003), and Russian Karelia (Kosmenko & Manjuhin 1999),

dated to 300 BC–AD 1500. These types of furnaces have been found also in central Sweden, radiocarbon dated to the Late Bronze Age (Hjärthner-Holdar 1993), and in recent years (through our own research) also in northernmost Sweden (Bennerhag *et al.* 2021). Typologically (based on the rectangular stone frame feature), these furnaces are considered to lack analogies with the European shaft furnace tradition and are therefore considered to constitute an eastern type (Kotivuori 2013; Lavento 1999; Peets 2003), although no analogies have been demonstrated with iron-production furnaces further east than Karelia (Kosmenko & Manjuhin 1999). The westernmost finds of these furnaces further predate the eastern finds (highlighted by Kotivuori 2013). This anteriority of the western finds, seemingly suggesting a punctuated diffusion, has not been problematized further in north Fennoscandian archaeological research, except for a few remarks related to ceramic research (Jørgensen & Olsen 1987).

When it comes to the southern explanation, contact networks with agropastoralist (typically referred as Germanic) societies in southern Scandinavia are considered crucial to the emergence of iron technology in the coastal areas (predominantly along the north Norwegian coast). As in the eastern explanation, this connection is based solely on stylistic assignments of a ceramic type—Risvik-type, found in the same contexts as iron-working remains (slag and furnace remains dated to about 400–200 BC)—and not the metallurgical material itself (Jørgensen 2010). The ceramic type is overall considered to define the affinity of the hunter-gatherer groups along the coastal area with southern Germanic/Nordic agropastoralist societies (Hansen & Olsen 2014; Jørgensen 2011). Furthermore, as in the eastern explanation, the southern connection is considered to have begun already during Bronze Age, materially manifested through the occurrence of burial cairns and settlement structures (including two- and three-aisled long houses) of (presumed) southern Scandinavian origin (Andreassen 2002; Arntzen 2015). Although the archaeological remains of burial cairns and two- and three-aisled long houses have been found also further north along the Swedish (Lindqvist & Granholm 2016; Ramqvist 2017) and Finnish coasts (Holmblad 2010), connections have not been as pronounced between early iron handling and southern contacts. This is probably due to a greater scarcity so far of early metallurgical finds in these areas. Some researchers have problematized the geographical linear view and questioned the Scandinavian origin of the Bronze Age burial cairns since radiocarbon datings contradict that the cairn

tradition is older in the south compared to the north (Damm & Forsberg 2014; Ramqvist 2017).

The localizationist view

Since the 1980s, a postcolonial, ethno-political revitalization movement has striven to challenge the nationalist and socio-evolutionary ideas of Arctic Fennoscandia as having a retarded and inferior cultural development (Hagström Yamamoto 2010; Loeffler 2005; Ojala 2009). Focus has been directed towards local societies, agency and the role of individual power strategies in prehistoric research (for a review, see Ojala 2009; Forsberg 2012). The movement has particularly resulted in a strong growth of research on the indigenous Sámi of the area, and particularly on the emergence of a Sámi ethnicity—Sámi archeology has even emerged as scientific field in northern Scandinavia (e.g. Hansen & Olsen 2014). The movement has been influential; broad groups of researchers today nominate the prehistoric hunter-gatherers as the ancestors of present-day Sámi (Forsberg 1996; Hansen & Olsen 2014). Others criticize the movement of being unreflectively self-glorifying and exclusive in a political context, questioning the plausibility of a now-living ethnic group to claim it was first (e.g. Wallerström 2006).

In the same way as previous national history writing placed metals at the forefront of discussions, metals still play an important role in the formulation of (Sámi) identity and ethnicity. The overall agreement within Sámi archeology is that the Sámi identity process had already started in the Late Bronze Age, when hunter-gatherer communities in Arctic Fennoscandia intensified their long-distance contacts with metal-producing agricultural societies in the Volga-Kama area, through which bronze and iron are considered to have spread to the hunter-gatherers in exchange for furs and other hunting products. The elements of the emergence of a Sámi ethnicity are influenced by theories on ethnicity as a social construction shaped by a practical need to arrange coexistence/interaction between two groups and communicated mainly through symbols expressed in the material culture (Hansen & Olsen 2014). Hence, contact with the eastern metal-producing agricultural societies is suggested to have triggered the hunter-gatherers' discovery of distinctive cultural characteristics and differences. The process is suggested also to be related to the above-described increased southern (and agricultural) contacts of coastal hunter-gatherer communities, which over time displayed great contrast to the remaining inland hunting-gatherer communities further north (Hansen & Olsen 2014).

The discovery of distinctiveness is manifest in the split of the former uniform textile ceramic tradition of Arctic Fennoscandia into the geographically complementary Risvik and Kjelmöy ceramics. The stylistic traits of the ceramics are considered the most important ethnic marker/symbolic language of the hunter-gatherers in their transactions to secure access to metals and overall in their interaction with metal-producing farming societies (Hansen & Olsen 2014; Jørgensen & Olsen 1987). The growing supply of iron in the Roman Iron Age has been suggested as contributing to a specialization in resource utilization by hunter-gatherer communities (towards reindeer hunting), involving the transition from stone to metal technology, and over time from hunting/fishing as main subsistence to domesticated reindeer herding during the Late Iron Age (Bergman *et al.* 2013; Mulk 1994; Storli 1993; see Ojala 2009 for further background on the emergence of Sámi ethnicity). Hence, in the same way as in the emergence of farming, and based on basic evolutionary and progressive explanatory models, iron is attributed with the ability to cause revolutionary socio-economic change.

With parallels to the role ascribed to local Mediterranean societies in recent iron research, Sámi archaeology has further presented several new perspectives regarding metals and related contacts and power relations of Sámi/hunter-gatherers from the Bronze Age onwards (Jørgensen 2010; Kuusela *et al.* 2018; Melheim 2012; Ramqvist 2012). Regarding iron technology, and through their eastern contacts with the Ananino culture, Sámi/hunter-gatherers have, for example, been attributed the role of local/indigenous developers of iron technology during the large-scale iron production in inland middle Sweden in the Migration period (AD 400–500) (Ramqvist 2012). In fact it is suggested that the Sámi/hunter-gatherers produced and delivered iron and fur to farming chiefdoms along the coast. The farming chiefdoms are considered as refiners of the iron, functioning as middlemen in the trading of iron and fur further south (Ramqvist 2012). Similar perspectives have recently been suggested regarding non-hierarchical relations between Sámi/hunter-gatherers and power centres operating in the Baltic sphere during the Middle Ages (AD 1000–1520), involving trade actions of metals and fur (Henriksen 2019; Kuusela *et al.* 2018).

Influence of long-standing European views

An in-depth review of the literature on the emergence of iron technology in Arctic Fennoscandia

reveals that explanations are recurrently understood and organized within the conventional framework of the time, course and cultural context of the introduction of iron technology in Europe, instead of challenging it. This also applies to postcolonial and ethnopolitical research of recent years, which has had a particularly strong impact on Arctic Fennoscandian iron research. Hence, to this day, the predominant scholarly opinion is that the Iron Age hunter-gatherer societies of Arctic Fennoscandia did not play any noteworthy role in metal technology on a broader European scale. The tenacious influence of the conventional framework in terms of a strong bias for origin and dualism in connection with diffusionist and evolutionary theories has made it almost impossible to interpret the northern finds in any other way. Archaeologists have been locked into an explanatory context where some aspects have simply been excluded from further investigation.

A basic example of how the narrative structure of evolutionary frameworks still implicitly recurs in interpretations of the emergence of iron technology in Arctic Fennoscandia consists of the idea of how the emergence of iron (from initial to fully fledged phase) follows a unilinear progressive development similar to the conventional explanatory models of European iron research. The diffusion is considered to begin with the introduction of metal objects arriving via eastern and southern trade/exchange networks, later followed by the appearance of actual knowledge of iron technology (e.g. Hood & Olsen 1988; Jørgensen 2010; Kotivuori 2013; Sundquist 1999). Similar arguments have been put forward regarding metal objects found in other parts of the northern circumpolar area, such as in northern Siberia and Alaska/Canada (Cooper *et al.* 2016; Dyakonov *et al.* 2019; Janz & Conolly 2019). Our findings from the Sangis and Vivungi sites, however, fit poorly with these explanations as there seems to have been no preceding phase where metal objects were imported before the skills to produce and manufacture iron was acquired. What we see is that all stages in iron technology were in place from the start, including skills in prospecting/collecting raw material (clay and ore) and in smelting and smithing iron.

The eastern and southern diffusion ideas are still more closely linked to the universal and progressive scheme of the Three-Age system, where bronze precedes iron in the diffusion from the east and the south and where it is assumed that some prior knowledge of bronze handling is required to be able to handle iron. But hitherto, north

Fennoscandian bronze craft is completely unexplored and undated. We do not know which process steps were performed in copper/bronze handling or even if it really preceded iron handling. Further, extensive stone smithing occurs in parallel with iron technology at both the Sangis and Vivungi sites, overall demonstrating the ramification of the evolutionary sequences of the Three Age system.

The spread of iron is further described as a one-directional, centre-periphery relationship where the peripheral communities of the arctic Fennoscandian hunter-gatherers are narrowed down to inferior/passive recipients of iron rather than active agents of iron and technological knowledge, typically with the application of dichotomies as tool for separation. Hence, the emergence of iron technology is inevitable linked to complex farming populations, regardless of temporal scale. In the same dichotomic way, early (to the mid twentieth century) Scandinavian archaeology typically treated the northern parts of Scandinavia as something separate, different and liminal in relation to the 'national' and 'southern Scandinavian/Nordic' (Hagström-Yamamoto 2010; Ojala & Ojala 2020). Likewise, the Arctic has been treated as something separate and different in relation to the Nordic (Bakka 1976), and inland as something separate from coastal Arctic Fennoscandia (Hansen & Olsen 2014; Jørgensen 2010; Sundquist 1999).

The center-periphery relationship relates to evolutionary-based models of different modes of trade associated with different types of societies (Renfrew 1975), generally taken as exclusive categories. Hence, while the exchange of the egalitarian hunter-gatherers typically is expressed in the form of reciprocity, the exchange of the hierarchical farming populations is expressed through redistribution. And we see parallels in the division of labour, in that the assumed occupations/know-how of the hunter-gatherers typically include forging, decorating and distributing rather than producing (from raw materials) metals.

The discursive dichotomy between farmers/centres and hunter-gatherers/periphery is maintained within recent research on the emergence of a Sámi ethnicity. Hence, the hunter-gatherers/ Sámi, although suggested producers (smelting the ores), are still not refiners or consumers, and they are still recipients of knowledge of metal technology from outside (Ramqvist 2012). There are parallels in the view of Romans and so-called barbarians in European iron research, where producers and refiners-consumers typically are regarded as belonging to different groups, with corresponding distance from perceived cultural centres (Pleiner 2006). Our finds of elaborate

craftsmanship among Arctic Fennoscandian hunter-gatherers in both coastal Sangis and inland Vivungi already during the Early Iron Age, and including both bloomery steel production and the mastering of advanced smithing techniques, fit poorly with one-directional, centre-periphery views and related evolutionary-based models.

With the assumed forging, decorating and distribution, rather than production of iron, follow further small-scale assumptions, where no extensive organization was needed, and where iron working therefore easily could be managed by a few persons (e.g. Jørgensen 2011). These assumptions further include interpretations of a small-tool tradition, and thus a lesser need of iron (Jørgensen 2010; Sundquist 1999). This long-prevalent idea of early iron production as primitive and low-tech, implying low efficiency and a limited amount of iron obtained at each run, means Arctic Fennoscandian iron research has typically been directed towards quantity rather than quality of iron. Conclusions have been based on the seemingly small amounts of residual products in the form of slag and their morphological appearance.

It is one thing that we do not find support in literature to explain our findings, and far more distressing to consider the extensive consequences of the long-time marginalization (on behalf of the broad history of iron technology) of important aspects and actors in the complex processes of iron technology in Arctic Fennoscandia. The assumed diminutive role of iron technology in hunter-gatherer contexts (albeit based on weak empirical grounds) has had a devastating influence on archaeologists' attitude even towards finds of actual iron-production sites in such contexts (since the 1980s), and although they in fact are radiocarbon-dated to the Pre-Roman Iron Age (Jørgensen 2010; Kotivuori 2013). Hence, these finds have been rather neglected, and without actual attempts to determine the characteristics behind the objects or the metallurgical remains. According to this essentialist reasoning, the scale of Arctic Fennoscandian production has not been considered sufficient to meet even the small iron demands of the hunter-gatherer groups, who consequently were dependent on the import of iron (Hulthén 1991; Jørgensen 2010; Sundquist 1999). Again, these inferences stand in stark contrast to our finds in Sangis and Vivungi, implying a rather comprehensive organization on a societal level and a production in parity with the assumed need of iron in a farming context.

While much recent literature dealing with the prehistoric Arctic north makes a significant and

much needed contribution to the knowledge and repositioning of ancient Arctic hunter-gatherer communities, regarding the introduction of ceramics, metals and cultivation which otherwise typically is attributed to agricultural groups, the literature still lingers with traditional discursive dichotomies, centre-periphery diffusion and evolutionary ideas. Hence, e.g. recent Stone Age research (Alenius *et al.* 2013; Nordqvist & Herva 2013) implicitly focuses on trying to confirm that the northern area advanced towards neolithization (through established evolutionary sequences) at an earlier stage than previously thought. In the same evolutionary vein as the interpretative framework of the emergence of iron technology and on weak contextual/archaeologically empirical ground (there is a general lack of actual archaeological traces of cultivation practices), the (assumed) small-scale finds of pollen evidence of cultivation, copper metals, semi-sedentary settlements and ceramics are taken as evidence for a long-term and initially small-scale/sporadic neolithization process (Alenius *et al.* 2013).

Other recent literature that strives to reposition the Arctic north and which generally criticizes the dichotomic picture and asymmetrical relations/passive role typically ascribed to northern hunter-gatherers (Forsberg 2012; Janz & Conolly 1919; Kuusela 2020; Kuusela *et al.* 2018; Melheim 2012; Ramqvist 2012), despite its general focus on the active role of local societies, is still locked in world system theory with a persistent focus on centre/periphery relations. There is further a persistent focus on bounded cultures/identities in much of this literature, where archaeological remains (according to typology and morphology) are assigned to different cultural groups and considered markers of ethnic identity. Hence, northern Fennoscandia as a border zone between western and eastern cultural spheres is a strong notion in Fennoscandian literature (e.g. Nordqvist 2018; Sørensen *et al.* 2013), along with the division of the coastal and inland communities of northern Fennoscandia into two different cultural and economic systems (based typically on the distribution of ceramics and metals), with inland societies considered proto-Sámi and coastal societies proto-farmers, antecedents of the Scandinavian/Germanic population (Ojala & Ojala 2020). Lately, since the archaeological material nevertheless show great diversity even within small regions (Kuusela 2020), archaeologists have divided Arctic Fennoscandia into even smaller systems (Ramqvist 2007; 2012), and further contributed to interpretations of the appearance of hybridity cultures in the form of, e.g., 'Sámi practising cultivation' (Bergman & Hörnberg 2015).

With the persistent ambition to fit material culture into existing developmental trajectories, or use it as markers of cultural identity, follows a lack of focus on *how* technology transferred, of the social content and form of exchange pathways and of the local adoption and maintenance of new technologies. This has recently been highlighted in archaeological literature (Ojala & Ojala 2020), such as the problems of applying find-categories in local contexts to large, homogenous Sámi (and Germanic) ethnic categories, and on weak empirical grounds (Ojala 2014). Although we reaffirm the importance of formulating a long-neglected past, regarding ethnic categorized historiography in northern Fennoscandia of recent years, we join Wallerström (2006) and question the exclusion to which it contributes in a political context. We do not want to limit the possibility for anyone/any group to experience connections to our findings. Hence, for us, it would be equally out of the question to denominate the ancient hunter-gatherers proto-Swedes, proto-Sámi, or some other proto-ethnic/cultural identity, both for exclusionary reasons and for the limitations shown through this article from the traditional classification of remains.

Also other archaeological literature, in part focusing on Arctic Fennoscandia (Damm 2012; Skandfer 2005) and other parts of the circumpolar north (see e.g. Jordan & Gibbs 2019) (preferably concerning ceramics), problematizes the equation of pots with ethnic and cultural groups, and further tries to overcome simplified models of the past from focusing on networks of contacts and common practices. In our interpretation of our findings, we are inspired by this research where overall there has been little prior focus on iron. We are further inspired by recent literature on Southeast Asia (Thailand) regarding metal technology (copper and bronze), which integrates (natural) scientific methods to increase the social knowledge of prehistoric societies (White & Hamilton 2018).

Discussion and conclusion

Our analysis of Arctic Fennoscandian iron research reveals a strong dominance of evolutionary frameworks based on asymmetrical relations, framing the Fennoscandian hunter-gatherers as passive recipients rather than active agents of iron and technological knowledge. It is a general situation in much iron research that while the origin framework has become more differentiated in recent decades, much research is still characterized by socio-evolutionary ideas. Such ideas have had a devastating influence on the attitude towards iron finds in Arctic Fennoscandian

archaeological research, with serious consequences for overall understanding in European iron research. Hence, when we now for the first time in this region analyse metal finds in depth, not only do we reveal early iron handling far from perceived centres, but also that iron was a substantial and integral part within the hitherto unrecognized context of the pre-historic hunter-gatherer community.

In terms of the spread of iron, diffusionist models have played a central role in Arctic Fennoscandian iron research—with metals and fur playing major roles in defining centres and peripheries—and with a strong focus on bounded cultures/identities with ceramics and metals defining the cultures and their geographical borders. Explanations further persistently build on the trade idea, where innovation/emergence of iron is understood as the outcome of the very interaction of different regional groups and the mere exposure of (metal) objects emanating from early metal-producing centres.

Overall, it is about a long list of explanations that simplify the complexity of transferring metals technology between societies (White & Hamilton 2018), and which limit the possibility to investigate *how* the metals really transferred. Hence, with polarization, bounded cultures/identities and progressive sequences in focus, fluidity and variety is easily lost. Not all communities would have followed the same trajectory in the adoption of innovations/technologies. There would have been many different strategies, which motivates us to explore the underlying mechanisms of the transfer of technological knowledge, possible exchange pathways, and how the inception of iron transformed society. Even though the exchange networks of an eastern origin have long been the focus of north Fennoscandian archaeologists, broader discussions over these relations are generally lacking, and the eastern contacts still play the role of the unknown and unexplored. Theories that have been put forth have not led to any in-depth studies of the material culture of the communities in the Volga-Kama region, or of the character of long-distance contacts (Ojala & Ojala 2020).

It is generally conceived a challenge for archaeologists to identify the social content and form of exchange pathways and networks, and the underlying mechanisms for the adoption and maintenance of a technology. Variables used mainly concern morphological and stylistic attributes of artifacts where similarities are taken as proxy for links between sites. These attributes, however, tell us nothing about the actual type of interaction (Roux 2019). Here archaeology has a lot to gain from an increased focus on the technological aspects through an

archaeometric approach, to reconstruct production methods and techniques (the *chaîne opératoire*) and get clues as to what levels of knowledge/skills and equipment would have been required to perform each identifiable transformation stage from ore to metal. This would open up a detailed identification of social processes and activities, and overall provide important insights into the adoption and role of metal in Arctic Fennoscandia and Europe. It would further lead to a systematic and sophisticated addressing of the transfer of metallurgy. Instead of bounded cultures and identities, material culture repertoires (technological style and knowledge) would in various ways work as common elements of shared cultural practices (Damm 2012; Skandfer 2009), or as Brosseder & Miller (2018, 16) put it, reveal the cultural ‘weft’ of connectivity across the ‘warp’ of distinct, yet interwoven societies.

To exemplify further through our findings, archaeometric analyses give us clues about the nature of the knowledge transfer, which in turn opens new perspectives on the networks of the Early Iron Age hunter-gatherers in Arctic Fennoscandia. Hence, archaeometric analyses reveal great similarities in the technological practices between our sites (despite the vast distance) and a general lack of experimentation in the metallurgical material. This indicates the transmission of technology as a full package—including objects, smithing and smelting techniques—all transferring at the same time, in turn implying the existence of distinct technological learning networks of skilled practitioners (Hjärthner-Holdar & Risberg 2009). Hence, the mastery of a craft such as metallurgy presupposes both theoretical and practical knowledge taught through guidance from an experienced person (White & Hamilton 2018), i.e. it would require a process of learning at an exploitable ore source to communicate the various stages of metal production through visual demonstrations and verbal explanations for the multifaceted knowledge transfer to occur.

The skilled and extensive metal production further opens new perspectives on the organizational ability and probable habitation patterns of the small communities, as well as of their desires and metal use. Much of the prospection and extraction (of clay, stone, ore and wood), and processing (coal production, furnace construction, roasting and smelting of ore, forging) reasonably required collective commitment by the small communities (White & Hamilton 2018), and even more so, as well as far-reaching and long-term planning, when we take the Arctic climate into consideration. Hence, with frost, ice and snow in combination with coldness and darkness during half the year, extensive planning and

organization of the small community is needed to succeed in implementing iron production in parallel with other necessary livelihood-/survival measures within the time frame allowed by climate. A crucial part of the iron-production work (many individuals for many hours) must take place while the ground is bare and thus start up in parallel to when winter supplies dried up and extensive effort was required (also many individuals for many hours) to manage food supply (typically fishing and the collection of berries and plants during summer). All in all, this probably required more permanent cohabiting than previously thought (see e.g. Skandfer 2009 for a similar discussion regarding Stone Age ceramics).

There was no inherent functional reason why metal objects or metal production should be adopted by the Early Iron Age hunter-gatherers in Arctic Fennoscandia, and it was thus not only up to the metal producers for the transfer to occur. Hence, in addition to the collective aspects of metal production described above, it also required the desires of the communities who adopted the metallurgical skills, and further circulated and used the metal objects. Transmission was the consequence of the desire to participate in networks of socio-cultural interaction, networks whose existence already depended on the regular movement of individuals and groups (Roberts & Vander Linden 2011). With such a perspective there is not a single line of development trajectory, but we get a punctuated transmission sequence reflecting a mosaic of community traditions, in part depending on the networks and cross-cultural affiliations between otherwise distinct and disparate societies. In sum, it is high time to recognize the Early Iron Age hunter-gatherers in Arctic Fennoscandia as early adopters of iron technology and active network participants. We have both material and methods for this.

Carina Bennerhag
The History Unit
Luleå tekniska universitet
Luleå 971 87
Sweden
Email: carina.bennerhag@ltu.se

Sara Hagström Yamamoto
The History Unit
Luleå tekniska universitet
Luleå 971 87
Sweden
Email: sara.hagstrom.yamamoto@vasteras.se

Kristina Söderholm
The History Unit
Luleå tekniska universitet
Luleå 971 87
Sweden
Email: kristina.soderholm@ltu.se

References

- Alenius, T., T. Mökkönen & A. Lahelma, 2013. Early farming in the northern Boreal Zone: reassessing the history of land use in southeastern Finland through high-resolution pollen analysis. *Geoarchaeology* 28, 1–24.
- Alpern, S.B. 2005. Did they or didn't they invent it? Iron in Sub-Saharan Africa. *History in Africa* 32, 41–94.
- Amzallag, N., 2009. From metallurgy to Bronze Age civilizations: the synthetic theory. *American Journal of Archaeology* 113, 497–519.
- Andreassen, D.M., 2002. Risvikkeramik: En analyse av teknologisk stil på Nordkalotten i sein steinbrukende tid [Risvik ceramic: an analysis of the technological style on the Nordkalotten during the Late Stone Age]. MA thesis, UiT The Arctic University of Norway.
- Arntzen, J.E., 2015. Sandvika in northern Norway: the northernmost 'bronze age' settlement in Scandinavia. *Fennoscandia Archaeologica* 32, 3–34.
- Bakka, E., 1976. *Arktisk og Nordisk i bronsealderen i Nordskandinavia* [Arctic and Nordic in the Bronze Age of northern Scandinavia]. (Det Kgl. Norske Videnskabers Selskab, Museet, Miscellanea 25.) Trondheim: Trondheim University.
- Bebber, M.R. 2021. The role of functional efficiency in the decline of North America's Copper Culture (8000–3000 BP): an experimental, ecological, and evolutionary approach. *Journal of Archaeological Method and Theory* 28, 1224–60.
- Bebermeier, W., M. Brumlich, V. Cordani, *et al.*, 2016. The coming of iron in a comparative perspective. *eTopoi. Journal for Ancient Studies Special Volume* 6, 152–89.
- Bennerhag, C., L. Grandin, E. Hjärthner-Holdar, O. Stilborg & K. Söderholm, 2021. Hunter-gatherer metallurgy in the Early Iron Age of northern Fennoscandia. *Antiquity* 95, 1511–26.
- Bergman, I. & G. Hörnberg, 2015. Early cereal cultivation at Sámi settlements: challenging the hunter-herder paradigm? *Arctic Anthropology* 52(2), 57–66.
- Bergman, I., O. Zackrisson & L. Liedgren, 2013. From hunting to herding: land use, ecosystem processes, and social transformation among Sami AD 800–1500. *Arctic Anthropology* 50(2), 25–39.
- Brosseder, U. & B. Miller, 2018. Global networks and local agents in the Iron Age Eurasian steppe, in *Globalization in Prehistory: Contact, exchange, and the 'people without history*, eds N. Boivin & M. Frachetti. Cambridge: Cambridge University Press, 162–83.
- Buchwald, V.F., 2005. *Iron and Steel in Ancient Times*. Copenhagen: Det Kongelige Danske Videnskabernes Selskab.

- Charlton, M.F., P. Crew, T. Rehren & S.J. Shennan, 2010. Explaining the evolution of ironmaking recipes—an example from northwest Wales. *Journal of Anthropological Archaeology* 29(3), 352–67.
- Childe, V.G., 1944. Archaeological ages as technological stages. *Journal of the Royal Anthropological Institute of Great Britain and Ireland* 74, 7–24.
- Cooper, H.K., O.K. Mason, V. Mair, J.F. Hoffecker & R. J. Speakman, 2016. Evidence of Eurasian metal alloys on the Alaskan coast in prehistory. *Journal of Archaeological Science* 74, 176–83.
- Damm, C.B., 2012. From entities to interaction: replacing pots and people with networks of transmission, in *A Linguistic Map of Prehistoric Northern Europe*, eds G. Riho & K. Petri. Helsinki: Société Finno-Ougrienne, 41–62.
- Damm, C. & L. Forsberg, 2014. Forager–farmer contacts in northern Fennoscandia, in *The Oxford Handbook of the Archaeology and Anthropology of Hunter-Gatherers*, eds V. Cummings, P. Jordan & M.k Zvelebil. Oxford: Oxford University Press, 838–56.
- Diaz-Andreu, M.&T. Champion (eds), 1996. *Nationalism and Archaeology in Europe*. London: UCL Press.
- Dyakonov, V., K. Pestereva, A. Stephanov & O. Mason, 2019. The spread of metal and metal production technology in the far northeast and Alaska over the second millennium BC to the first millennium AD. *World Archaeology* 51(3), 355–81.
- Eliyahu-Behar, A., N. Yahalom-mack, Y. Gadot & I. Finkelstein, 2013. Iron smelting and smithing in major urban centers in Israel during the Iron Age. *Journal of Archaeological Science* 40, 4319–30.
- Engels, F., 1972. *The Origins of the Family, Private Property and the State*. New York (NY): International Publishers.
- Erä-Esko, A., 1969. Akinakeslöytö Pohjois-Suomesta [Akinakai finds from northern Finland]. *Suomen Museo* 76, 85–93.
- Erb-Satullo, N.L., 2019. The innovation and adoption of iron in the ancient Near East. *Journal of Archaeological Research* 27(4), 557–607.
- Forsberg, L., 1996. Forskningslinjer inom samisk förhistoria [Research lines within Sami prehistory]. *Arkeologi i Norr* 6/7 (1993/94), 165–86.
- Forsberg, L., 2012. Assymmetric twins? Some reflections on coastal and inland societies in the Bothnian area during the Epineolithic and Early Metal Age, in *Local Societies in Bronze Age Northern Europe*, eds N. Anfinset & M. Wrigglesworth. Sheffield: Equinox Publishing, 31–5.
- Gassmann, G. & A. Schäfer, 2018. Doubting radiocarbon dating from in-slag charcoal: five thousand years of iron production at Wetzlar-Dalheim. *Archeologické rozhledy* 70, 309–27.
- Godfrey, E. & M. van Nie, 2004. A Germanic ultrahigh carbon steel punch of the Late Roman-Iron Age. *Journal of Archaeological Science* 31(8), 1117–25.
- Hagström Yamamoto, S., 2010. *I gränslandet mellan svenskt och samiskt: Identitetsdiskurser och förhistoria i Norrland från 1870-tal till 2000-tal* [In the borderland between Swedish and Sami: identity discourses and prehistory in Norrland from the 1870s to the 2000s]. (OPIA 52.) Uppsala: Institutionen för Arkeologi och Antik Historia, Uppsala universitet.
- Hakamäki, V. & J.-M. Kuusela, 2013. Examining the topography and social context of metal age artefact finds in northern Finland. *Fennoscandia Archaeologica* 30, 95–106.
- Hansen, L.I. & B. Olsen, 2014. *Hunters in Transition: An outline of early Sámi history*. Leiden: Brill.
- Hansson, S., 1987. *Från Nasafjäll till SSAB. Järn-och gruwhantering i Norrbotten under 300 år* [From Nasafjäll to SSAB. 300 years of iron and mining management in Norrbotten]. Luleå: Centek förlag.
- Henriksen, J.E., 2019. Trade, manufacture, dismantling and reassembling? Metal processing and eastern ornaments at Brodtkorbneset and Steintjørna. *Iskos* 22, 40–66.
- Higham, C.F.W., 2004. Mainland Southeast Asia from the Neolithic to the Iron Age, in *Southeast Asia: From prehistory to history*, eds I. Glover & P. Bellwood. London: Routledge Curzon, 41–67.
- Hjärthner-Holdar, E. 1993. *Järnets och järnmetallurgins introduktion i Sverige* [The introduction of iron and iron metallurgy to Sweden]. (Societas Archaeologica Upsaliensis 16.) Uppsala: University of Uppsala.
- Hjärthner-Holdar, E. & C. Risberg. 2009. Technology of iron: choices and innovation. *Materials and Manufacturing Processes* 24, 981–6.
- Hjärthner-Holdar, E., L. Grandin, K. Sköld & A. Svensson, 2018. By who, for whom? Landscape, process and economy in the bloomery iron production AD 400–1000. *Journal of Archaeology and Ancient History* 21, 1–50.
- Holmblad, P., 2010. *Coastal communities on the Move. House and polity interaction in Southern Ostrobothnia 1500 BC–AD 1*. (Archaeology and Environment 26.) Umeå: Umeå universitet, Department of Historical, Philosophical and Religious Studies.
- Hood, B.C. & B. Olsen, 1988. Virdnejavri 112. A Late Stone Age-Early Metal period site from interior Finnmark, north Norway. *Acta Archaeologica* 58, 105–25.
- Hulthén, B., 1991. *On Ceramic Ware in Northern Scandinavia During the Neolithic, Bronze and Early Iron Age. A ceramic-ecological study*. (Archaeology and Environment 8.) Umeå: Umeå universitet.
- Janz, L. & J. Conolly, 2019. Margins of the centre or critical peripheries? *World Archaeology* 51(3), 347–54.
- Jordan, P. & K. Gibbs (eds), 2019. *Ceramics in Circumpolar Prehistory: Technology, lifeways and cuisine*. Cambridge: Cambridge University Press.
- Jordan, P. & M. Zvelebil (eds), 2009. *Ceramics before Farming: The dispersal of pottery among prehistoric Eurasian hunter-gatherers*. London/New York: Routledge.
- Jørgensen, R., 2010. Production or Trade? The Supply of Iron to North Norway during the Iron Age. Unpublished PhD dissertation, Tromsø University.

- Jørgensen, R., 2011. Prehistoric iron production in north Norway. *Acta Archaeologica* 82, 97–128.
- Jørgensen, R. & B. Olsen, 1987. Asbestkeramikk i Nord Norge. [Asbestos tempered ceramics in northern Norway]. *Finskt museum* 94, 5–39.
- Kanjanajuntorn, P., 2020. The three-age system: a struggle for Southeast Asian prehistoric periodisation. *SPAFA Journal* 4. DOI: 10.26721/spafajournal.v4i0.623
- Karlsson, C. & G. Magnusson (eds), 2020. *Iron and the Transformation of Society: Reflexion of Viking Age metallurgy*. Stockholm: Jernkontoret.
- Killick, D., 2009. Cairo to Cape: the spread of metallurgy through eastern and southern Africa. *Journal of World Prehistory* 22(4), 399–414.
- Killick, D. & T.R. Fenn, 2012. Archaeometallurgy: the study of preindustrial mining and metallurgy. *Annual Review of Anthropology* 41, 559–75.
- Kosmenko, M.G. & I.S. Manjuhin, 1999. Ancient iron production in Karelia. *Fennoscandia Archaeologica* 16, 31–46.
- Kotivuori, H., 2013. Tidiga spår av järnhantering i Norra Finland [Early traces of iron working in northern Finland], in *Övnstypologi og övnskronologi i den nordiske jernvinna: Jernvinna i Oppland (Symposium på Kittilbu, June 16–18, 2009)* [Furnace typology and furnace chronology in Nordic iron production: iron production in Oppland (Symposium at Kittilbu, June 16–18, 2009)], eds B. Rundberget, J.H. Larsen & T. H.B. Haraldsen. Oslo: Portal, 55–8.
- Kuusela, J.M., 2020. Signs of cultural diversity in the 13th to 15th centuries AD coastal region of the Bothnian Bay in northwestern Fennoscandia. *Arctic Anthropology* 57 (1), 53–71.
- Kuusela, J.-M., R. Nurmi & V. Hakamäki, 2018. Unhierarchical and hierarchical core-periphery relations: North Fennoscandian trade network from the Middle Ages to the post-sixteenth century. *American Anthropologist* 120(1), 765–80.
- Lavento, M., 1999. An iron furnace from the Early Metal period at Kitulansuo in Ristiina, in the southern part of the Lake Saimaa water system. *Fennoscandia Archaeologica* 16, 75–80.
- Layton, R. (ed.), 1994. *Who Needs the Past? Indigenous values and archaeology*. London: Routledge.
- Lindqvist, A.-K. & N. Granholm, 2016. Stolpbyggda hus vid Umeälvens mynning. Den yngre bronsåldern I ny skepnad [Post-built houses at the Ume river outlet. New insights on the early Bronze Age]. *Arkeologi i Norr* 15, 37–62.
- Loeffler, D., 2005. *Contested Landscapes/Contested Heritage: History and heritage in Sweden and their archaeological implications concerning the interpretation of the Norrlandian past*. Umeå: Umeå Universitet.
- Magnusson, G. 1987. Järn, kolonisation och landskapsutnyttjande i Norrlands inland [Iron, colonization and landscape utilization in the interior of Norrland]. *Bebyggelsehistorik tidskrift* 14, 127–36.
- Melheim, L., 2012. Reconsidering a periphery: scenarios of copper production in southern Norway, in *Local Societies in Bronze Age Northern Europe*, eds N. Anfinset & M. Wrigglesworth. Sheffield: Equinox, 89–107.
- Mirau, N.A., 1997. Social context of early ironworking in the Levant, *Urbanism in Antiquity: From Mesopotamia to Crete*, in eds W.A. Aufrecht, N.A. Mirau, S. W. Gauley. Sheffield: Sheffield Academic Press, 99–115.
- Morgan, L.H., 1877. *Ancient Society or Research in the Lines of Human Progress from Savagery through Barbarism to Civilization*. Chicago (IL): Charles H. Kerr.
- Mulk, I.-M., 1994. *Sirkas: ett samiskt fångstsamhälle i förändring Kr.f.-1600 e.Kr* [Sirkas: a Sámi hunting community in change from the birth of Christ until 1600 AD]. (Studia Archaeologica Universitatis Umenensis 6). Umeå: Umeå Universitet.
- Norberg, P., 1958. *Forna tiders järnbruk i Norr- och Västerbotten* [Ancient ironworks in the counties of Norr- and Västerbotten]. Stockholm: Almqvist & Wiksell.
- Nordqvist, K., 2018. The Stone Age of North-Eastern Europe 5500–1800 calBC. Bridging the Gap between the East and the West. PhD dissertation, University of Oulu.
- Nordqvist, K. & V-P. Herva, 2013. Copper use, cultural change and Neolithization in north-eastern Europe (c. 5500–1800 BC). *European Journal of Archaeology* 32, 401–32.
- Ojala, C-G., 2009. *Sámi Prehistories: The Politics of Archaeology and Identity in Northernmost Europe*. (OPIA 47.). Uppsala: Institutionen för Arkeologi och Antik Historia, Uppsala universitet.
- Ojala, C-G., 2014. East and West, North and South in Sápmi – Networks and Boundaries in Sámi Archaeology in Sweden, in *Sounds Like Theory. XII Nordic Theoretical Archaeology Group Meeting in Oulu 25.–28.4.2012*, eds J. Ikäheimo, A-K. Salmi & T. Äikäs. (Monographs of the Archaeological Society of Finland 2.) Helsinki: Archaeological Society of Finland, 173–85.
- Ojala, K. & C-G. Ojala, 2020. Northern connections: interregional contacts in Bronze Age northern and middle Sweden. *Open Archaeology* 6(1), 151–71.
- Peets, J., 2003. Raa vägi: raua tootmine ja sepatöö eestis ja naaberpiirkondades muinas- ja keskajal [The power of iron. Iron production and blacksmithing in Estonia and neighbouring areas in prehistoric period and the middle ages]. Unpublished PhD dissertation, Ajaloo instituut, Tallinn.
- Pleiner, R., 2000. *Iron in Archaeology: The European bloomery smelters*. Prague: Archeologický Ústav Avěr.
- Pleiner, R., 2006. *Iron in Archaeology: Early European blacksmiths*. Prague: Archeologický Ústav Avěr.
- Ramqvist, P.H., 2007. Fem Norrland. Om norrländska regioner och deras interaktion [Five Norrland. About the Norrlandic regions and their interaction]. *Arkeologi i norr* 10, 153–76.
- Ramqvist, P.H., 2012. *Norrländska samspel under järnåldern. Människor i vikingatidens Mittnorden. Föredrag vid de*

- Mittnordiska Arkeologidagarna i Östersund 2010* [Norrländic interactions during the Iron Age. People in the Mid-Nordic area of the Viking Age. Lecture at the Mid-Nordic Archeology Days in Östersund 2010], ed. O. Hemmendorff. Östersund: Jamtli Förlag, 32–53.
- Ramqvist, P.H., 2017. Om äldre gravskick i det norrländska kustområdet [About ancient burials in the Norrländic coastal area]. *Arkeologi i norr* 16, 87–110.
- Renfrew, C., 1969. The autonomy of the south-east European Copper Age. *Proceedings of the Prehistoric Society* 35, 12–47.
- Renfrew, C., 1975. Trade as action at a distance, in *Ancient Civilization and Trade*, eds J.A. Sabloff & C. C. Lamberg-Karlovsky. Albuquerque (NM): University of New Mexico Press, 3–59.
- Renzi, M., S. Rovira, M.C. Rovira-Hortalá & I. Montero Ruiz, 2013. Questioning research on early iron in the Mediterranean, in *The World of Iron*, eds J. Humphris & S. Rovira. London: Archetype, 178–87.
- Rijk, P. & I. Joosten, 2014. Heeten revisited – Germanic iron production in the Netherlands, in *Early Iron in Europe*, eds B. Cech & T. Rehren. Dremil-Lafage: Éditions Mergoïl, 65–80.
- Roberts, B., 2009. Origins, transmission and traditions: analyzing early metal in western Europe, in *Metals and Societies: Studies in honour of Barbara S. Ottaway*, eds T.L. Kienlin & B.W. Roberts. Bonn: R. Habelt, 129–42.
- Roberts, B. & M. Vander Linden (eds), 2011. *Investigating Archaeological Cultures: Material Culture, Variability, and Transmission*. Berlin: Springer.
- Roux, V., 2019. Modeling the relational structure of ancient societies through the chaîne opératoire: the Late Chalcolithic societies of the southern Levant as a case study, in *Integrating Qualitative and Social Science Factors in Archaeological Modelling*, eds M. Saqalli & M. Vander Linden. Cham: Springer, 163–84.
- Rudebeck, E., 2000. *Tilling Nature Harvesting Culture – Exploring images of the human being in the transition to agriculture*. (Acta Archaeologica Lundensia 32.) Stockholm: Almqvist & Wiksell.
- Serning, I., 1960. *Övre Norrlands Järnålder* [Upper Norrland's Iron Age]. (Skrifter utgivna av Vetenskapliga biblioteket i Umeå 4.) Umeå.
- Skandfer, M., 2005. Early northern comb ware in Finnmark: the concept of Säräisnieni 1 reconsidered. *Fennoscandia Archaeologica* 23, 3–27.
- Skandfer, M., 2009. All change? Exploring the role of technological choice in the early northern Comb Ware of Finnmark, arctic Norway, in *Ceramics before Farming: The dispersal of pottery among prehistoric Eurasian hunter-gatherers*, eds P. Jordan & M. Zvelebil. Walnut Creek (CA): Left Coast Press, 347–74.
- Smith, C. & H.M. Wobst (eds), 2005. *Indigenous archaeologies: decolonising theory and practice*. London: Routledge.
- Sørensen, M., T. Rankama, J. Kankaanpää, et al., 2013. The first eastern migrations of people and knowledge into Scandinavia: evidence from studies of Mesolithic technology, 9th–8th millennium BC. *Norwegian Archaeological Review* 46(1), 19–56.
- Stenvik, L.F., 2003. Iron production in Scandinavian archaeology. *Norwegian Archeological Review* 36(2), 11–134.
- Storli, I., 1993. Sami Viking Age pastoralism – or 'the fur-trade paradigm' reconsidered. *Norwegian Archaeological Review* 26, 1–20.
- Sundquist, Ø., 1999. Traces of iron in prehistoric Finnmark. *Fennoscandia Archaeologica* 16, 47–57.
- Thomsen, C.J., 1848. *A Guide to Northern Antiquities* (trans. F. Egerton). London: John Bain.
- Veldhuijzen, H.A. & T.H. Rehren, 2007. Slags and the city, in *Metals and Mines: Studies in archaeometallurgy*, eds S. La Niece, D. Hook & P.T. Craddock. London: Archetype, 189–201.
- Wallerström, T., 2006. *Vilka var först?: en nordskandinavisk konflikt som historisk-arkeologiskt dilemma* [Who was first? A northern Scandinavian conflict as an historic-archaeological dilemma]: with an English summary. Stockholm: Riksantikvarieämbetet.
- Wertime, T.A., 1973. The beginnings of metallurgy: A new look. *Science* 182, 875–87.
- Wertime, T.A. & J.D. Muhly, 1980. *The Coming of the Age of Iron*. New Haven (CT): Yale University Press.
- White, J.C. & E.G. Hamilton, 2018. *Ban Chiang, Northeast Thailand, Volume 2A: Background to the study of the metal remains* (University Museum Monograph 149.) Philadelphia (PA): University of Pennsylvania Museum of Archaeology and Anthropology.
- Yahalom-Mack, N. & A. Eliyahu-Behar, 2015. The transition from bronze to iron in Canaan: chronology, technology and context. *Radiocarbon* 57, 285–305.
- Zachrisson, I., 1976. *Lapps and Scandinavians. Archaeological finds from northern Sweden*. (Early Norrland 10.) Stockholm: Almqvist & Wiksell.
- Zangato, E. & A.F.C. Holl, 2010. On the iron front: new evidence from Central Africa. *Journal of African Archaeology* 8, 7–23.
- Zavvalov, V.I. & N.N. Terekhova, 2018. Two iron technology diffusion routes in Eastern Europe. *Archeologické Rozhledy* 70, 328–34.

Author biographies

Carina Bennerhag is Master of Philosophy in archaeology and a PhD student in history of technology with long professional experience in north Swedish archaeology. She is well-versed in north Scandinavian prehistoric material culture with specialty in metallurgy.

Sara Hagström Yamamoto is Doctor of Philosophy in archaeology with significant experience in Scandinavian archaeological research with specialty in discourse analysis.

Kristina Söderholm is a professor in history of technology with long experience in interdisciplinary research on technology development and diffusion.